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POPULATION REVEALED BY WISE*

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## A STUDY OF THE DIVERSE T DWARF POPULATION REVEALED BY *WISE*

GREGORY N. MACE<sup>1,2</sup>, J. DAVY KIRKPATRICK<sup>2</sup>, MICHAEL C. CUSHING<sup>3</sup>, CHRISTOPHER R. GELINO<sup>2</sup>, ROGER L. GRIFFITH<sup>2</sup>,  
MICHAEL F. SKRUTSKIE<sup>4</sup>, KENNETH A. MARSH<sup>5</sup>, EDWARD L. WRIGHT<sup>1</sup>, PETER R. EISENHARDT<sup>6</sup>, IAN S. MCLEAN<sup>1</sup>,  
MAGGIE A. THOMPSON<sup>7</sup>, KATHOLEEN MIX<sup>2</sup>, VANESSA BAILEY<sup>8</sup>, CHARLES A. BEICHMAN<sup>2</sup>,  
JOSHUA S. BLOOM<sup>9</sup>, ADAM J. BURGASSER<sup>10,11</sup>, JONATHAN J. FORTNEY<sup>12</sup>, PHILIP M. HINZ<sup>8</sup>,  
RUSSELL P. KNOX<sup>8</sup>, PATRICK J. LOWRANCE<sup>2</sup>, MARK S. MARLEY<sup>13</sup>, CAROLINE V. MORLEY<sup>12</sup>,  
TIMOTHY J. RODIGAS<sup>8</sup>, DIDIER SAUMON<sup>14</sup>, SCOTT S. SHEPPARD<sup>15</sup>, AND NATHAN D. STOCK<sup>8</sup>

<sup>1</sup> Department of Physics and Astronomy, UCLA, 430 Portola Plaza, Box 951547, Los Angeles, CA 90095-1547, USA; gmace@astro.ucla.edu

<sup>2</sup> Infrared Processing and Analysis Center, MS 100-22, California Institute of Technology, Pasadena, CA 91125, USA

<sup>3</sup> Department of Physics and Astronomy, MS 111, University of Toledo, 2801 W. Bancroft St., Toledo, OH 43606-3328, USA

<sup>4</sup> Department of Astronomy, University of Virginia, Charlottesville, VA 22904, USA

<sup>5</sup> School of Physics and Astronomy, Cardiff University, Cardiff CF24 3AA, UK

<sup>6</sup> NASA Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

<sup>7</sup> Department of Astrophysical Sciences, Princeton University, Peyton Hall, 4 Ivy Lane, Princeton, NJ 08544-1001, USA

<sup>8</sup> Steward Observatory, The University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721, USA

<sup>9</sup> Department of Astronomy, University of California, Berkeley, CA 94720, USA

<sup>10</sup> Department of Physics, University of California, San Diego, CA 92093, USA

<sup>11</sup> Department of Physics, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139, USA

<sup>12</sup> Department of Astronomy and Astrophysics, University of California, Santa Cruz, CA 95064, USA

<sup>13</sup> NASA Ames Research Center, Moffett Field, CA 94035, USA

<sup>14</sup> Los Alamos National Laboratory, Los Alamos, NM 87545, USA

<sup>15</sup> Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd. NW, Washington, DC 20015, USA

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### ABSTRACT

We report the discovery of 87 new T dwarfs uncovered with the *Wide-field Infrared Survey Explorer (WISE)* and 3 brown dwarfs with extremely red near-infrared colors that exhibit characteristics of both L and T dwarfs. Two of the new T dwarfs are likely binaries with  $L7 \pm 1$  primaries and mid-type T secondaries. In addition, our follow-up program has confirmed 10 previously identified T dwarfs and 4 photometrically selected L and T dwarf candidates in the literature. This sample, along with the previous *WISE* discoveries, triples the number of known brown dwarfs with spectral types later than T5. Using the *WISE* All-Sky Source Catalog we present updated color–color and color–type diagrams for all the *WISE*-discovered T and Y dwarfs. Near-infrared spectra of the new discoveries are presented along with spectral classifications. To accommodate later T dwarfs we have modified the integrated flux method of determining spectral indices to instead use the median flux. Furthermore, a newly defined *J*-narrow index differentiates the early-type Y dwarfs from late-type T dwarfs based on the *J*-band continuum slope. The *K/J* indices for this expanded sample show that 32% of late-type T dwarfs have suppressed *K*-band flux and are blue relative to the spectral standards, while only 11% are redder than the standards. Comparison of the *Y/J* and *K/J* index to models suggests diverse atmospheric conditions and supports the possible re-emergence of clouds after the L/T transition. We also discuss peculiar brown dwarfs and candidates that were found not to be substellar, including two young stellar objects and two active galactic nuclei. The substantial increase in the number of known late-type T dwarfs provides a population that will be used to test models of cold atmospheres and star formation. The coolest *WISE*-discovered brown dwarfs are the closest of their type and will remain the only sample of their kind for many years to come.

**Key words:** binaries: general – brown dwarfs – galaxies: active – infrared: stars – stars: low-mass

**Online-only material:** color figures

### 1. INTRODUCTION

Brown dwarfs were initially theorized nearly 50 years ago as the lowest mass products of star formation (Kumar 1963; Hayashi & Nakano 1963). Without the energy provided by hydrogen burning, brown dwarfs cool as they age and transition to later spectral types (e.g., Burgasser 2004, Figure 2). As a result, older field brown dwarfs can have higher masses than young brown dwarfs, even though they have the same effective temperature and spectral type (Baraffe et al. 2003; Burrows et al. 1997). Brown dwarfs are classified by their spectral morphology, which is primarily related to effective temperature, but is also modulated by metallicity, clouds, gravity, and binarity. The cooling process results in a dearth of field L

dwarfs and a surplus of T dwarfs relative to the initial mass function (Burgasser 2004). Since Gl 229B was discovered in 1995 (Nakajima et al. 1995), the T dwarf sample has increased in spurts thanks primarily to the Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006), the Sloan Digital Sky Survey (SDSS; York et al. 2000), the United Kingdom Infrared Telescope Infrared Deep Sky Survey (UKIDSS; Lawrence et al. 2007), and the Canada–France–Hawaii Telescope Legacy Survey (CFHTLS; Delorme et al. 2008b). T dwarfs are classified by increased methane, water, and molecular hydrogen collision-induced absorption (CIA) in the near-infrared (Burgasser et al. 2002, 2006b; Geballe et al. 2002), and have inferred temperatures between  $\sim 500$  and  $\sim 1300$  K (Cushing et al. 2008, 2011; Stephens et al. 2009).

The cool brown dwarfs discovered by the *Wide-field Infrared Survey Explorer* (*WISE*; Wright et al. 2010) will provide the most robust tests of cool atmospheric models. Recent analysis of the T9 spectral standard UGPS J072227.51–054031.2 (Bochanski et al. 2011; Leggett et al. 2012; Lucas et al. 2010), and the Y dwarfs presented by Cushing et al. (2011), highlights the shortcomings of current models to match the low-flux near-infrared spectra of the coolest known objects. One promising avenue is the recent work of Morley et al. (2012) to include sulfide clouds in modeling the coolest brown dwarf atmospheres.

Tight constraints on the field mass function can be imposed by a complete census of the low-mass component of the solar neighborhood, of which the local T-dwarf component is a vital part. Our knowledge of the functional form of the mass function has a compounding influence on models of galaxy, star, and planet formation processes. Also, knowledge of the low-mass component of the solar neighborhood can be used to determine the minimum mass for star formation (Burgasser 2004; Allen et al. 2005). To approach a complete volume-limited census, we have chosen brown dwarf candidates from the *WISE* All-Sky Source Catalog by imposing methane sensitive color constraints. Employing various near-infrared spectrographs, which provide diverse resolution and wavelength coverage, we have produced accurate classifications for these candidates through comparison to spectroscopic standards. Astrometric monitoring of the coolest objects provides trigonometric parallax measurements, as discussed by Marsh et al. (2013) and Beichman et al. (2013). Kirkpatrick et al. (2012) use this information to determine absolute magnitude relationships and constrain the mass function.

In this paper we present the spectra of 100 T dwarfs, including 90 newly reported sources, which comprise approximately one-third of the present sample. Combined with the 89 T dwarfs reported by Kirkpatrick et al. (2011), *WISE* has more than tripled the number of brown dwarfs with spectral types later than T5. In Section 2 we discuss our photometric selection criteria and present *WISE* All-Sky photometry for all the objects in Kirkpatrick et al. (2011) and the new brown dwarfs presented here. In Section 3 we present our follow-up photometry and spectroscopy for the new T dwarfs and a few objects in the literature. Spectral classification, indices, and further analysis are presented in Section 4, along with comments on noteworthy objects. In Section 5 we present a dedicated discussion on the re-emergence of clouds in late-type T dwarfs. Interlopers, which mimic brown dwarfs in *WISE* color space, are discussed in Section 6. Our results are summarized in Section 7. In the Appendix we discuss our motivation for redefining spectral indices as the median flux over a wavelength range rather than the integrated flux.

## 2. CANDIDATE SELECTION

The *WISE* All-Sky Data Release (Cutri et al. 2012) is the culmination of a two-pass all-sky survey at 3.4, 4.6, 12, and 22  $\mu\text{m}$ , hereafter referred to as bands  $W1$ ,  $W2$ ,  $W3$ , and  $W4$ , respectively (Wright et al. 2010). Designed as a variant of the methane imaging technique (Tinney et al. 2005), the  $W1 - W2$  color compares the flux from the deep 3.3  $\mu\text{m}$   $\text{CH}_4$  absorption band to the bright 4.6  $\mu\text{m}$  flux in T and Y dwarfs (Mainzer et al. 2011). Cooler T and Y dwarf atmospheres possess redder  $W1 - W2$  colors than M and L dwarfs. In  $W3$  and  $W4$ , past the blackbody peak for the coolest T dwarf, the flux decreases and is further reduced by  $\text{NH}_3$  absorption (Saumon et al. 2003; Burrows et al. 2003). Objects with  $W2 - W3 \geq 4.0$  can

be disregarded as brown dwarf candidates, and only 2 of 13 candidates with  $W2 - W3 > 3.0$  are T dwarfs (see Section 6).

Initial candidate selection, as described by Kirkpatrick et al. (2011), was made using the *WISE* Preliminary Data Release.<sup>16</sup> Our search required  $W1 - W2$  colors (or limits) greater than 1.5 mag, which corresponds roughly to types  $\geq T5$ , and  $W2 - W3 < 3.0$  mag, which reduces the number of very red extragalactic contaminants and sources embedded in star formation regions. To identify brown dwarfs earlier than T5 we searched for objects with  $W1 - W2 > 0.4$  mag and no association with a 2MASS source (implying that the  $J - W2$  color is either very red or the object has moved). Extragalactic contaminants were culled from the bright source candidates using the following criteria:  $W1 - W2 > 0.96(W2 - W3) - 0.96$  (as shown in Figure 3 of Kirkpatrick et al. 2011). Spectroscopic follow-up of our initial candidates confirmed  $\sim 100$  new brown dwarfs. Kirkpatrick et al. (2011) provide photometry from the *WISE* Preliminary Data Release for these new objects and the objects in Mainzer et al. (2011) and Burgasser et al. (2011).

Making use of the *WISE* All-Sky Data Release,<sup>17</sup> specifically the database of extractions from the atlas images which is a union of the *WISE* All-Sky Source Catalog and the *WISE* All-Sky Reject Table, we modified our selection criteria to identify the reddest candidates. The details of our query method can be found in Kirkpatrick et al. (2012). Briefly, we required  $W1 - W2 > 2.0$  mag,  $W2 - W3 < 3.5$  mag, signal-to-noise ratio (S/N)  $> 3$  per frame at  $W2$ , that the source is not blended with another source in visual inspection, that the source is point-like, and that the absolute Galactic latitude be greater than  $3^\circ$  if its Galactic longitude falls within  $20^\circ$  of the Galactic center. To aid in follow-up, finder charts of a  $2' \times 2'$  field around each candidate were constructed using DSS2 *BRI* (epoch  $\sim 1980$ s), SDSS *ugriz* (where available; epoch  $\sim 2000$ ), 2MASS *JHK<sub>s</sub>* (epoch  $\sim 2000$ ), and *WISE* four-band data (epoch  $\sim 2010$ ). Prioritization was accomplished by visually inspecting each of these finder charts.<sup>18</sup> T dwarf candidates that were detected at visual wavelengths and showed no clear proper motion were excluded from further follow-up.

Comparison of the *WISE* photometry in the Preliminary Data Release and the All-Sky Data Release reveals measurement biases of  $\sim 0.3$ , 0.05, and 0.4 mag in  $W1$ ,  $W2$ , and  $W3$ , respectively. This is a known difference in the catalogs and is further discussed in Section 6.3 of the *WISE* Explanatory Supplement.<sup>19</sup> The Pass-2 source extraction, which produced the All-Sky Source Catalog, implemented a number of improvements listed in Section 4.1 of the Explanatory Supplement. Because the *WISE* All-Sky Data Release is the premier data product from the *WISE* mission, we present this new photometry in Table 1 for the brown dwarfs in Kirkpatrick et al. (2011) and in Table 2 present photometry for our newly confirmed brown dwarfs.

Figures 1 and 2 present the updated  $W1 - W2$  and  $W2 - W3$  colors as a function of spectral type for objects in Tables 1 and 2 and for Y dwarfs from Kirkpatrick et al. (2012). Similar plots were included in Kirkpatrick et al. (2011) for M, L, T, and Y dwarfs, but here we focus on the T dwarf sequence. The gradual onset of methane absorption at 3.3  $\mu\text{m}$  (Noll et al. 2000)

<sup>16</sup> See <http://wise2.ipac.caltech.edu/docs/release/prelim/expSUP/>.

<sup>17</sup> See <http://wise2.ipac.caltech.edu/docs/release/allsky/>.

<sup>18</sup> In lieu of creating  $\sim 90$  additional figures for the finder charts of the new objects, we point the readers to the excellent DSS+SDSS+2MASS+*WISE* Finder Chart Service at IRSA (<http://irsa.ipac.caltech.edu/>).

<sup>19</sup> See <http://wise2.ipac.caltech.edu/docs/release/allsky/expSUP/>.

**Table 1**  
Updated *WISE* All-Sky Photometry for Discoveries from Kirkpatrick et al. (2011)

| Object Name              | NIR Sp.<br>Type | W1<br>(mag)  | W2<br>(mag)  | W3<br>(mag)  | W4<br>(mag) | W1 – W2<br>(mag) | W2 – W3<br>(mag) |
|--------------------------|-----------------|--------------|--------------|--------------|-------------|------------------|------------------|
| (1)                      | (2)             | (3)          | (4)          | (5)          | (6)         | (7)              | (8)              |
| WISE J000849.75–173922.9 | T6              | 16.41 ± 0.09 | 14.56 ± 0.07 | >12.15       | >8.49       | 1.86 ± 0.12      | <2.40            |
| WISE J003119.76–384036.1 | L2 pec (blue)   | 12.40 ± 0.03 | 12.01 ± 0.02 | 11.56 ± 0.17 | >8.76       | 0.39 ± 0.04      | 0.45 ± 0.17      |
| WISE J004928.48+044059.9 | L9              | 13.45 ± 0.03 | 12.97 ± 0.03 | 12.01 ± 0.29 | 8.39 ± 0.27 | 0.48 ± 0.04      | 0.96 ± 0.29      |
| WISE J010637.07+151852.8 | M8 pec          | 13.08 ± 0.03 | 12.73 ± 0.03 | 12.49 ± 0.37 | >8.81       | 0.35 ± 0.04      | 0.24 ± 0.38      |
| WISE J012333.23+414203.8 | T7              | 17.04 ± 0.11 | 15.03 ± 0.07 | 12.99 ± 0.45 | >9.20       | 2.01 ± 0.14      | 2.03 ± 0.46      |
| WISE J013836.58–032221.2 | T3              | 14.43 ± 0.03 | 13.40 ± 0.03 | 12.35 ± 0.35 | >9.30       | 1.03 ± 0.05      | 1.05 ± 0.35      |
| WISE J014807.25–720258.7 | T9.5            | >18.94       | 14.69 ± 0.05 | >12.86       | >9.52       | >4.25            | <1.83            |
| WISE J015010.89+382724.1 | T0              | 13.65 ± 0.03 | 12.98 ± 0.03 | 11.74 ± 0.19 | >9.04       | 0.67 ± 0.04      | 1.24 ± 0.20      |
| WISE J020625.27+264023.6 | L9 pec (red)    | 13.40 ± 0.03 | 12.82 ± 0.03 | 11.33 ± 0.22 | >8.88       | 0.59 ± 0.04      | 1.49 ± 0.22      |
| WISE J022105.97+384203.2 | T6.5            | 16.87 ± 0.15 | 14.70 ± 0.08 | >12.69       | >9.24       | 2.18 ± 0.17      | <2.00            |
| WISE J022322.36–293257.2 | T7/7.5          | 17.16 ± 0.12 | 14.02 ± 0.04 | 12.64 ± 0.32 | >9.64       | 3.13 ± 0.13      | 1.39 ± 0.32      |
| WISE J022623.98–021142.8 | T7              | 17.60 ± 0.19 | 14.59 ± 0.06 | >12.86       | >9.18       | 3.01 ± 0.20      | <1.74            |
| WISE J025409.51+022358.6 | T8              | 15.76 ± 0.05 | 12.74 ± 0.03 | 11.49 ± 0.14 | >9.44       | 3.02 ± 0.06      | 1.25 ± 0.14      |
| WISE J030533.51+395434.6 | T6              | 17.38 ± 0.24 | 14.69 ± 0.07 | >12.64       | >9.12       | 2.69 ± 0.25      | <2.05            |
| WISE J030724.59+290447.4 | T6.5            | 17.22 ± 0.21 | 14.99 ± 0.11 | >12.39       | >8.74       | 2.23 ± 0.24      | <2.60            |
| WISE J031325.94+780744.3 | T8.5            | 15.88 ± 0.06 | 13.19 ± 0.03 | 11.32 ± 0.12 | 9.00 ± 0.37 | 2.69 ± 0.07      | 1.87 ± 0.12      |
| WISE J032337.53–602554.5 | T8.5            | 18.10 ± 0.32 | 14.50 ± 0.05 | >12.73       | >9.18       | 3.61 ± 0.33      | <1.76            |
| WISE J033349.34–585618.1 | T3              | 13.99 ± 0.03 | 13.25 ± 0.03 | 12.30 ± 0.21 | >9.20       | 0.75 ± 0.04      | 0.95 ± 0.22      |
| WISE J041022.71+150248.4 | Y0              | >18.33       | 14.18 ± 0.06 | >11.86       | >8.90       | >4.15            | <2.32            |
| WISE J041054.48+141131.1 | T6              | 17.02 ± 0.16 | 15.08 ± 0.10 | >12.10       | >9.01       | 1.95 ± 0.19      | <2.98            |
| WISE J044853.28–193548.6 | T5 pec          | 16.52 ± 0.09 | 14.30 ± 0.05 | >12.49       | >9.17       | 2.22 ± 0.10      | <1.81            |
| WISE J045853.89+643452.5 | T8.5            | 16.67 ± 0.11 | 13.03 ± 0.03 | 12.60 ± 0.41 | >9.28       | 3.64 ± 0.12      | 0.43 ± 0.41      |
| WISE J050003.04–122343.2 | T8              | 17.66 ± 0.24 | 13.94 ± 0.04 | 11.56 ± 0.15 | 8.99 ± 0.36 | 3.72 ± 0.25      | 2.38 ± 0.15      |
| WISE J051317.27+060814.7 | T6.5            | 15.82 ± 0.07 | 13.86 ± 0.05 | >12.40       | >9.10       | 1.97 ± 0.08      | <1.46            |
| WISE J052536.35+673952.6 | T6 pec          | >17.98       | 15.04 ± 0.09 | >12.81       | >9.20       | >2.94            | <2.23            |
| WISE J052844.51–330823.9 | T7 pec          | 17.73 ± 0.23 | 14.60 ± 0.06 | 12.27 ± 0.24 | >9.33       | 3.13 ± 0.24      | 2.33 ± 0.25      |
| WISE J053957.00–103436.7 | T5.5            | 17.28 ± 0.22 | 14.83 ± 0.08 | >12.64       | >8.95       | 2.46 ± 0.23      | <2.18            |
| WISE J054231.26–162829.1 | T6.5            | 16.39 ± 0.09 | 13.98 ± 0.05 | >12.35       | >8.78       | 2.41 ± 0.10      | <1.63            |
| WISE J061135.13–041024.0 | T0              | 13.57 ± 0.03 | 12.93 ± 0.03 | >12.06       | >9.08       | 0.63 ± 0.04      | <0.88            |
| WISE J061208.69–492024.2 | T3.5            | 15.41 ± 0.03 | 14.11 ± 0.03 | 12.81 ± 0.27 | >9.78       | 1.30 ± 0.05      | 1.30 ± 0.27      |
| WISE J061213.85–303612.5 | T6              | 16.35 ± 0.07 | 14.03 ± 0.04 | 12.96 ± 0.45 | >8.93       | 2.32 ± 0.08      | 1.07 ± 0.45      |
| WISE J061407.49+391235.9 | T6              | 16.47 ± 0.12 | 13.65 ± 0.04 | 12.02 ± 0.28 | >9.07       | 2.83 ± 0.12      | 1.63 ± 0.28      |
| WISE J062309.94–045624.6 | T8              | 17.33 ± 0.20 | 13.82 ± 0.04 | >12.63       | >9.07       | 3.52 ± 0.20      | <1.18            |
| WISE J062542.21+564625.4 | T6              | 16.33 ± 0.08 | 14.38 ± 0.06 | 12.44 ± 0.35 | >8.77       | 1.95 ± 0.10      | 1.94 ± 0.36      |
| WISE J062720.07–111428.0 | T6              | 15.00 ± 0.04 | 13.26 ± 0.03 | 11.53 ± 0.21 | >8.96       | 1.74 ± 0.05      | 1.73 ± 0.21      |
| WISE J065609.59+420531.9 | T3              | 14.31 ± 0.03 | 13.22 ± 0.03 | 12.04 ± 0.30 | >8.72       | 1.09 ± 0.05      | 1.18 ± 0.30      |
| WISE J074457.25+562821.0 | T8              | 17.08 ± 0.15 | 14.49 ± 0.06 | 12.48 ± 0.36 | >9.17       | 2.59 ± 0.16      | 2.01 ± 0.36      |
| WISE J075003.78+272545.4 | T8.5            | >18.11       | 14.46 ± 0.07 | >12.69       | >8.96       | >3.65            | <1.78            |
| WISE J075108.80–763449.5 | T9              | 17.54 ± 0.13 | 14.52 ± 0.04 | 11.44 ± 0.08 | >9.21       | 3.01 ± 0.14      | 3.08 ± 0.09      |
| WISE J075946.98–490454.0 | T8              | >17.92       | 13.86 ± 0.04 | >12.95       | >9.15       | >4.05            | <0.92            |
| WISE J081958.05–033528.5 | T4              | 14.38 ± 0.03 | 13.08 ± 0.04 | 11.83 ± 0.28 | >8.81       | 1.31 ± 0.05      | 1.25 ± 0.28      |
| WISE J082131.64+144319.2 | T5.5            | 16.49 ± 0.12 | 14.37 ± 0.07 | >12.58       | >8.96       | 2.12 ± 0.14      | <1.78            |
| WISE J083641.10–185947.0 | T8 pec          | >18.41       | 15.18 ± 0.10 | >12.47       | >9.18       | >3.23            | <2.71            |
| WISE J085716.24+560407.6 | T8              | 17.49 ± 0.21 | 14.11 ± 0.05 | >12.49       | >9.29       | 3.37 ± 0.22      | <1.63            |
| WISE J090649.35+473538.5 | T8              | 17.48 ± 0.23 | 14.65 ± 0.08 | >12.06       | >8.96       | 2.83 ± 0.24      | <2.59            |
| WISE J092906.77+040957.9 | T6.5            | 16.63 ± 0.12 | 14.23 ± 0.06 | >11.91       | >9.07       | 2.40 ± 0.13      | <2.32            |
| WISE J095259.29+195508.1 | T6              | 16.87 ± 0.16 | 14.34 ± 0.06 | >12.18       | >8.99       | 2.53 ± 0.17      | <2.16            |
| WISE J101808.04–244557.9 | T8              | 17.38 ± 0.21 | 14.17 ± 0.05 | >12.55       | >9.17       | 3.21 ± 0.22      | <1.62            |
| WISE J101905.62+652954.2 | T6              | 16.42 ± 0.07 | 14.03 ± 0.04 | >12.40       | >9.44       | 2.39 ± 0.08      | <1.63            |
| WISE J104245.23–384238.3 | T8.5            | >18.57       | 14.52 ± 0.06 | >12.95       | >9.26       | >4.06            | <1.57            |
| WISE J112254.72+255022.2 | T6              | 16.20 ± 0.08 | 13.97 ± 0.05 | >12.39       | >8.99       | 2.22 ± 0.10      | <1.58            |
| WISE J115013.85+630241.5 | T8              | 16.99 ± 0.11 | 13.40 ± 0.03 | 12.32 ± 0.24 | >9.23       | 3.59 ± 0.11      | 1.08 ± 0.25      |
| WISE J121756.90+162640.8 | T9              | 16.80 ± 0.13 | 13.09 ± 0.03 | 12.12 ± 0.31 | >8.90       | 3.71 ± 0.14      | 0.97 ± 0.31      |
| WISE J131106.20+012254.3 | T9:             | 18.27 ± 0.46 | 14.76 ± 0.09 | >12.32       | >9.25       | 3.50 ± 0.47      | <2.45            |
| WISE J131141.92+362924.7 | L5 pec (blue)   | 13.51 ± 0.03 | 13.11 ± 0.03 | 12.74 ± 0.44 | >8.88       | 0.40 ± 0.04      | 0.38 ± 0.44      |
| WISE J132004.16+603426.3 | T6.5            | 16.94 ± 0.11 | 14.41 ± 0.05 | >12.42       | >9.43       | 2.52 ± 0.12      | <2.00            |
| WISE J132233.64–234016.8 | T8              | 16.99 ± 0.14 | 13.93 ± 0.04 | >12.70       | 8.78 ± 0.35 | 3.06 ± 0.14      | <1.23            |
| WISE J134806.99+660328.4 | L9              | 14.43 ± 0.03 | 13.76 ± 0.03 | 12.65 ± 0.29 | >9.62       | 0.68 ± 0.04      | 1.11 ± 0.30      |
| WISE J140518.39+553421.3 | Y0 (pec?)       | >18.82       | 14.10 ± 0.04 | 12.43 ± 0.27 | >9.40       | >4.72            | 1.67 ± 0.28      |
| WISE J143602.20–181421.9 | T8 pec          | 17.21 ± 0.14 | 14.71 ± 0.06 | >12.28       | >9.23       | 2.50 ± 0.16      | <2.43            |
| WISE J145715.03+581510.2 | T7              | 16.83 ± 0.08 | 14.47 ± 0.04 | 13.34 ± 0.53 | >9.64       | 2.36 ± 0.09      | 1.13 ± 0.53      |
| WISE J150649.97+702736.1 | T6              | 13.39 ± 0.02 | 11.27 ± 0.02 | 10.15 ± 0.03 | >9.07       | 2.12 ± 0.03      | 1.12 ± 0.04      |
| WISE J151906.63+700931.4 | T8              | 17.17 ± 0.09 | 14.14 ± 0.03 | 13.44 ± 0.47 | >9.86       | 3.03 ± 0.10      | 0.70 ± 0.47      |
| WISE J154151.65–225024.9 | Y0.5            | 16.74 ± 0.17 | 14.25 ± 0.06 | >12.31       | >8.89       | 2.49 ± 0.18      | <1.93            |

**Table 1**  
(Continued)

| Object Name              | NIR Sp.<br>Type | W1<br>(mag)  | W2<br>(mag)  | W3<br>(mag)  | W4<br>(mag) | W1 – W2<br>(mag) | W2 – W3<br>(mag) |
|--------------------------|-----------------|--------------|--------------|--------------|-------------|------------------|------------------|
| (1)                      | (2)             | (3)          | (4)          | (5)          | (6)         | (7)              | (8)              |
| WISE J161215.94–342028.5 | T6.5            | >18.19       | 13.96 ± 0.05 | >12.47       | >9.12       | >4.23            | <1.49            |
| WISE J161441.46+173935.5 | T9              | >17.90       | 14.25 ± 0.05 | >12.45       | >9.21       | >3.65            | <1.80            |
| WISE J161705.74+180714.1 | T8              | 17.12 ± 0.15 | 14.16 ± 0.05 | 12.49 ± 0.36 | >9.38       | 2.96 ± 0.16      | 1.67 ± 0.36      |
| WISE J162208.93–095934.4 | T6              | 16.50 ± 0.14 | 14.17 ± 0.06 | >12.55       | >8.53       | 2.33 ± 0.15      | <1.62            |
| WISE J162725.65+325524.6 | T6              | 16.25 ± 0.07 | 13.60 ± 0.04 | 12.56 ± 0.35 | >9.25       | 2.65 ± 0.08      | 1.04 ± 0.35      |
| WISE J164715.57+563208.3 | L9 pec (red)    | 13.60 ± 0.02 | 13.09 ± 0.02 | 12.06 ± 0.09 | >9.62       | 0.52 ± 0.03      | 1.03 ± 0.10      |
| WISE J165311.05+444422.8 | T8              | 16.49 ± 0.07 | 13.81 ± 0.04 | 12.26 ± 0.23 | >9.49       | 2.68 ± 0.08      | 1.55 ± 0.24      |
| WISE J171104.60+350036.8 | T8              | >18.15       | 14.72 ± 0.06 | >12.76       | >9.45       | >3.43            | <1.96            |
| WISE J171717.02+612859.3 | T8              | 18.42 ± 0.20 | 15.09 ± 0.05 | 13.51 ± 0.38 | >10.07      | 3.33 ± 0.20      | 1.58 ± 0.39      |
| WISE J172844.93+571642.7 | T6              | 17.96 ± 0.18 | 15.01 ± 0.05 | >13.49       | >9.84       | 2.95 ± 0.19      | <1.51            |
| WISE J173835.53+273259.0 | Y0              | >18.41       | 14.55 ± 0.06 | 11.93 ± 0.19 | >8.98       | >3.86            | 2.62 ± 0.20      |
| WISE J174124.25+255319.6 | T9              | 15.38 ± 0.05 | 12.33 ± 0.03 | 10.83 ± 0.09 | >8.60       | 3.05 ± 0.06      | 1.50 ± 0.09      |
| WISE J180435.37+311706.4 | T9.5:           | >18.64       | 14.70 ± 0.06 | >12.55       | >9.42       | >3.94            | <2.15            |
| WISE J181210.85+272144.3 | T8.5:           | 17.80 ± 0.29 | 14.23 ± 0.05 | >12.26       | >9.31       | 3.58 ± 0.29      | <1.97            |
| WISE J182831.08+265037.7 | ≥Y2             | >18.47       | 14.39 ± 0.06 | >12.53       | >8.75       | >4.08            | <1.87            |
| WISE J183058.56+454257.4 | L9              | 14.81 ± 0.03 | 14.17 ± 0.04 | >13.17       | >9.67       | 0.65 ± 0.05      | <1.00            |
| WISE J184124.73+700038.0 | T5              | 16.59 ± 0.05 | 14.39 ± 0.03 | 13.67 ± 0.47 | >9.54       | 2.20 ± 0.06      | 0.71 ± 0.47      |
| WISE J185215.76+353716.7 | T7              | 16.55 ± 0.10 | 14.24 ± 0.05 | 12.55 ± 0.32 | >8.87       | 2.31 ± 0.11      | 1.69 ± 0.32      |
| WISE J190624.74+450807.1 | T6              | 16.09 ± 0.06 | 13.82 ± 0.04 | 13.03 ± 0.43 | >9.66       | 2.27 ± 0.07      | 0.79 ± 0.43      |
| WISE J195246.65+724000.8 | T4              | 14.22 ± 0.03 | 13.02 ± 0.03 | 12.05 ± 0.14 | >9.44       | 1.21 ± 0.04      | 0.96 ± 0.14      |
| WISE J195905.65–333833.5 | T8              | 16.44 ± 0.10 | 13.88 ± 0.05 | >12.14       | >8.76       | 2.56 ± 0.11      | <1.74            |
| WISE J201824.97–742327.5 | T7              | 16.54 ± 0.11 | 13.62 ± 0.04 | >12.52       | >9.22       | 2.92 ± 0.11      | <1.10            |
| WISE J205628.91+145953.2 | Y0              | >18.25       | 13.93 ± 0.05 | 12.00 ± 0.27 | >8.78       | >4.33            | 1.93 ± 0.27      |
| WISE J213456.73–713744.5 | T9 pec          | >17.74       | 13.99 ± 0.05 | 12.33 ± 0.31 | >9.02       | >3.75            | 1.66 ± 0.32      |
| WISE J215751.35+265931.4 | T7              | 17.13 ± 0.15 | 14.48 ± 0.06 | >11.91       | >8.58       | 2.65 ± 0.16      | <2.57            |
| WISE J220922.11–273439.6 | T7              | 16.50 ± 0.11 | 13.84 ± 0.05 | >12.28       | >9.12       | 2.66 ± 0.12      | <1.56            |
| WISE J221354.68+091139.4 | T7              | 16.69 ± 0.11 | 14.60 ± 0.07 | >12.34       | >9.04       | 2.10 ± 0.13      | <2.26            |
| WISE J222623.05+044004.0 | T8/8.5          | 17.29 ± 0.22 | 14.71 ± 0.09 | >12.24       | >9.08       | 2.58 ± 0.24      | <2.47            |
| WISE J223729.52–061434.4 | T5              | >17.49       | 14.73 ± 0.09 | >12.28       | >8.85       | >2.75            | <2.45            |
| WISE J223937.55+161716.1 | T3              | 14.67 ± 0.04 | 13.44 ± 0.03 | 12.14 ± 0.33 | >8.92       | 1.23 ± 0.05      | 1.30 ± 0.33      |
| WISE J225540.75–311842.0 | T8              | 16.92 ± 0.17 | 14.18 ± 0.06 | >12.20       | >9.09       | 2.74 ± 0.18      | <1.98            |
| WISE J231336.38–803700.1 | T8              | 16.30 ± 0.07 | 13.64 ± 0.03 | 12.40 ± 0.25 | >9.58       | 2.65 ± 0.07      | 1.24 ± 0.25      |
| WISE J231939.14–184404.4 | T7.5            | 17.15 ± 0.16 | 13.76 ± 0.05 | >12.06       | 9.07 ± 0.51 | 3.39 ± 0.17      | <1.70            |
| WISE J232519.53–410535.0 | T9 pec          | 17.60 ± 0.25 | 14.13 ± 0.05 | >12.49       | >9.04       | 3.47 ± 0.25      | <1.64            |
| WISE J232728.74–273056.6 | L9              | 14.05 ± 0.03 | 13.18 ± 0.03 | 11.82 ± 0.22 | >9.24       | 0.87 ± 0.05      | 1.36 ± 0.22      |
| WISE J234026.61–074508.1 | T7              | 15.95 ± 0.08 | 13.58 ± 0.04 | >12.37       | >9.00       | 2.37 ± 0.09      | <1.21            |
| WISE J234351.20–741846.9 | T6              | 15.74 ± 0.05 | 13.73 ± 0.04 | >12.43       | >9.37       | 2.01 ± 0.06      | <1.30            |
| WISE J234446.23+103415.6 | T9              | >18.03       | 15.11 ± 0.12 | 11.76 ± 0.25 | >8.56       | >2.92            | 3.35 ± 0.28      |
| WISE J234841.10–102844.1 | T7              | 16.89 ± 0.15 | 14.40 ± 0.06 | >12.56       | >9.09       | 2.49 ± 0.16      | <1.84            |
| WISE J235941.07–733504.8 | T6.5            | 15.25 ± 0.04 | 13.32 ± 0.03 | 11.57 ± 0.13 | >9.38       | 1.93 ± 0.05      | 1.75 ± 0.13      |

**Notes.** Scholz et al. (2011) independently discovered the T9 dwarf WISE J1741+2553, first announced in Gelino et al. (2011), and also noted WISE J0254+0223 as a proper motion object of presumably late type.

complicates the functional form of the  $W1 - W2$  color around the L-T transition. Although the dispersion in the  $W1 - W2$  color for the late-type T dwarfs is large ( $\sim 1.5$  mag), early-type T dwarfs display a considerably smaller dispersion until T4 or T5. Most objects later than T9 only have  $W2$  and  $W3$  detections, resulting in  $W1 - W2$  lower limits. The gap between the limits and the verified detections of the late-type sources implies that the  $W1$  limit is an overestimate and the resultant  $W1 - W2$  color limits are artificially high. Upper limits in  $W2 - W3$  are a result of non-detections in  $W3$ , which is the case for many of our new T dwarfs. The dispersion in the  $W1 - W2$  and  $W2 - W3$  colors is likely caused by clouds and/or non-equilibrium chemistry in T dwarf atmospheres (Saumon et al. 2003), and are largest for spectral types later than T4.

### 3. FOLLOW-UP PHOTOMETRY AND SPECTROSCOPY

T dwarf candidates selected by *WISE* colors alone are reliable when they fall within the core of the T dwarf  $W1 - W2$  versus

$W2 - W3$  color-color diagram in Figure 3. However, near the periphery of this region the number of non-stellar interlopers increases. Additional photometry of *WISE* candidates allows us to identify sources that have near-infrared colors characteristic of brown dwarfs, and provides near-IR magnitudes that guide facility selection for spectroscopic observation.

#### 3.1. Follow-up Photometric Observations

Most of our photometric observations are described in Cushing et al. (2011) and Kirkpatrick et al. (2011, 2012). We have separated the 2MASS and Mauna Kea Observatories Near-Infrared (MKO; Simons & Tokunaga 2002; Tokunaga et al. 2002) systems since care should be taken when making comparisons between the two filter systems whose different bandpasses produce slightly different magnitudes. Some of our photometry is provided by the 2MASS All-Sky Point

**Table 2**  
*WISE All-Sky Photometry for Brown Dwarf Discoveries from This Paper*

| Object Name                           | W1<br>(mag)  | W2<br>(mag)  | W3<br>(mag)  | W4<br>(mag) | W1 – W2<br>(mag) | W2 – W3<br>(mag) |
|---------------------------------------|--------------|--------------|--------------|-------------|------------------|------------------|
| (1)                                   | (2)          | (3)          | (4)          | (5)         | (6)              | (7)              |
| WISE J000517.48+373720.5              | 16.88 ± 0.12 | 13.27 ± 0.03 | 11.99 ± 0.24 | >9.23       | 3.61 ± 0.12      | 1.28 ± 0.24      |
| WISE J003829.05+275852.1              | 18.04 ± 0.29 | 14.38 ± 0.05 | 12.46 ± 0.31 | >8.78       | 3.67 ± 0.29      | 1.91 ± 0.32      |
| WISE J003830.54+840517.7              | 17.53 ± 0.17 | 15.34 ± 0.09 | >13.18       | >9.53       | 2.19 ± 0.19      | <2.16            |
| WISE J004024.88+090054.8              | 16.06 ± 0.08 | 13.92 ± 0.07 | >12.06       | >8.65       | 2.13 ± 0.11      | <1.87            |
| WISE J004542.56+361139.1              | 15.34 ± 0.04 | 13.73 ± 0.03 | 12.61 ± 0.35 | >9.28       | 1.61 ± 0.05      | 1.12 ± 0.35      |
| WISE J004945.61+215120.0              | 15.47 ± 0.04 | 12.97 ± 0.03 | 11.73 ± 0.17 | >9.21       | 2.50 ± 0.05      | 1.24 ± 0.17      |
| WISE J013525.64+171503.4              | 17.19 ± 0.15 | 14.74 ± 0.07 | >12.73       | >8.86       | 2.45 ± 0.17      | <2.02            |
| WISE J021010.25+400829.6              | 16.29 ± 0.09 | 14.74 ± 0.08 | >12.66       | >9.17       | 1.55 ± 0.12      | <2.08            |
| WISE J023318.05+303030.5              | 16.59 ± 0.12 | 14.46 ± 0.07 | >12.25       | >9.06       | 2.13 ± 0.14      | <2.22            |
| WISE J024512.62–345047.8              | 17.92 ± 0.31 | 14.56 ± 0.06 | 12.19 ± 0.27 | >9.20       | 3.36 ± 0.32      | 2.38 ± 0.27      |
| WISE J024714.52+372523.5              | >18.37       | 14.70 ± 0.08 | >12.58       | >9.11       | >3.67            | <2.11            |
| WISE J025934.00–034645.7              | 17.33 ± 0.14 | 15.10 ± 0.08 | >12.90       | >9.46       | 2.23 ± 0.16      | <2.20            |
| WISE J031614.68+382008.0              | 14.72 ± 0.04 | 13.56 ± 0.04 | 12.37 ± 0.39 | >8.78       | 1.16 ± 0.06      | 1.19 ± 0.40      |
| WISE J031624.35+430709.1              | >17.86       | 14.56 ± 0.07 | >12.82       | >9.18       | >3.30            | <1.74            |
| WISE J032120.91–734758.8              | >19.19       | 15.60 ± 0.08 | 13.01 ± 0.32 | >9.19       | >3.59            | 2.59 ± 0.33      |
| WISE J032517.69–385454.1              | 18.46 ± 0.31 | 14.98 ± 0.06 | 13.22 ± 0.46 | >9.66       | 3.47 ± 0.31      | 1.76 ± 0.46      |
| WISE J032547.72+083118.2              | 15.44 ± 0.06 | 13.49 ± 0.04 | >11.66       | >8.80       | 1.95 ± 0.07      | <1.83            |
| WISE J033515.01+431045.1              | >18.15       | 14.60 ± 0.08 | >12.42       | >8.95       | >3.55            | <2.18            |
| WISE J033605.05–014350.4              | >17.96       | 14.54 ± 0.07 | >12.56       | >9.01       | >3.42            | <1.98            |
| WISE J033651.90+282628.8              | 16.01 ± 0.08 | 14.44 ± 0.07 | >12.47       | >8.93       | 1.57 ± 0.11      | <1.97            |
| WISE J041358.14–475039.3              | >19.39       | 15.69 ± 0.08 | >13.14       | >9.53       | >3.70            | <2.55            |
| WISE J042417.94+072744.1              | >18.44       | 15.33 ± 0.13 | >12.68       | >9.02       | >3.11            | <2.65            |
| WISE J043052.92+463331.6              | >18.08       | 14.40 ± 0.07 | 11.51 ± 0.18 | >8.69       | >3.69            | 2.88 ± 0.19      |
| WISE J051208.66–300404.4              | >18.24       | 15.24 ± 0.10 | 12.53 ± 0.31 | >9.48       | >3.00            | 2.71 ± 0.32      |
| WISE J054047.00+483232.4              | >18.25       | 15.07 ± 0.12 | >12.09       | >9.27       | >3.18            | <2.98            |
| WISE J054601.19–095947.5              | 15.94 ± 0.07 | 13.96 ± 0.05 | >12.56       | >9.05       | 1.97 ± 0.08      | <1.40            |
| WISE J061437.73+095135.0              | 16.92 ± 0.19 | 14.29 ± 0.07 | >12.04       | 8.90 ± 0.39 | 2.62 ± 0.20      | <2.25            |
| WISE J062905.13+241804.9              | 14.36 ± 0.03 | 13.63 ± 0.04 | 11.83 ± 0.25 | >8.99       | 0.74 ± 0.06      | 1.80 ± 0.25      |
| WISE J064205.58+410155.5              | 13.36 ± 0.03 | 12.55 ± 0.03 | 11.70 ± 0.31 | >8.76       | 0.81 ± 0.04      | 0.85 ± 0.31      |
| WISE J070159.79+632129.2              | 14.20 ± 0.03 | 13.22 ± 0.03 | 12.48 ± 0.42 | >9.08       | 0.98 ± 0.05      | 0.74 ± 0.42      |
| WISE J072312.44+340313.5              | >18.27       | 14.73 ± 0.08 | >12.21       | >8.92       | >3.54            | <2.52            |
| WISE J073347.94+754439.2              | 17.16 ± 0.14 | 14.77 ± 0.07 | 12.20 ± 0.23 | >9.04       | 2.39 ± 0.15      | 2.57 ± 0.24      |
| WISE J075430.95+790957.8              | 14.41 ± 0.03 | 13.73 ± 0.03 | 12.30 ± 0.26 | >9.52       | 0.67 ± 0.05      | 1.43 ± 0.26      |
| WISE J081117.81–805141.3              | 17.29 ± 0.12 | 14.38 ± 0.04 | 11.85 ± 0.15 | 9.09 ± 0.30 | 2.91 ± 0.13      | 2.53 ± 0.15      |
| WISE J081220.04+402106.2              | 18.24 ± 0.47 | 15.08 ± 0.10 | >12.76       | >9.06       | 3.16 ± 0.48      | <2.32            |
| WISE J092055.40+453856.3 <sup>a</sup> | 13.06 ± 0.02 | 12.39 ± 0.03 | 11.29 ± 0.17 | >9.08       | 0.67 ± 0.04      | 1.10 ± 0.17      |
| WISE J095047.32+011733.3 <sup>b</sup> | 18.05 ± 0.34 | 14.48 ± 0.06 | >12.85       | >9.20       | 3.56 ± 0.34      | <1.63            |
| WISE J102557.72+030755.7              | 17.89 ± 0.38 | 14.10 ± 0.06 | >12.19       | >8.81       | 3.79 ± 0.38      | <1.90            |
| WISE J103907.73–160002.9              | 16.65 ± 0.11 | 14.16 ± 0.05 | 12.73 ± 0.52 | >8.94       | 2.49 ± 0.12      | 1.43 ± 0.52      |
| WISE J105047.90+505606.2              | 18.05 ± 0.34 | 14.94 ± 0.08 | >12.95       | >9.02       | 3.11 ± 0.35      | <1.99            |
| WISE J105130.01–213859.7              | 17.17 ± 0.17 | 14.54 ± 0.06 | >12.69       | >9.17       | 2.62 ± 0.18      | <1.85            |
| WISE J112438.12–042149.7              | 16.56 ± 0.12 | 14.05 ± 0.05 | >12.49       | >8.58       | 2.51 ± 0.13      | <1.56            |
| WISE J114340.22+443123.8              | 18.51 ± 0.39 | 15.27 ± 0.08 | >13.00       | >9.70       | 3.25 ± 0.39      | <2.27            |
| WISE J122152.28–313600.8              | 15.86 ± 0.06 | 13.85 ± 0.04 | 12.35 ± 0.35 | >9.14       | 2.01 ± 0.07      | 1.50 ± 0.35      |
| WISE J122558.86–101345.0              | 16.34 ± 0.09 | 13.99 ± 0.05 | 12.11 ± 0.30 | >9.10       | 2.36 ± 0.10      | 1.88 ± 0.30      |
| WISE J124629.65–313934.2 <sup>c</sup> | 13.33 ± 0.02 | 12.38 ± 0.02 | 11.41 ± 0.12 | >8.83       | 0.94 ± 0.03      | 0.98 ± 0.12      |
| WISE J125015.56+262846.9              | 16.36 ± 0.09 | 14.58 ± 0.07 | >12.84       | >9.06       | 1.78 ± 0.11      | <1.74            |
| WISE J125715.90+400854.2              | 16.74 ± 0.10 | 14.47 ± 0.05 | >12.40       | >8.76       | 2.28 ± 0.11      | <2.06            |
| WISE J130141.62–030212.9              | 18.06 ± 0.38 | 14.95 ± 0.09 | >12.24       | >8.88       | 3.11 ± 0.39      | <2.72            |
| WISE J131833.98–175826.5              | 18.10 ± 0.34 | 14.75 ± 0.07 | >12.43       | >9.47       | 3.35 ± 0.34      | <2.32            |
| WISE J133750.46+263648.6              | 16.31 ± 0.08 | 14.62 ± 0.06 | >12.22       | >9.03       | 1.69 ± 0.10      | <2.39            |
| WISE J134802.49–134412.0 <sup>d</sup> | 16.15 ± 0.07 | 14.18 ± 0.05 | >12.14       | >9.14       | 1.97 ± 0.08      | <2.03            |
| WISE J140035.40–385013.5              | 15.34 ± 0.04 | 13.75 ± 0.03 | >12.78       | >9.47       | 1.60 ± 0.05      | <0.97            |
| WISE J142320.84+011638.0 <sup>e</sup> | 18.01 ± 0.30 | 14.85 ± 0.07 | >12.66       | >9.41       | 3.16 ± 0.30      | <2.19            |
| WISE J144901.85+114710.9 <sup>f</sup> | 17.39 ± 0.16 | 14.84 ± 0.07 | >12.40       | >9.44       | 2.55 ± 0.17      | <2.43            |
| WISE J150502.39–285345.5 <sup>g</sup> | 14.02 ± 0.03 | 13.30 ± 0.04 | 11.76 ± 0.26 | >8.70       | 0.72 ± 0.05      | 1.53 ± 0.28      |
| WISE J151721.13+052929.3              | >18.10       | 15.13 ± 0.08 | >13.13       | >9.52       | >2.97            | <2.01            |
| WISE J152305.10+312537.6              | 17.91 ± 0.21 | 14.39 ± 0.04 | >13.32       | >9.62       | 3.52 ± 0.22      | <1.08            |
| WISE J154214.00+223005.2              | >18.88       | 15.02 ± 0.06 | >12.88       | >9.51       | >3.86            | <2.15            |
| WISE J154352.78–043909.5 <sup>h</sup> | 16.11 ± 0.08 | 14.39 ± 0.06 | >12.51       | >8.42       | 1.72 ± 0.10      | <1.89            |
| WISE J154459.27+584204.5              | 18.39 ± 0.30 | 15.03 ± 0.06 | >13.42       | >9.75       | 3.36 ± 0.31      | <1.62            |
| WISE J162541.36+152811.1 <sup>g</sup> | 16.90 ± 0.13 | 14.72 ± 0.07 | >12.50       | >9.15       | 2.18 ± 0.15      | <2.22            |
| WISE J162918.56+033535.6 <sup>g</sup> | 13.40 ± 0.03 | 12.50 ± 0.03 | 11.32 ± 0.14 | >8.64       | 0.90 ± 0.04      | 1.18 ± 0.14      |
| WISE J163236.47+032927.3              | 15.90 ± 0.07 | 14.34 ± 0.06 | >12.71       | >9.11       | 1.56 ± 0.09      | <1.63            |

**Table 2**  
(Continued)

| Object Name                             | W1<br>(mag)  | W2<br>(mag)  | W3<br>(mag)  | W4<br>(mag) | W1 – W2<br>(mag) | W2 – W3<br>(mag) |
|---|--------------|--------------|--------------|-------------|------------------|------------------|
| (1)                                     | (2)          | (3)          | (4)          | (5)         | (6)              | (7)              |
| WISE J163645.56–074325.1                | 16.20 ± 0.12 | 14.69 ± 0.09 | >12.40       | >8.81       | 1.51 ± 0.14      | <2.29            |
| WISE J170745.85–174452.5                | 16.54 ± 0.15 | 13.68 ± 0.05 | >11.89       | >8.87       | 2.85 ± 0.16      | <1.79            |
| WISE J172134.46+111739.4                | 15.90 ± 0.06 | 14.28 ± 0.06 | >12.27       | >8.86       | 1.62 ± 0.09      | <2.02            |
| WISE J173035.99+420742.5                | 15.11 ± 0.03 | 14.61 ± 0.05 | >13.47       | >9.50       | 0.51 ± 0.06      | <1.13            |
| WISE J173421.02+502349.9                | 15.41 ± 0.03 | 14.34 ± 0.04 | >13.48       | >9.85       | 1.07 ± 0.05      | <0.87            |
| WISE J173623.03+605920.2                | >18.70       | 15.35 ± 0.07 | 13.29 ± 0.41 | >9.85       | >3.36            | 2.06 ± 0.42      |
| WISE J173859.27+614242.1                | 14.06 ± 0.03 | 13.34 ± 0.03 | 12.20 ± 0.15 | >9.86       | 0.72 ± 0.04      | 1.14 ± 0.15      |
| WISE J174113.12+132711.9                | 17.50 ± 0.29 | 14.73 ± 0.08 | >12.49       | >8.67       | 2.77 ± 0.30      | <2.24            |
| WISE J174303.71+421150.0                | 15.40 ± 0.04 | 13.92 ± 0.04 | 12.38 ± 0.25 | >9.50       | 1.48 ± 0.05      | 1.54 ± 0.25      |
| WISE J174556.65+645933.8                | >19.48       | 16.40 ± 0.09 | >14.22       | >10.54      | >3.08            | <2.18            |
| WISE J174640.78–033818.0                | >18.02       | 14.79 ± 0.10 | >12.17       | >8.80       | >3.23            | <2.62            |
| WISE J175510.28+180320.2                | 14.60 ± 0.03 | 13.74 ± 0.04 | 12.36 ± 0.31 | >9.28       | 0.87 ± 0.05      | 1.38 ± 0.32      |
| WISE J175929.37+544204.7                | >18.55       | 15.51 ± 0.08 | >13.61       | >9.44       | >3.05            | <1.90            |
| WISE J180901.07+383805.4 <sup>i</sup>   | >18.00       | 15.19 ± 0.09 | >12.56       | >9.52       | >2.81            | <2.64            |
| WISE J180952.53–044812.5                | 13.29 ± 0.03 | 12.73 ± 0.03 | 12.38 ± 0.48 | >8.98       | 0.56 ± 0.04      | 0.35 ± 0.48      |
| WISE J181243.14+200746.4                | >18.55       | 15.35 ± 0.12 | >12.89       | >9.23       | >3.20            | <2.46            |
| WISE J181329.40+283533.3                | 15.72 ± 0.06 | 14.07 ± 0.05 | 12.54 ± 0.35 | >9.38       | 1.65 ± 0.07      | 1.53 ± 0.35      |
| WISE J184041.77+293229.2                | >18.53       | 15.12 ± 0.09 | 12.71 ± 0.40 | >9.37       | >3.41            | 2.41 ± 0.41      |
| WISE J190903.16–520433.5                | >18.20       | 15.34 ± 0.13 | 12.56 ± 0.40 | >9.25       | >2.85            | 2.79 ± 0.42      |
| WISE J191359.78+644456.6                | 17.37 ± 0.12 | 15.07 ± 0.05 | >12.90       | >9.63       | 2.30 ± 0.13      | <2.18            |
| WISE J192841.35+235604.9                | 13.94 ± 0.04 | 12.11 ± 0.03 | 11.03 ± 0.13 | >8.91       | 1.83 ± 0.04      | 1.09 ± 0.13      |
| WISE J195436.15+691541.3                | 17.35 ± 0.08 | 14.97 ± 0.04 | >13.84       | >9.51       | 2.38 ± 0.09      | <1.14            |
| WISE J195500.42–254013.9                | >18.13       | 15.02 ± 0.11 | >12.34       | >8.51       | >3.12            | <2.67            |
| WISE J200804.71–083428.5                | 16.25 ± 0.10 | 14.23 ± 0.06 | >12.64       | >8.86       | 2.02 ± 0.12      | <1.59            |
| WISE J201404.13+042408.5                | >17.94       | 15.16 ± 0.12 | >12.30       | >8.95       | >2.78            | <2.87            |
| WISEPC J201546.27+664645.1 <sup>j</sup> | 16.70 ± 0.09 | 14.68 ± 0.06 | 13.02 ± 0.45 | >9.14       | 2.02 ± 0.11      | 1.66 ± 0.46      |
| WISE J201920.76–114807.5                | 17.29 ± 0.21 | 14.32 ± 0.06 | >12.20       | >9.03       | 2.96 ± 0.22      | <2.12            |
| WISE J203042.79+074934.7                | 12.96 ± 0.03 | 12.12 ± 0.03 | 10.96 ± 0.11 | >8.96       | 0.83 ± 0.04      | 1.16 ± 0.11      |
| WISE J204356.42+622048.9                | 13.90 ± 0.03 | 13.02 ± 0.03 | 12.12 ± 0.22 | >9.27       | 0.87 ± 0.04      | 0.90 ± 0.22      |
| WISE J212321.92–261405.1                | 16.95 ± 0.13 | 14.52 ± 0.13 | >11.62       | >8.24       | 2.42 ± 0.19      | <2.90            |
| WISE J214706.78–102924.0                | >17.60       | 15.06 ± 0.12 | >12.47       | >8.80       | >2.54            | <2.59            |
| WISE J223617.59+510551.9                | 13.84 ± 0.03 | 12.48 ± 0.03 | 11.02 ± 0.08 | >9.32       | 1.36 ± 0.04      | 1.47 ± 0.09      |
| WISE J223720.39+722833.8                | 15.67 ± 0.06 | 13.61 ± 0.04 | 12.62 ± 0.38 | >9.38       | 2.06 ± 0.07      | 0.99 ± 0.38      |
| WISE J230133.32+021635.0                | 16.30 ± 0.08 | 14.34 ± 0.06 | >12.47       | >9.13       | 1.96 ± 0.10      | <1.88            |
| WISE J230356.79+191432.9                | 16.50 ± 0.10 | 14.67 ± 0.07 | >12.66       | >8.74       | 1.83 ± 0.12      | <2.00            |
| WISE J233543.79+422255.2                | 18.55 ± 0.51 | 15.31 ± 0.10 | 12.98 ± 0.49 | >9.36       | 3.24 ± 0.52      | 2.34 ± 0.50      |
| WISE J234228.98+085620.2 <sup>f</sup>   | 16.07 ± 0.08 | 13.97 ± 0.05 | 12.63 ± 0.53 | 9.08 ± 0.54 | 2.10 ± 0.09      | 1.34 ± 0.53      |
| WISE J235716.49+122741.8                | 15.84 ± 0.06 | 13.99 ± 0.05 | 12.35 ± 0.40 | >9.16       | 1.85 ± 0.08      | 1.64 ± 0.40      |

**Notes.**

<sup>a</sup> L dwarf candidate, Aberasturi et al. (2011).

<sup>b</sup> ULAS J095047.28+011734.3, Leggett et al. (2012).

<sup>c</sup> IR source, Andrei et al. (2011).

<sup>d</sup> LHS 2803B, Deacon et al. (2012).

<sup>e</sup> BD +01° 2920B, Pinfield et al. (2012).

<sup>f</sup> T7 candidates, Scholz (2010).

<sup>g</sup> PSO J226.2599–28.8959, PSO J246.4222+15.4698, PSO J247.3273+03.5932, Deacon et al. (2011).

<sup>h</sup> VHS J154352.78–043909.6, Lodieu et al. (2012).

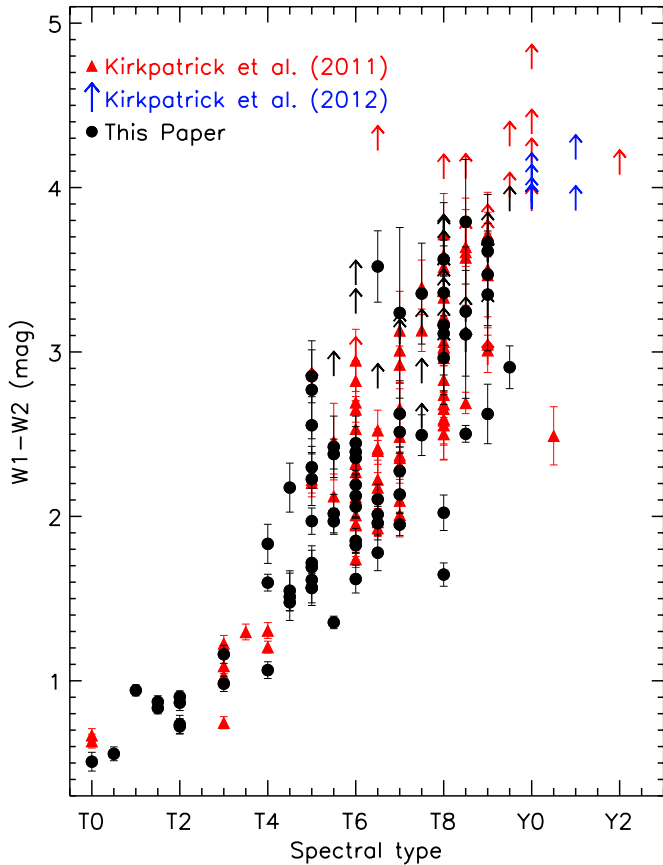
<sup>i</sup> WISE J180901.07+383805.4, Luhman et al. (2012).

<sup>j</sup> A nearby object caused source confusion in the pipeline used to generate the All-Sky Catalog, resulting in a non-detection of this object. The magnitudes reported here were taken from the first-pass processing operations co-add Source Working Database.

Source Catalog and the Reject Table.<sup>20</sup> Other follow-up ground-based photometry on the 2MASS system is from the 2MASS camera on the 1.5 m Kuiper Telescope at Steward Observatory and the Peters Automated Infrared Imaging Telescope (PAIRITEL; Bloom et al. 2006) on the 1.3 m telescope at Fred Lawrence Whipple Observatory. Photometry on the MKO system is from the Wide-field Infrared Camera (WIRC; Wil-

son et al. 2003) at the 5 m Hale Telescope at Palomar Observatory, the Persson’s Auxilliary Nasmyth Infrared Camera (PANIC; Martini et al. 2004) on the 6.5 m Magellan telescope at Las Campanas Observatory, and the NOAO Extremely Wide Field Infrared Imager (NEWFIRM; Autry et al. 2003) on the 4 m Victor M. Blanco Telescope at Cerro Tololo Inter-American Observatory (CTIO). Ten of our candidates are available in UKIDSS Data Release 8 (Hewett et al. 2006; Lawrence et al. 2007; Casali et al. 2007; Hambly et al. 2008; Hodgkin et al. 2009). Photometric filters installed in the Ohio State

<sup>20</sup> See <http://www.ipac.caltech.edu/2mass/releases/allsky/doc/explsup.html> for details.



**Figure 1.** *WISE*  $W1 - W2$  color vs. spectral type. Objects from Kirkpatrick et al. (2011) (including those announced by Mainzer et al. 2011, Cushing et al. 2011, and Burgasser et al. 2011) are marked with red triangles and limit arrows. The Y dwarfs from Kirkpatrick et al. (2012) are marked with blue squares and limit arrows. T dwarfs announced in this paper are marked with black circles and limit arrows.

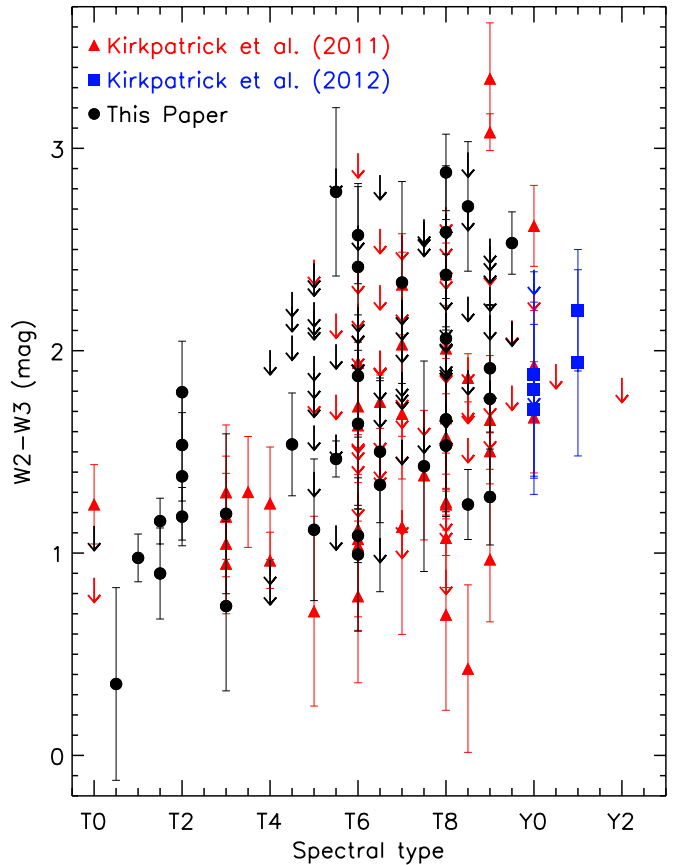
(A color version of this figure is available in the online journal.)

Infrared Imager/Spectrometer (OSIRIS; Depoy et al. 1993) use Barr filters which produce T dwarf photometry most similar to the MKO system (Kirkpatrick et al. 2012, Section 2.2.5), so they are listed with the MKO measurements. All images were acquired between 2010 August and 2012 August, and source extractions from our observations use source apertures that are  $1.5 \times$  FWHM of the source point-spread function.

Figures 5, 7, and 8 of Kirkpatrick et al. (2011) specify the  $J - H$ ,  $J - W2$ , and  $H - W2$  colors of M, L, T, and Y dwarfs. Objects lacking photometry in Table 3 of that paper, but having follow-up photometry now, are presented in Table 3 of this paper. Photometry of new T dwarf candidates is listed in Table 4. For the figures in this paper we use magnitudes on the 2MASS system. MKO magnitudes are depicted in Kirkpatrick et al. (2011, 2012).

The  $J - H$  color-type diagram for *WISE*-discovered T and Y dwarfs is shown in Figure 4. The reversal in the  $J - H$  color shown in Figure 7 of Kirkpatrick et al. (2012) can also be seen in Figure 4 around  $T7 \pm 1$ . However, the turnaround in the  $J - H$  color is driven by only a few objects later than T8 and there are large uncertainties in our colors, making a clear identification of the reversal location difficult.

The  $J - W2$  and  $H - W2$  colors, shown in Figures 5 and 6, of early-type T dwarfs are slightly bluer (or flat) for successive types before they become redder for late-type T dwarfs. These colors are complicated as  $H_2$  CIA, non-equilibrium CO and



**Figure 2.** *WISE*  $W2 - W3$  color vs. spectral type. Same symbols as in Figure 1. (A color version of this figure is available in the online journal.)

$CO_2$  absorption, and the shift of the Planck peak to longer wavelengths influence the emergent flux (Linsky 1969; Borysov et al. 1997; Frommhold et al. 2010; Saumon et al. 2012; Abel et al. 2012).

The Infrared Array Camera (IRAC; Fazio et al. 2004) on board the *Spitzer Space Telescope* (Werner et al. 2004) was used during the warm *Spitzer* mission to obtain deeper photometry in its 3.6 and  $4.5 \mu\text{m}$  channels (hereafter, *ch1* and *ch2*, respectively) allowing the *WISE*  $W1$  and  $W2$  filters to be robustly measured. These observations were made as part of Cycle 7 and Cycle 8 programs 70062 and 80109 (PI: Kirkpatrick). *Spitzer*/IRAC photometry is listed in Tables 3 and 4 along with our ground-based photometry. The  $ch1 - ch2$  color, as a function of spectral type, is shown in Figure 7. The trend is similar to the *WISE*  $W1 - W2$  colors (Figure 1), but differences in the *WISE* and *Spitzer*/IRAC passbands (Mainzer et al. 2011) result in a shallower slope in the  $ch1 - ch2$  color, as a function of spectral type, than the  $W1 - W2$  color. Figure 8 directly compares the  $ch1 - ch2$  and  $W1 - W2$  colors for T dwarfs. Figure 1 of Griffith et al. (2012) shows the  $ch1 - ch2$  and  $W1 - W2$  colors of many *WISE* candidate and confirmed brown dwarfs, clearly identifying the dip in  $ch1 - ch2$  at the L/T transition and the dispersion in colors at later spectral types that are also seen in Figure 8.

### 3.2. Follow-up Spectroscopic Observations

Summaries of the spectroscopic follow-up observations of the 90 new brown dwarfs and 14 known objects from the literature are given in Tables 5 and 6, respectively. Our observation and data reduction procedures are discussed in



**Table 3**  
Additional Follow-up 2MASS, MKO, and IRAC Photometry for Discoveries from Kirkpatrick et al. (2011)

| Object          | Obs. | 2MASS Filter System |                   |                               | MKO Filter System |                   | Spitzer/IRAC Observations |                     |                                  |
|-----------------|------|---------------------|-------------------|-------------------------------|-------------------|-------------------|---------------------------|---------------------|----------------------------------|
| Name            | Ref. | <i>J</i><br>(mag)   | <i>H</i><br>(mag) | <i>K<sub>s</sub></i><br>(mag) | <i>J</i><br>(mag) | <i>H</i><br>(mag) | <i>ch1</i><br>(mag)       | <i>ch2</i><br>(mag) | <i>ch1</i> – <i>ch2</i><br>(mag) |
| (1)             | (2)  | (3)                 | (4)               | (5)                           | (6)               | (7)               | (8)                       | (9)                 | (10)                             |
| WISE J0448–1935 | ...  | ...                 | ...               | ...                           | ...               | ...               | 15.37 ± 0.02              | 14.16 ± 0.02        | 1.21 ± 0.03                      |
| WISE J0656+4205 | ...  | ...                 | ...               | ...                           | ...               | ...               | 13.64 ± 0.02              | 13.26 ± 0.02        | 0.38 ± 0.03                      |
| WISE J0744+5628 | ...  | ...                 | ...               | ...                           | ...               | ...               | 16.27 ± 0.03              | 14.55 ± 0.02        | 1.71 ± 0.04                      |
| WISE J0759–4904 | 3    | ...                 | ...               | ...                           | 17.38 ± 0.05      | 17.41 ± 0.04      | ...                       | ...                 | ...                              |
| WISE J0821+1443 | ...  | ...                 | ...               | ...                           | ...               | ...               | 15.59 ± 0.03              | 14.51 ± 0.02        | 1.08 ± 0.03                      |
| WISE J0836–1859 | 1    | 18.99 ± 0.22        | 18.79 ± 0.26      | >18.48                        | ...               | ...               | ...                       | ...                 | ...                              |
| WISE J1018–2445 | 1    | 17.82 ± 0.12        | 18.00 ± 0.23      | 17.81 ± 0.31                  | ...               | ...               | ...                       | ...                 | ...                              |
| WISE J1042–3842 | 4    | ...                 | ...               | ...                           | 18.98 ± 0.09      | 19.08 ± 0.11      | ...                       | ...                 | ...                              |
| WISE J1436–1814 | 2    | 17.52 ± 0.13        | >17.62            | >16.97                        | ...               | ...               | ...                       | ...                 | ...                              |
| WISE J1612–3420 | 4    | ...                 | ...               | ...                           | 16.65 ± 0.03      | 16.96 ± 0.03      | ...                       | ...                 | ...                              |
| WISE J1812+2721 | ...  | ...                 | ...               | ...                           | ...               | ...               | 16.32 ± 0.03              | 14.17 ± 0.02        | 2.15 ± 0.04                      |
| WISE J1830+4542 | ...  | ...                 | ...               | ...                           | ...               | ...               | 14.29 ± 0.02              | 14.13 ± 0.02        | 0.16 ± 0.03                      |
| WISE J1906+4508 | ...  | ...                 | ...               | ...                           | ...               | ...               | 15.03 ± 0.02              | 13.82 ± 0.02        | 1.21 ± 0.03                      |
| WISE J1959–3338 | ...  | ...                 | ...               | ...                           | ...               | ...               | 15.36 ± 0.02              | 13.79 ± 0.02        | 1.58 ± 0.03                      |
| WISE J2018–7423 | 4    | ...                 | ...               | ...                           | 16.83 ± 0.03      | 17.17 ± 0.04      | 15.28 ± 0.02              | 13.55 ± 0.02        | 1.73 ± 0.03                      |
| WISE J2313–8037 | ...  | ...                 | ...               | ...                           | ...               | ...               | 15.29 ± 0.02              | 13.68 ± 0.02        | 1.61 ± 0.03                      |
| WISE J2343–7418 | ...  | ...                 | ...               | ...                           | ...               | ...               | 15.04 ± 0.02              | 13.75 ± 0.02        | 1.28 ± 0.03                      |

**Notes.** Ref. for *JHK* instrument or catalog: 2MASS filter system: (1) Bigelow/2MASS, (2) PAIRITEL; MKO filter system: (3) Magellan/PANIC, (4) CTIO-4m/NEWFIRM.

**Table 4**  
Follow-up 2MASS, MKO, and IRAC Photometry for New Brown Dwarf Discoveries

| Object Name     | Obs. Ref.      | 2MASS Filter System |                |                            | MKO Filter System |                | Spitzer/IRAC Observations |                  |                        |
|-----------------|----------------|---------------------|----------------|----------------------------|-------------------|----------------|---------------------------|------------------|------------------------|
|                 |                | <i>J</i> (mag)      | <i>H</i> (mag) | <i>K<sub>s</sub></i> (mag) | <i>J</i> (mag)    | <i>H</i> (mag) | <i>ch1</i> (mag)          | <i>ch2</i> (mag) | <i>ch1 - ch2</i> (mag) |
| (1)             | (2)            | (3)                 | (4)            | (5)                        | (6)               | (7)            | (8)                       | (9)              | (10)                   |
| WISE J0005+3737 | 9              | ...                 | ...            | ...                        | 18.33 ± 0.12      | 18.10 ± 0.08   | 15.43 ± 0.02              | 13.28 ± 0.02     | 2.15 ± 0.03            |
| WISE J0038+2758 | 5              | ...                 | ...            | ...                        | 18.61 ± 0.02      | 18.92 ± 0.04   | 16.45 ± 0.04              | 14.41 ± 0.02     | 2.04 ± 0.04            |
| WISE J0038+8405 | 4              | 17.53 ± 0.06        | 17.06 ± 0.11   | > 16.50                    | ...               | ...            | 16.33 ± 0.04              | 14.99 ± 0.02     | 1.34 ± 0.04            |
| WISE J0040+0900 | 1              | 16.50 ± 0.12        | 16.54 ± 0.27   | > 15.74                    | ...               | ...            | 15.07 ± 0.02              | 13.76 ± 0.02     | 1.31 ± 0.03            |
|                 | 7 <sup>a</sup> | ...                 | ...            | ...                        | ...               | 16.560.02      | ...                       | ...              | ...                    |
| WISE J0045+3611 | 1              | 16.15 ± 0.08        | 16.04 ± 0.15   | 15.80 ± 0.20               | ...               | ...            | 14.68 ± 0.02              | 13.75 ± 0.02     | 0.94 ± 0.03            |
| WISE J0049+2151 | 1              | 16.72 ± 0.16        | > 16.51        | > 15.86                    | ...               | ...            | 15.01 ± 0.02              | 13.04 ± 0.02     | 1.97 ± 0.03            |
| WISE J0135+1715 | ...            | ...                 | ...            | ...                        | ...               | ...            | 16.08 ± 0.03              | 14.57 ± 0.02     | 1.51 ± 0.04            |
| WISE J0210+4008 | 2              | 16.77 ± 0.19        | 16.06 ± 0.18   | > 15.88                    | ...               | ...            | ...                       | ...              | ...                    |
| WISE J0233+3030 | 1              | 16.85 ± 0.14        | > 17.18        | > 17.04                    | ...               | ...            | 15.63 ± 0.03              | 14.35 ± 0.02     | 1.28 ± 0.03            |
| WISE J0245-3450 | 9              | ...                 | ...            | ...                        | 17.77 ± 0.09      | ...            | 16.05 ± 0.03              | 14.59 ± 0.02     | 1.46 ± 0.04            |
| WISE J0247+3725 | 3              | 18.44 ± 0.17        | 18.24 ± 0.19   | 18.37 ± 0.30               | ...               | ...            | 16.70 ± 0.04              | 14.56 ± 0.02     | 2.14 ± 0.05            |
| WISE J0259-0346 | ...            | ...                 | ...            | ...                        | ...               | ...            | 16.22 ± 0.03              | 14.88 ± 0.02     | 1.34 ± 0.04            |
| WISE J0316+3820 | 1              | 16.06 ± 0.09        | 15.44 ± 0.11   | 15.27 ± 0.15               | ...               | ...            | 14.10 ± 0.02              | 13.52 ± 0.02     | 0.58 ± 0.03            |
|                 | 3              | 16.21 ± 0.08        | 15.50 ± 0.08   | 15.33 ± 0.10               | ...               | ...            | ...                       | ...              | ...                    |
| WISE J0316+4307 | 5              | ...                 | ...            | ...                        | 19.47 ± 0.04      | 19.70 ± 0.09   | 16.64 ± 0.04              | 14.58 ± 0.02     | 2.06 ± 0.05            |
| WISE J0321-7347 | 9              | ...                 | ...            | ...                        | 19.13 ± 0.11      | 19.06 ± 0.12   | 17.28 ± 0.06              | 15.36 ± 0.02     | 1.92 ± 0.06            |
| WISE J0325-3854 | 9*             | ...                 | ...            | ...                        | ~19.40            | ~19.30         | 17.12 ± 0.05              | 14.99 ± 0.02     | 2.14 ± 0.06            |
| WISE J0325+0831 | 4              | 16.54 ± 0.07        | 16.15 ± 0.08   | ...                        | ...               | ...            | 14.70 ± 0.02              | 13.59 ± 0.02     | 1.11 ± 0.03            |
| WISE J0335+4310 | 3              | > 19.73             | > 19.18        | > 18.56                    | ...               | ...            | 16.60 ± 0.04              | 14.38 ± 0.02     | 2.21 ± 0.04            |
|                 | 5              | ...                 | ...            | ...                        | 20.07 ± 0.30      | 19.60 ± 0.26   | ...                       | ...              | ...                    |
| WISE J0336-0143 | 4              | > 19.00             | > 18.25        | ...                        | ...               | ...            | 17.26 ± 0.06              | 14.62 ± 0.02     | 2.64 ± 0.06            |
| WISE J0336+2826 | 1              | 16.54 ± 0.12        | 16.53 ± 0.27   | 15.77 ± 0.24               | ...               | ...            | 15.31 ± 0.02              | 14.36 ± 0.02     | 0.95 ± 0.03            |
|                 | 7 <sup>b</sup> | ...                 | ...            | ...                        | ...               | 16.28 ± 0.03   | ...                       | ...              | ...                    |
| WISE J0413-4750 | 9              | ...                 | ...            | ...                        | 20.29 ± 0.20      | 20.12 ± 0.20   | 17.80 ± 0.09              | 15.49 ± 0.02     | 2.32 ± 0.09            |
| WISE J0424+0727 | 3              | 18.71 ± 0.16        | 18.76 ± 0.22   | 18.87 ± 0.40               | ...               | ...            | 16.75 ± 0.04              | 15.18 ± 0.02     | 1.56 ± 0.05            |
| WISE J0430+4633 | 5              | ...                 | ...            | ...                        | 19.03 ± 0.05      | 19.25 ± 0.13   | 16.13 ± 0.03              | 14.22 ± 0.02     | 1.91 ± 0.04            |
| WISE J0512-3004 | 5              | ...                 | ...            | ...                        | 19.21 ± 0.09      | 19.66 ± 0.41   | 17.64 ± 0.08              | 15.58 ± 0.02     | 2.06 ± 0.08            |
| WISE J0540+4832 | 5              | ...                 | ...            | ...                        | 18.49 ± 0.02      | 18.62 ± 0.05   | 16.97 ± 0.05              | 14.77 ± 0.02     | 2.20 ± 0.05            |
| WISE J0546-0959 | 1              | 16.18 ± 0.09        | 16.27 ± 0.22   | > 15.47                    | ...               | ...            | 15.01 ± 0.02              | 13.92 ± 0.02     | 1.09 ± 0.03            |
| WISE J0614+0951 | 3              | 16.90 ± 0.08        | 16.82 ± 0.10   | 16.81 ± 0.14               | ...               | ...            | 15.49 ± 0.03              | 14.10 ± 0.02     | 1.39 ± 0.03            |
| WISE J0629+2418 | 1              | 16.34 ± 0.13        | 15.47 ± 0.15   | 15.13 ± 0.15               | ...               | ...            | ...                       | ...              | ...                    |
|                 | 4              | 16.39 ± 0.05        | 15.58 ± 0.06   | 15.09 ± 0.07               | ...               | ...            | ...                       | ...              | ...                    |
| WISE J0642+4101 | 1              | 16.16 ± 0.10        | 15.09 ± 0.07   | 14.28 ± 0.06               | ...               | ...            | 12.94 ± 0.02              | 12.65 ± 0.02     | 0.29 ± 0.02            |
| WISE J0701+6321 | 1              | 15.79 ± 0.06        | 15.08 ± 0.07   | 14.88 ± 0.11               | ...               | ...            | 13.65 ± 0.02              | 13.24 ± 0.02     | 0.42 ± 0.03            |
| WISE J0723+3403 | 4              | 18.21 ± 0.14        | > 18.47        | > 17.06                    | ...               | ...            | 16.77 ± 0.04              | 14.68 ± 0.02     | 2.08 ± 0.05            |
| WISE J0733+7544 | 2              | 17.20 ± 0.21        | > 17.75        | 15.81 ± 0.27               | ...               | ...            | 16.00 ± 0.03              | 14.81 ± 0.02     | 1.19 ± 0.04            |
| WISE J0754+7909 | 1              | 16.17 ± 0.11        | 15.44 ± 0.14   | 14.93 ± 0.12               | ...               | ...            | 13.81 ± 0.02              | 13.82 ± 0.02     | -0.01 ± 0.03           |
|                 | 4              | 16.24 ± 0.05        | 15.27 ± 0.06   | 15.05 ± 0.08               | ...               | ...            | ...                       | ...              | ...                    |
| WISE J0811-8051 | 9              | ...                 | ...            | ...                        | 19.90 ± 0.18      | 19.88 ± 0.21   | 16.82 ± 0.05              | 14.40 ± 0.02     | 2.42 ± 0.05            |

Table 4  
(Continued)

| Object<br>Name  | Obs.<br>Ref.   | 2MASS Filter System      |                          |                                      | MKO Filter System        |                          | <i>Spitzer</i> /IRAC Observations |                            |                                   |
|-----------------|----------------|--------------------------|--------------------------|--------------------------------------|--------------------------|--------------------------|-----------------------------------|----------------------------|-----------------------------------|
|                 |                | <i>J</i><br>(mag)<br>(3) | <i>H</i><br>(mag)<br>(4) | <i>K<sub>s</sub></i><br>(mag)<br>(5) | <i>J</i><br>(mag)<br>(6) | <i>H</i><br>(mag)<br>(7) | <i>ch1</i><br>(mag)<br>(8)        | <i>ch2</i><br>(mag)<br>(9) | <i>ch1 - ch2</i><br>(mag)<br>(10) |
| WISE J0812+4021 | 3              | 18.39 ± 0.16             | 18.30 ± 0.20             | 19.15 ± 0.51                         | ...                      | ...                      | 16.93 ± 0.05                      | 15.30 ± 0.02               | 1.63 ± 0.05                       |
| WISE J0920+4538 | 1              | 15.22 ± 0.05             | 14.16 ± 0.05             | 13.73 ± 0.05                         | ...                      | ...                      | ...                               | ...                        | ...                               |
|                 | 4              | 15.16 ± 0.04             | 14.13 ± 0.09             | 13.78 ± 0.06                         | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J0950+0117 | 5              | ...                      | ...                      | ...                                  | 18.09 ± 0.07             | 18.07 ± 0.08             | 16.31 ± 0.03                      | 14.42 ± 0.02               | 1.88 ± 0.04                       |
|                 | 7 <sup>c</sup> | ...                      | ...                      | ...                                  | 18.05 ± 0.04             | 18.24 ± 0.15             | ...                               | ...                        | ...                               |
| WISE J1025+0307 | 5              | ...                      | ...                      | ...                                  | 17.93 ± 0.03             | 18.36 ± 0.05             | 16.32 ± 0.03                      | 14.19 ± 0.02               | 2.12 ± 0.04                       |
|                 | 7 <sup>d</sup> | ...                      | ...                      | ...                                  | 17.84 ± 0.03             | 18.30 ± 0.12             | ...                               | ...                        | ...                               |
| WISE J1039-1600 | 3              | 17.26 ± 0.12             | 17.19 ± 0.20             | >17.13                               | ...                      | ...                      | 15.79 ± 0.03                      | 14.23 ± 0.02               | 1.55 ± 0.03                       |
|                 | 4              | 17.34 ± 0.08             | >17.87                   | >17.03                               | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J1050+5056 | 5              | ...                      | ...                      | ...                                  | 17.94 ± 0.02             | 18.31 ± 0.03             | 16.55 ± 0.04                      | 14.90 ± 0.02               | 1.65 ± 0.04                       |
| WISE J1051-2138 | 9              | ...                      | ...                      | ...                                  | 18.93 ± 0.10             | 19.19 ± 0.39             | 16.43 ± 0.04                      | 14.60 ± 0.02               | 1.83 ± 0.04                       |
| WISE J1124-0421 | 1              | 16.72 ± 0.13             | >16.32                   | >16.37                               | ...                      | ...                      | 15.37 ± 0.02                      | 14.10 ± 0.02               | 1.27 ± 0.03                       |
| WISE J1143+4431 | 5              | ...                      | ...                      | ...                                  | 18.76 ± 0.04             | 19.04 ± 0.06             | 17.14 ± 0.06                      | 15.16 ± 0.02               | 1.98 ± 0.06                       |
| WISE J1221-3136 | 1              | 16.38 ± 0.13             | 16.06 ± 0.18             | >15.63                               | ...                      | ...                      | 15.09 ± 0.02                      | 13.89 ± 0.02               | 1.20 ± 0.03                       |
| WISE J1225-1013 | 1              | 16.43 ± 0.10             | 16.30 ± 0.22             | >15.87                               | ...                      | ...                      | 15.31 ± 0.02                      | 13.96 ± 0.02               | 1.35 ± 0.03                       |
|                 | 9              | ...                      | ...                      | ...                                  | ...                      | 16.46 ± 0.15             | ...                               | ...                        | ...                               |
| WISE J1246-3139 | 1              | 15.02 ± 0.04             | 14.19 ± 0.03             | 13.97 ± 0.06                         | ...                      | ...                      | 12.77 ± 0.02                      | 12.45 ± 0.02               | 0.32 ± 0.02                       |
| WISE J1250+2628 | 2              | 16.93 ± 0.20             | >17.10                   | 15.72 ± 0.21                         | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J1257+4008 | 3              | 17.23 ± 0.09             | 16.96 ± 0.13             | 17.00 ± 0.19                         | ...                      | ...                      | 15.92 ± 0.03                      | 14.49 ± 0.02               | 1.43 ± 0.04                       |
| WISE J1301-0302 | 5              | ...                      | ...                      | ...                                  | 18.00 ± 0.02             | 18.39 ± 0.06             | 16.64 ± 0.04                      | 14.89 ± 0.02               | 1.74 ± 0.05                       |
| WISE J1318-1758 | 3              | 18.43 ± 0.19             | 17.71 ± 0.23             | >17.67                               | ...                      | ...                      | 16.79 ± 0.05                      | 14.73 ± 0.02               | 2.06 ± 0.05                       |
| WISE J1337+2636 | 1              | 16.67 ± 0.15             | >16.12                   | >16.97                               | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J1348-1344 | 1              | 16.48 ± 0.12             | 16.09 ± 0.17             | >16.45                               | ...                      | ...                      | 15.30 ± 0.03                      | 14.10 ± 0.02               | 1.20 ± 0.03                       |
|                 | 4              | 16.67 ± 0.10             | 16.67 ± 0.13             | >17.01                               | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J1400-3850 | 1              | 16.04 ± 0.10             | 15.82 ± 0.17             | >16.07                               | ...                      | ...                      | 14.53 ± 0.02                      | 13.85 ± 0.02               | 0.68 ± 0.03                       |
| WISE J1423+0116 | 5              | ...                      | ...                      | ...                                  | 18.55 ± 0.03             | 18.96 ± 0.07             | 16.73 ± 0.04                      | 14.69 ± 0.02               | 2.03 ± 0.05                       |
|                 | 7 <sup>e</sup> | ...                      | ...                      | ...                                  | 18.76 ± 0.12             | ...                      | ...                               | ...                        | ...                               |
| WISE J1449+1147 | 4              | >17.96                   | >17.32                   | >16.64                               | ...                      | ...                      | 16.11 ± 0.03                      | 14.92 ± 0.02               | 1.19 ± 0.04                       |
|                 | 7 <sup>f</sup> | ...                      | ...                      | ...                                  | 17.36 ± 0.02             | 17.73 ± 0.07             | ...                               | ...                        | ...                               |
| WISE J1505-2853 | 1              | 15.83 ± 0.07             | 15.24 ± 0.08             | 15.06 ± 0.13                         | ...                      | ...                      | 13.56 ± 0.02                      | 13.29 ± 0.02               | 0.27 ± 0.03                       |
|                 | 4              | 15.97 ± 0.08             | 15.09 ± 0.10             | 14.69 ± 0.06                         | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J1517+0529 | 7 <sup>g</sup> | ...                      | ...                      | ...                                  | 18.54 ± 0.05             | 18.85 ± 0.15             | 16.85 ± 0.05                      | 15.10 ± 0.02               | 1.74 ± 0.05                       |
| WISE J1523+3125 | 5              | ...                      | ...                      | ...                                  | 18.27 ± 0.07             | 18.69 ± 0.18             | 15.95 ± 0.03                      | 14.28 ± 0.02               | 1.68 ± 0.04                       |
| WISE J1542+2230 | 5              | ...                      | ...                      | ...                                  | 20.25 ± 0.13             | 21.80 ± 0.80             | 17.26 ± 0.06                      | 15.06 ± 0.02               | 2.20 ± 0.06                       |
| WISE J1543-0439 | 1              | 16.51 ± 0.13             | >15.98                   | >16.34                               | ...                      | ...                      | 15.43 ± 0.02                      | 14.54 ± 0.02               | 0.89 ± 0.03                       |
| WISE J1544+5842 | 3              | 18.52 ± 0.17             | 18.34 ± 0.29             | >17.98                               | ...                      | ...                      | 16.68 ± 0.04                      | 14.95 ± 0.02               | 1.73 ± 0.05                       |
| WISE J1625+1528 | 3              | 17.14 ± 0.11             | 16.85 ± 0.14             | 16.98 ± 0.21                         | ...                      | ...                      | 15.77 ± 0.03                      | 14.75 ± 0.02               | 1.02 ± 0.04                       |
| WISE J1629+0335 | 1              | 15.29 ± 0.04             | 14.49 ± 0.04             | 14.18 ± 0.06                         | ...                      | ...                      | 12.82 ± 0.02                      | 12.57 ± 0.02               | 0.25 ± 0.02                       |
|                 | 4              | 15.22 ± 0.05             | 14.43 ± 0.08             | 14.04 ± 0.03                         | ...                      | ...                      | ...                               | ...                        | ...                               |
| WISE J1632+0329 | 1              | 16.75 ± 0.12             | 16.43 ± 0.19             | >16.63                               | ...                      | ...                      | 15.28 ± 0.02                      | 14.47 ± 0.02               | 0.81 ± 0.03                       |

**Table 4**  
(Continued)

| Object<br>Name  | Obs.<br>Ref. | 2MASS Filter System |                   |                               | MKO Filter System |                   | <i>Spitzer</i> /IRAC Observations |                     |                           |
|-----------------|--------------|---------------------|-------------------|-------------------------------|-------------------|-------------------|-----------------------------------|---------------------|---------------------------|
|                 |              | <i>J</i><br>(mag)   | <i>H</i><br>(mag) | <i>K<sub>s</sub></i><br>(mag) | <i>J</i><br>(mag) | <i>H</i><br>(mag) | <i>ch1</i><br>(mag)               | <i>ch2</i><br>(mag) | <i>ch1 - ch2</i><br>(mag) |
| (1)             | (2)          | (3)                 | (4)               | (5)                           | (6)               | (7)               | (8)                               | (9)                 | (10)                      |
| WISE J1636-0743 | ...          | ...                 | ...               | ...                           | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J1707-1744 | 1            | 16.30 ± 0.12        | >15.45            | >15.85                        | ...               | ...               | 14.98 ± 0.02                      | 13.62 ± 0.02        | 1.35 ± 0.03               |
|                 | 5            | ...                 | ...               | ...                           | 16.35 ± 0.02      | 17.11 ± 0.03      | ...                               | ...                 | ...                       |
|                 | 8            | ...                 | ...               | ...                           | 16.33 ± 0.02      | 16.58 ± 0.03      | ...                               | ...                 | ...                       |
| WISE J1721+1117 | 1            | 16.46 ± 0.15        | >16.24            | >16.12                        | ...               | ...               | 15.24 ± 0.02                      | 14.35 ± 0.02        | 0.89 ± 0.03               |
| WISE J1730+4207 | 2            | 16.95 ± 0.18        | 16.00 ± 0.19      | >15.65                        | ...               | ...               | 14.73 ± 0.02                      | 14.56 ± 0.02        | 0.17 ± 0.03               |
| WISE J1734+5023 | 1            | 16.34 ± 0.11        | 15.85 ± 0.14      | >15.37                        | ...               | ...               | 15.23 ± 0.02                      | 14.38 ± 0.02        | 0.84 ± 0.03               |
| WISE J1736+6059 | 4            | >18.91              | >18.14            | >16.96                        | ...               | ...               | 16.97 ± 0.05                      | 15.37 ± 0.02        | 1.60 ± 0.05               |
| WISE J1738+6142 | 2            | ...                 | 16.32 ± 0.22      | 15.14 ± 0.16                  | ...               | ...               | 13.56 ± 0.02                      | 13.33 ± 0.02        | 0.23 ± 0.03               |
|                 | 4            | 17.82 ± 0.13        | 16.34 ± 0.08      | 15.27 ± 0.10                  | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J1741+1327 | ...          | ...                 | ...               | ...                           | ...               | ...               | 16.01 ± 0.03                      | 14.67 ± 0.02        | 1.35 ± 0.04               |
| WISE J1743+4211 | 1            | 15.84 ± 0.06        | 15.57 ± 0.14      | 15.43 ± 0.19                  | ...               | ...               | 14.72 ± 0.02                      | 13.93 ± 0.02        | 0.79 ± 0.03               |
|                 | 4            | 15.83 ± 0.06        | 15.73 ± 0.09      | 16.03 ± 0.22                  | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J1745+6459 | ...          | ...                 | ...               | ...                           | ...               | ...               | 17.41 ± 0.07                      | 16.14 ± 0.03        | 1.27 ± 0.07               |
| WISE J1746-0338 | 3            | 17.53 ± 0.17        | 17.57 ± 0.34      | >17.08                        | ...               | ...               | 16.03 ± 0.03                      | 14.44 ± 0.02        | 1.59 ± 0.04               |
|                 | 8            | ...                 | ...               | ...                           | 17.17 ± 0.03      | 17.45 ± 0.04      | ...                               | ...                 | ...                       |
| WISE J1755+1803 | 1            | 16.02 ± 0.09        | 15.22 ± 0.09      | 14.68 ± 0.13                  | ...               | ...               | 14.09 ± 0.02                      | 13.77 ± 0.02        | 0.32 ± 0.03               |
| WISE J1759+5442 | 5            | ...                 | ...               | ...                           | 17.93 ± 0.01      | 18.26 ± 0.03      | 16.64 ± 0.04                      | 15.12 ± 0.02        | 1.52 ± 0.05               |
| WISE J1809+3838 | ...          | ...                 | ...               | ...                           | ...               | ...               | 16.49 ± 0.04                      | 14.90 ± 0.02        | 1.59 ± 0.04               |
| WISE J1809-0448 | 1            | 15.14 ± 0.05        | 14.28 ± 0.05      | 13.96 ± 0.06                  | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J1812+2007 | 5            | ...                 | ...               | ...                           | 18.54 ± 0.02      | 18.95 ± 0.06      | 16.96 ± 0.05                      | 15.02 ± 0.02        | 1.93 ± 0.05               |
|                 | 8            | ...                 | ...               | ...                           | 18.75 ± 0.07      | 18.94 ± 0.09      | ...                               | ...                 | ...                       |
| WISE J1813+2835 | ...          | ...                 | ...               | ...                           | ...               | ...               | 15.82 ± 0.03                      | 14.19 ± 0.02        | 1.63 ± 0.03               |
| WISE J1840+2932 | 5            | ...                 | ...               | ...                           | 17.89 ± 0.01      | 18.12 ± 0.03      | 16.67 ± 0.04                      | 15.20 ± 0.02        | 1.47 ± 0.05               |
| WISE J1909-5204 | 6            | ...                 | ...               | ...                           | 17.35 ± 0.09      | 17.26 ± 0.06      | 16.37 ± 0.04                      | 15.21 ± 0.02        | 1.17 ± 0.04               |
| WISE J1913+6444 | 4            | 17.32 ± 0.10        | 16.89 ± 0.14      | >16.49                        | ...               | ...               | 16.29 ± 0.03                      | 14.99 ± 0.02        | 1.30 ± 0.04               |
| WISE J1928+2356 | 2            | 14.34 ± 0.06        | 14.31 ± 0.06      | 14.09 ± 0.06                  | ...               | ...               | 13.14 ± 0.02                      | 12.06 ± 0.02        | 1.08 ± 0.02               |
| WISE J1954+6915 | 4            | 17.73 ± 0.12        | 17.19 ± 0.16      | 17.06 ± 0.38                  | ...               | ...               | 16.04 ± 0.03                      | 14.83 ± 0.02        | 1.22 ± 0.04               |
| WISE J1955-2540 | 5            | ...                 | ...               | ...                           | 17.58 ± 0.02      | 18.00 ± 0.05      | 16.61 ± 0.04                      | 15.03 ± 0.02        | 1.58 ± 0.05               |
| WISE J2008-0834 | 1            | 16.37 ± 0.12        | 16.69 ± 0.31      | >15.66                        | ...               | ...               | 15.16 ± 0.02                      | 14.11 ± 0.02        | 1.06 ± 0.03               |
| WISE J2014+0424 | 3            | 18.76 ± 0.22        | 18.66 ± 0.30      | 17.84 ± 0.29                  | ...               | ...               | 16.35 ± 0.04                      | 14.77 ± 0.02        | 1.58 ± 0.04               |
| WISE J2015+6646 | 4            | 16.91 ± 0.07        | 16.50 ± 0.09      | >16.43                        | ...               | ...               | 16.33 ± 0.03                      | 14.62 ± 0.02        | 1.71 ± 0.04               |
| WISE J2019-1148 | 4            | >14.93              | >13.95            | >14.11                        | ...               | ...               | 16.03 ± 0.03                      | 14.25 ± 0.02        | 1.78 ± 0.04               |
|                 | 8            | ...                 | ...               | ...                           | 18.09 ± 0.06      | 18.23 ± 0.07      | ...                               | ...                 | ...                       |
|                 | 9            | ...                 | ...               | ...                           | 18.54 ± 0.08      | 18.32 ± 0.11      | ...                               | ...                 | ...                       |
| WISE J2030+0749 | 1            | 14.23 ± 0.03        | 13.44 ± 0.03      | 13.32 ± 0.04                  | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J2043+6220 | 1            | 15.60 ± 0.07        | 14.70 ± 0.07      | 14.42 ± 0.07                  | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J2123-2614 | 2            | 17.44 ± 0.26        | >17.30            | >15.85                        | ...               | ...               | 15.94 ± 0.03                      | 14.45 ± 0.02        | 1.49 ± 0.04               |
| WISE J2147-1029 | 3            | 17.66 ± 0.22        | 17.81 ± 0.36      | >17.12                        | ...               | ...               | 16.55 ± 0.04                      | 14.96 ± 0.02        | 1.59 ± 0.04               |
| WISE J2236+5105 | ...          | ...                 | ...               | ...                           | ...               | ...               | ...                               | ...                 | ...                       |
| WISE J2237+7228 | 1            | 15.76 ± 0.07        | 15.94 ± 0.21      | >15.99                        | ...               | ...               | 14.61 ± 0.02                      | 13.56 ± 0.02        | 1.05 ± 0.03               |

**Table 4**  
(Continued)

| Object<br>Name  | Obs.<br>Ref.   | 2MASS Filter System |                   |                               | MKO Filter System |                   | Spitzer/IRAC Observations |                     |                           |
|-----------------|----------------|---------------------|-------------------|-------------------------------|-------------------|-------------------|---------------------------|---------------------|---------------------------|
|                 |                | <i>J</i><br>(mag)   | <i>H</i><br>(mag) | <i>K<sub>s</sub></i><br>(mag) | <i>J</i><br>(mag) | <i>H</i><br>(mag) | <i>ch1</i><br>(mag)       | <i>ch2</i><br>(mag) | <i>ch1 - ch2</i><br>(mag) |
| (1)             | (2)            | (3)                 | (4)               | (5)                           | (6)               | (7)               | (8)                       | (9)                 | (10)                      |
| WISE J2301+0216 | 1              | 16.71 ± 0.15        | >16.09            | >17.18                        | ...               | ...               | 15.60 ± 0.03              | 14.37 ± 0.02        | 1.23 ± 0.03               |
|                 | 7 <sup>h</sup> | ...                 | ...               | ...                           | 16.36 ± 0.01      | 16.70 ± 0.03      | ...                       | ...                 | ...                       |
| WISE J2303+1914 | 1              | 16.86 ± 0.16        | >16.02            | >17.10                        | ...               | ...               | ...                       | ...                 | ...                       |
| WISE J2335+4222 | ...            | ...                 | ...               | ...                           | ...               | ...               | 16.53 ± 0.04              | 15.30 ± 0.02        | 1.23 ± 0.05               |
| WISE J2342+0856 | 2              | 16.73 ± 0.18        | 16.26 ± 0.23      | >15.94                        | ...               | ...               | 15.29 ± 0.02              | 13.99 ± 0.02        | 1.30 ± 0.03               |
|                 | 7 <sup>i</sup> | ...                 | ...               | ...                           | 16.37 ± 0.01      | 16.73 ± 0.03      | ...                       | ...                 | ...                       |
| WISE J2357+1227 | 1              | 16.52 ± 0.14        | >15.75            | >16.12                        | ...               | ...               | 15.26 ± 0.02              | 14.10 ± 0.02        | 1.16 ± 0.03               |
|                 | 7 <sup>j</sup> | ...                 | ...               | ...                           | 16.10 ± 0.01      | 16.49 ± 0.03      | ...                       | ...                 | ...                       |

**Notes.** Ref. for *JHK* instrument or catalog: 2MASS filter system: (1) 2MASS All-Sky Point Source Catalog, (2) 2MASS Reject Table, (3) Bigelow/2MASS, (4) PAIRITEL; MKO filter system: (5) Palomar/WIRC, (6) Magellan/PANIC, (7) UKIDSS, (8) CTIO-4m/NEWFIRM, Other filter System: (9) SOAR/OSIRIS.

\* Approximate magnitudes based on images with only three 2MASS sources available for photometric calibration.

<sup>a</sup>  $K = 16.55 \pm 0.05$  (mag).

<sup>b</sup>  $Z = 19.75 \pm 0.09$  (mag),  $Y = 17.48 \pm 0.02$  (mag),  $K = 16.40 \pm 0.04$  (mag).

<sup>c</sup>  $Y = 18.96 \pm 0.06$  (mag).

<sup>d</sup>  $Y = 18.92 \pm 0.05$  (mag).

<sup>e</sup>  $Y = 19.51 \pm 0.14$  (mag).

<sup>f</sup>  $Y = 18.35 \pm 0.04$  (mag),  $K = 18.10 \pm 0.15$  (mag).

<sup>g</sup>  $Y = 19.57 \pm 0.07$  (mag).

<sup>h</sup>  $Y = 17.62 \pm 0.02$  (mag),  $K = 16.87 \pm 0.05$  (mag).

<sup>i</sup>  $Y = 17.42 \pm 0.02$  (mag),  $K = 16.98 \pm 0.07$  (mag).

<sup>j</sup>  $Y = 17.34 \pm 0.02$  (mag),  $K = 16.52 \pm 0.04$  (mag).

**Table 5**  
Follow-up Near-IR Spectroscopy and Spectral Classifications for T Dwarf Discoveries

| Object Name<br>and J2000 Coordinates<br>(1) | NIR Sp.<br>Type<br>(2) | Spectrograph<br>(3) | Int. Time<br>(s)<br>(4) | Tell. Corr.<br>Star<br>(5) | Obs. Date<br>(UT)<br>(6) |
|---|------------------------|---------------------|-------------------------|----------------------------|--------------------------|
| WISE J0005+3737                             | T9                     | Keck/NIRSPEC-J      | 2400                    | HD 9711                    | 2011 Oct 7               |
| WISE J0038+2758                             | T9                     | Keck/NIRSPEC-J      | 4800                    | HD 7215                    | 2011 Sep 8               |
| WISE J0038+8405                             | T6                     | Keck/NIRSPEC-J      | 3600                    | HD 33541                   | 2011 Aug 9               |
| WISE J0040+0900                             | T7                     | IRTF/SpeX           | 1200                    | HD 7215                    | 2011 Nov 30              |
| WISE J0045+3611                             | T5                     | IRTF/SpeX           | 1200                    | HD 9711                    | 2011 Aug 25              |
| WISE J0049+2151                             | T8.5                   | IRTF/SpeX           | 1200                    | HD 9711                    | 2011 Aug 25              |
| WISE J0135+1715                             | T6                     | IRTF/SpeX           | 1200                    | HD 19600                   | 2011 Aug 25              |
| WISE J0210+4008                             | T4.5                   | IRTF/SpeX           | 1200                    | HD 19600                   | 2011 Nov 30              |
| WISE J0233+3030                             | T6                     | IRTF/SpeX           | 1200                    | HD 19600                   | 2011 Aug 25              |
| WISE J0245-3450                             | T8                     | IRTF/SpeX           | 1200                    | HD 18735                   | 2011 Aug 25              |
| WISE J0247+3725                             | T8                     | Gemini/GNIRS        | 6000                    | HD 21038                   | 2012 Jan 5               |
| WISE J0259-0346                             | T5                     | Keck/NIRSPEC-J      | 1200                    | HD 18571                   | 2011 Oct 9               |
| WISE J0316+3820                             | T3                     | Palomar/TSpec       | 480                     | HD 20842                   | 2011 Jul 13              |
| WISE J0316+4307                             | T8                     | Keck/NIRSPEC-J      | 2400                    | HD 21038                   | 2011 Sep 5               |
|   | T8                     | Keck/NIRSPEC-H      | 1800                    | HD 21038                   | 2011 Sep 6               |
|   | T8                     | Keck/NIRSPEC-J      | 3600                    | HD 9711                    | 2011 Oct 7               |
| WISE J0321-7347                             | T8                     | Magellan/FIRE       | 1775                    | HD 80885                   | 2012 Jan 5               |
| WISE J0325-3854                             | T9                     | Keck/NIRSPEC-J      | 1200                    | HD 24966                   | 2011 Sep 8               |
|   | T9                     | Keck/NIRSPEC-J      | 2400                    | HD 24966                   | 2011 Oct 7               |
| WISE J0325+0831                             | T7                     | IRTF/SpeX           | 1560                    | HD 22859                   | 2011 Sep 11              |
| WISE J0335+4310                             | T9                     | Keck/NIRSPEC-J      | 2400                    | HD 21038                   | 2012 Sep 25              |
| WISE J0336-0143                             | T8:                    | Keck/NIRSPEC-J      | 600                     | HD 18571                   | 2011 Sep 8               |
| WISE J0336+2826                             | T5                     | IRTF/SpeX           | 960                     | HD 202990                  | 2011 Sep 11              |
| WISE J0413-4750                             | T9                     | Magellan/FIRE       | 1775                    | HD 30252                   | 2012 Jan 5               |
| WISE J0424+0727                             | T7.5                   | Keck/NIRSPEC-J      | 2400                    | HD 31411                   | 2012 Sep 24              |
| WISE J0430+4633                             | T8                     | Keck/NIRSPEC-J      | 4200                    | HD 31069                   | 2012 Sep 24              |
| WISE J0512-3004                             | T8.5                   | Keck/NIRSPEC-J      | 2400                    | HD 36965                   | 2012 Sep 25              |
| WISE J0540+4832                             | T8.5                   | Keck/NIRSPEC-J      | 2400                    | HD 45105                   | 2012 Sep 25              |
| WISE J0546-0959                             | T5                     | IRTF/SpeX           | 1200                    | HD 37887                   | 2012 Feb 1               |
| WISE J0614+0951                             | T7                     | Palomar/TSpec       | 2700                    | HD 35036                   | 2012 Jan 6               |
| WISE J0629+2418                             | T2 sb                  | IRTF/SpeX           | 1200                    | HD 43607                   | 2012 Feb 13              |
| WISE J0642+4101                             | extremely red          | Palomar/TSpec       | 1080                    | HD 45105                   | 2012 Jan 7               |
| WISE J0701+6321                             | T3                     | Palomar/TSpec       | 1440                    | HD 33654                   | 2012 Jan 6               |
| WISE J0723+3403                             | T9:                    | Keck/NIRSPEC-J      | 2400                    | HD 57208                   | 2012 Apr 9               |
| WISE J0733+7544                             | T6                     | Palomar/TSpec       | 3000                    | HD 43607                   | 2012 Jan 6               |
| WISE J0754+7909                             | extremely red          | Palomar/TSpec       | 1440                    | HD 33541                   | 2012 Jan 7               |
| WISE J0811-8051                             | T9.5:                  | Magellan/FIRE       | 1268                    | HD 52364                   | 2012 Jan 5               |
| WISE J0812+4021                             | T8                     | Gemini/GNIRS        | 3000                    | HD 45105                   | 2011 Mar 13              |
| WISE J1025+0307                             | T8.5                   | Magellan/FIRE       | 960                     | HD 84920                   | 2012 May 6               |
| WISE J1039-1600                             | T7.5                   | IRTF/SpeX           | 1920                    | HD 88766                   | 2012 Feb 13              |
| WISE J1050+5056                             | T8                     | Keck/NIRSPEC-J      | 1800                    | HD 99966                   | 2012 Jun 9               |
| WISE J1051-2138                             | T9:                    | Palomar/TSpec       | 1800                    | HD 91398                   | 2012 Jan 6               |
| WISE J1124-0421                             | T7                     | IRTF/SpeX           | 1680                    | HD 93346                   | 2012 Jan 31              |
| WISE J1143+4431                             | T8.5                   | Keck/NIRSPEC-J      | 2100                    | HD 99966                   | 2012 Jun 9               |
| WISE J1221-3136                             | T6.5                   | IRTF/SpeX           | 1440                    | HD 112305                  | 2012 May 13              |
| WISE J1225-1013                             | T6                     | IRTF/SpeX           | 1200                    | HD 101122                  | 2012 Jan 13              |
| WISE J1250+2628                             | T6.5                   | Keck/NIRSPEC-J      | 1440                    | HD 122945                  | 2012 Jun 8               |
| WISE J1257+4008                             | T7                     | IRTF/SpeX           | 1200                    | HD 109615                  | 2012 May 13              |
| WISE J1301-0302                             | T8.5                   | Keck/NIRSPEC-J      | 1440                    | HD 118054                  | 2012 Jun 9               |
| WISE J1318-1758                             | T9:                    | Palomar/TSpec       | 2400                    | HD 114243                  | 2012 Jan 6               |
| WISE J1337+2636                             | T5                     | Keck/NIRSPEC-J      | 1440                    | HD 122945                  | 2012 Jun 8               |
| WISE J1400-3850                             | T4                     | IRTF/SpeX           | 1440                    | HD 120486                  | 2012 Feb 13              |
| WISE J1517+0529                             | T8                     | Keck/NIRSPEC-J      | 2400                    | HD 140775                  | 2012 Apr 9               |
| WISE J1523+3125                             | T6.5 pec               | Gemini/GNIRS        | 2400                    | HD 136831                  | 2011 Jul 4               |
| WISE J1542+2230                             | T9.5                   | <i>HST</i> /WFC3    | 2012                    | ...                        | 2012 Mar 4               |
| WISE J1544+5842                             | T7.5                   | Keck/NIRSPEC-J      | 900                     | HD 143187                  | 2011 Aug 8               |
| WISE J1632+0329                             | T5                     | IRTF/SpeX           | 1200                    | HD 145647                  | 2011 Sep 11              |
| WISE J1636-0743                             | T4.5                   | IRTF/SpeX           | 1200                    | HD 148968                  | 2011 Aug 25              |
| WISE J1707-1744                             | T5:                    | Palomar/TSpec       | 3600                    | HD 131951                  | 2011 May 12              |
| WISE J1721+1117                             | T6                     | IRTF/SpeX           | 960                     | HD 167163                  | 2011 Aug 25              |
| WISE J1730+4207                             | T0 sb                  | IRTF/SpeX           | 1200                    | HD 174567                  | 2011 Jul 29              |
| WISE J1734+5023                             | T4                     | IRTF/SpeX           | 1200                    | HD 184195                  | 2011 Jul 29              |
| WISE J1736+6059                             | T8                     | Keck/NIRSPEC-J      | 1800                    | HD 172728                  | 2012 Sep 3               |

**Table 5**  
(Continued)

| Object Name<br>and J2000 Coordinates<br>(1) | NIR Sp.<br>Type<br>(2) | Spectrograph<br>(3) | Int. Time<br>(s)<br>(4) | Tell. Corr.<br>Star<br>(5) | Obs. Date<br>(UT)<br>(6) |
|---|------------------------|---------------------|-------------------------|----------------------------|--------------------------|
| WISE J1738+6142                             | extremely red          | Palomar/TSpec       | 1440                    | HD 143187                  | 2011 Jul 13              |
|   | extremely red          | IRTF/SpeX           | 1200                    | 55 Dra                     | 2012 Jul 23              |
| WISE J1741+1327                             | T5                     | IRTF/SpeX           | 1200                    | HD 167163                  | 2011 Aug 25              |
| WISE J1743+4211                             | T4.5                   | Palomar/TSpec       | 1200                    | HD 158261                  | 2011 May 12              |
| WISE J1745+6459                             | T7                     | Keck/NIRSPEC-J      | 1800                    | HD 172728                  | 2012 Jun 8               |
| WISE J1746-0338                             | T6                     | Palomar/TSpec       | 3600                    | HD 161868                  | 2011 May 13              |
| WISE J1755+1803                             | T2                     | Palomar/TSpec       | 720                     | HD 165029                  | 2011 Jul 13              |
| WISE J1759+5442                             | T7                     | Keck/NIRSPEC-J      | 1440                    | HD 172728                  | 2012 Jun 8               |
| WISE J1809-0448                             | T0.5                   | IRTF/SpeX           | 960                     | HD 167163                  | 2012 Jul 23              |
| WISE J1812+2007                             | T9                     | Keck/NIRSPEC-J      | 1800                    | HD 199217                  | 2012 Sep 3               |
| WISE J1813+2835                             | T8                     | Keck/NIRSPEC-J      | 1800                    | HD 165029                  | 2012 Jun 8               |
| WISE J1840+2932                             | T6                     | Keck/NIRSPEC-J      | 1800                    | HD 165029                  | 2012 Sep 3               |
| WISE J1909-5204                             | T5.5                   | Magellan/FIRE       | 720                     | HD 182000                  | 2012 Sep 5               |
| WISE J1913+6444                             | T5:                    | Palomar/TSpec       | 1800                    | HD 184195                  | 2011 Jul 13              |
| WISE J1928+2356                             | T6                     | IRTF/SpeX           | 1200                    | HD 192538                  | 2011 Sep 11              |
| WISE J1954+6915                             | T5.5                   | Keck/NIRSPEC-J      | 1440                    | HD 172728                  | 2012 Jun 9               |
| WISE J1955-2540                             | T8                     | Keck/NIRSPEC-J      | 1440                    | HD 190285                  | 2012 Jun 9               |
| WISE J2008-0834                             | T5.5                   | IRTF/SpeX           | 1200                    | HD 202990                  | 2011 Sep 11              |
| WISE J2014+0424                             | T6.5 pec               | Gemini/GNIRS        | 3600                    | HD 198070                  | 2011 Aug 28              |
| WISE J2015+6646                             | T8                     | Palomar/TSpec       | 2400                    | HD 214019                  | 2011 Jul 14              |
| WISE J2019-1148                             | T8:                    | Palomar/TSpec       | 2400                    | HD 202990                  | 2011 Jul 14              |
| WISE J2030+0749                             | T1.5                   | IRTF/SpeX           | 1200                    | HD 198070                  | 2011 Sep 11              |
| WISE J2043+6220                             | T1.5                   | IRTF/SpeX           | 720                     | HD 192538                  | 2012 May 28              |
| WISE J2123-2614                             | T5.5                   | IRTF/SpeX           | 1200                    | HD 202941                  | 2011 Aug 25              |
| WISE J2147-1029                             | T7.5                   | Keck/NIRSPEC-J      | 1400                    | HD 203769                  | 2012 Jun 9               |
| WISE J2236+5105                             | T5.5                   | Palomar/TSpec       | 1440                    | HD 223386                  | 2012 Jan 6               |
| WISE J2237+7228                             | T6                     | Keck/NIRSPEC-J      | 1200                    | HD 207636                  | 2011 Sep 8               |
| WISE J2301+0216                             | T6.5                   | IRTF/SpeX           | 1440                    | HD 215143                  | 2011 Sep 11              |
| WISE J2303+1914                             | T4:                    | Palomar/TSpec       | 1440                    | HD 209932                  | 2012 Jan 7               |
| WISE J2335+4222                             | T7                     | Keck/NIRSPEC-J      | 2400                    | HD 222749                  | 2011 Sep 5               |
|   | T7                     | Keck/NIRSPEC-H      | 1200                    | HD 222749                  | 2011 Sep 6               |
| WISE J2357+1227                             | T6                     | IRTF/SpeX           | 1200                    | HD 210501                  | 2011 Aug 25              |

**Notes.** Classification notes: “pec” - peculiar, “sb” - spectral binary, “:” - low S/N, “extremely red” - discussed in Section 4.2.

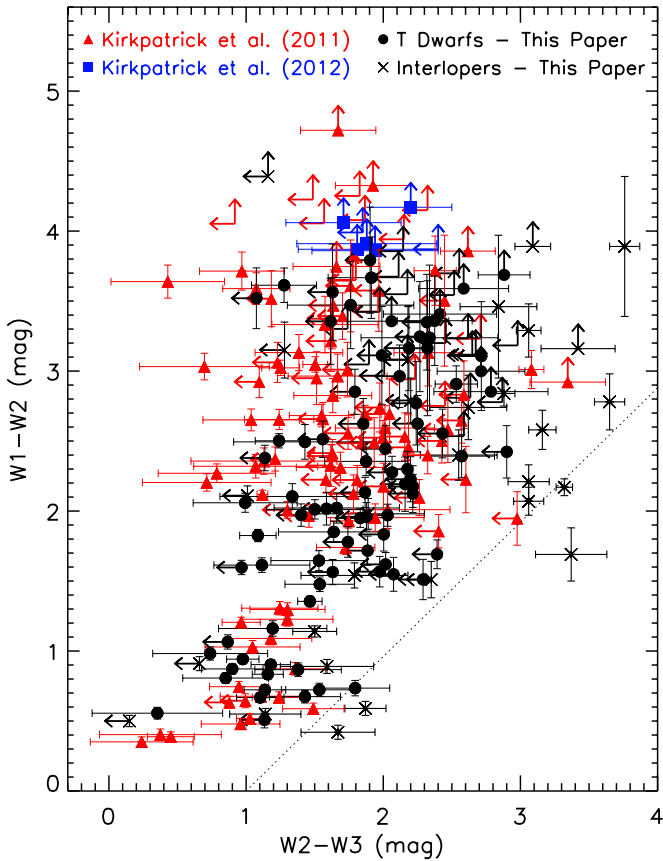
**Table 6**  
New Near-IR Spectroscopy and Spectral Classifications for Other Brown Dwarfs from the Literature

| Object Name<br>(1)       | NIR Sp.<br>Type<br>(2) | Spectrograph<br>(3) | Int. Time<br>(s)<br>(4) | Tell. Corr.<br>Star<br>(5) | Obs. Date<br>(UT)<br>(6) | Published<br>NIR Sp. Type<br>(7) | Discovery<br>Paper<br>(8) |
|--------------------------|------------------------|---------------------|-------------------------|----------------------------|--------------------------|----------------------------------|---------------------------|
| WISE J0920+4538          | L9 sb?                 | Palomar/TSpec       | 1440                    | HD 89239                   | 2012 Jan 7               | L4/5 Candidate                   | Aberasturi et al. (2011)  |
| ULAS J095047.28+011734.3 | T8                     | Magellan/FIRE       | 1080                    | HD 75159                   | 2012 May 5               | T8                               | Leggett et al. (2012)     |
| WISE J1246-3139          | T1                     | Palomar/TSpec       | 1440                    | HD 109134                  | 2012 Jan 7               | IR Source                        | Andrei et al. (2011)      |
| LHS 2803B                | T5.5                   | IRTF/SpeX           | 1440                    | HD 134013                  | 2012 May 13              | T5.5                             | Deacon et al. (2012)      |
| BD +01° 2920B            | T8                     | Magellan/FIRE       | 1440                    | HD 113147                  | 2012 May 5               | T8p                              | Pinfield et al. (2012)    |
| WISE J1449+1147          | T5 pec                 | Palomar/TSpec       | 3600                    | HD 131951                  | 2011 May 12              | T7 Candidate                     | Scholz (2010)             |
|                          | T5 pec                 | Gemini/GNIRS        | 2400                    | HD 147295                  | 2011 Jul 4               | ...                              | ...                       |
| PSO J226.2599-28.8959    | T2:                    | Palomar/TSpec       | 2400                    | HD 133652                  | 2011 May 13              | T1.5                             | Deacon et al. (2011)      |
| VHS J154352.78-043909.6  | T5:                    | IRTF/SpeX           | 720                     | HD 148968                  | 2011 Aug 25              | T4.5                             | Lodieu et al. (2012)      |
| PSO J246.4222+15.4698    | T4.5:                  | Palomar/TSpec       | 2400                    | HD 145122                  | 2011 May 13              | T4.5                             | Deacon et al. (2011)      |
| PSO J247.3273+03.5932    | T2                     | Palomar/TSpec       | 2400                    | HD 140775                  | 2011 May 13              | T2                               | Deacon et al. (2011)      |
| WISE J1717+6129          | T8                     | Gemini/GNIRS        | 2400                    | HD 199217                  | 2011 Jun 14              | T8:                              | Kirkpatrick et al. (2011) |
| WISE J1809+3838          | T7.5                   | IRTF/SpeX           | 1800                    | HD 174567                  | 2011 Jul 28              | T7                               | Luhman et al. (2012)      |
| WISE J2342+0856          | T6.5                   | IRTF/SpeX           | 1920                    | HD 210501                  | 2011 Sep 11              | T7 Candidate                     | Scholz (2010)             |
| WISE J2344+1034          | T9                     | Gemini/GNIRS        | 6600                    | HD 222749                  | 2011 Jun 15              | T9:                              | Kirkpatrick et al. (2011) |

**Notes.** Classification notes: “pec” - peculiar, “sb?” - possible spectral binary “:” - low S/N.

detail in Kirkpatrick et al. (2011, 2012). The analysis by Kirkpatrick et al. (2012) of the low-mass end of the field brown dwarf mass function used objects observed prior to 2012 May 1 (UT) and spectral types for WISE J152305.10+312537.6,

WISE J180901.07+383805.4, WISE J201404.13+042408.5, and WISE J201920.76-114807.5 have been adjusted by half spectral types in this paper. An improved spectrum of the T9 dwarf WISE J033515.01+431045.1 has increased the



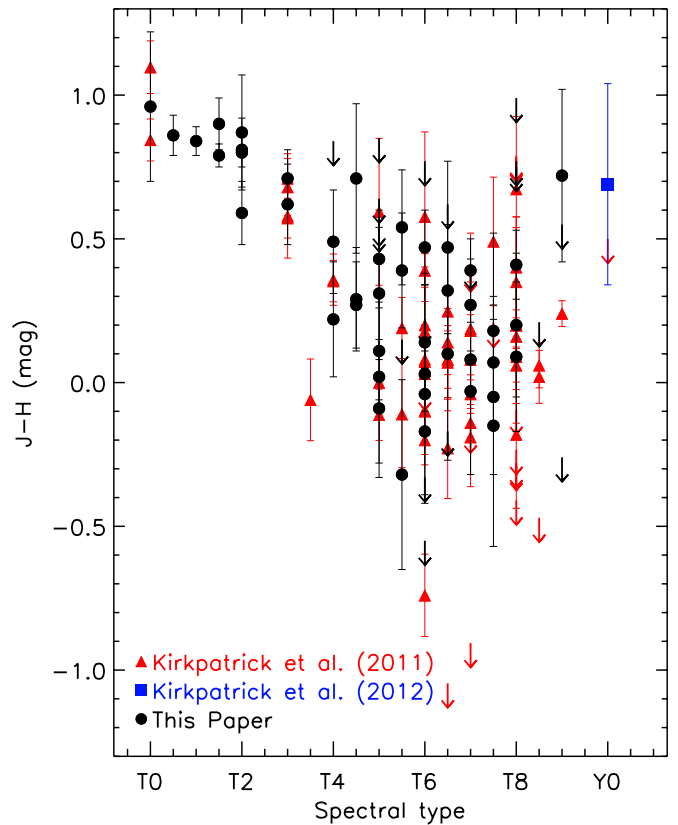
**Figure 3.** WISE  $W1 - W2$  vs.  $W2 - W3$  color-color diagram. Same symbols as in Figure 1. Interlopers are marked by black x's and limits. The dotted line identifies our  $W1 - W2 > 0.96(W2 - W3) - 0.96$  selection criterion.

(A color version of this figure is available in the online journal.)

precision of the spectral type provided by Kirkpatrick et al. (2012).

No changes were made in our procedures for spectra acquired with SpeX (Rayner et al. 2003) at NASA's Infrared Telescope Facility (IRTF), the Triple Spectrograph (TSPEC; Herter et al. 2008) at Palomar Observatory, or the Wide Field Camera 3 (WFC3; Kimble et al. 2008) onboard the *Hubble Space Telescope* (*HST*). Non-peculiar T dwarf spectra from SpeX and TSPEC are sorted by spectral type (see Section 4.1 for classification procedure) and shown in Figures 9 and 10, respectively. Figure 11 shows the WFC3 confirmed T9.5 dwarf WISE J154214.00+223005.2.

We spectroscopically confirmed seven of our candidates employing the Gemini Near-Infrared Spectrograph (GNIRS; Elias et al. 2006) at the Gemini-North Telescope on Mauna Kea, HI. We used the cross-dispersed mode with the 32 lines  $\text{mm}^{-1}$  grating and a  $1''$  wide slit which provided an R of 540 over the  $0.8\text{--}2.5\ \mu\text{m}$  wavelength range. A series of 300 s exposures were obtained at two positions along the  $7''$  long slit. An A0 V standard star was obtained either before or after each science target for telluric correction and flux calibration purposes. The data were reduced with a modified version of the Spextool data reduction package (Cushing et al. 2004). The raw frames were first cleaned of fixed patterns using the `cleanir.py` routine provided by Gemini Observatory. A normalized flat-field image was then generated using the nightly calibration frames. Pairs of images taken at two different positions along the slit were then pair-subtracted and flat-fielded. The spectra



**Figure 4.**  $J - H$  color vs. spectral type. Same symbols as in Figure 1. A turnaround in the  $J - H$  color at  $T7 \pm 1$  is seen here, but it is tentative based on the large dispersion and uncertainties in our photometry.

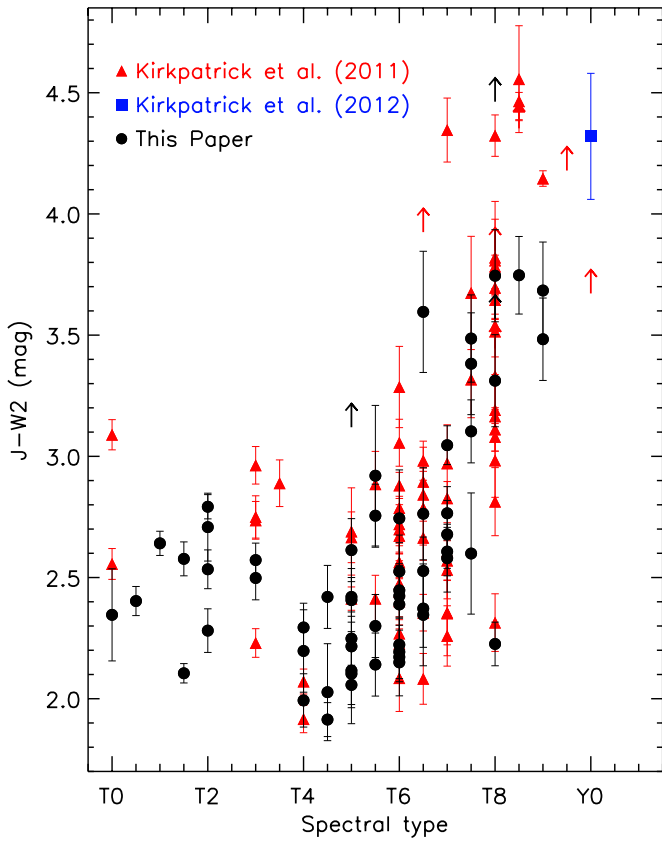
(A color version of this figure is available in the online journal.)

were then extracted after subtracting off residual background and wavelength calibrated using the night sky OH emission lines. The raw spectra were corrected for telluric absorption using the spectra of the associated A0 V standard star and the technique described in Vacca et al. (2003). Finally the spectra from the individual orders were merged to produce a continuous  $0.8\text{--}2.4\ \mu\text{m}$  spectrum. The GNIRS spectra of our new T dwarfs are shown in Figure 10 and are colored blue to differentiate them from the other instruments.

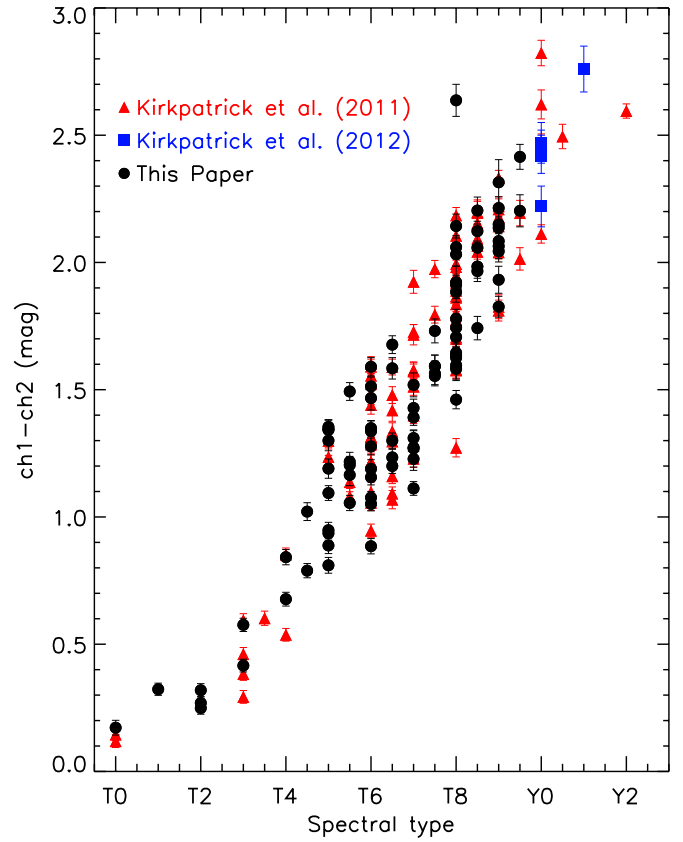
Since the publication of Kirkpatrick et al. (2011), the reduction procedure has changed for spectra from the Folded-port Infrared Echelle (FIRE; Simcoe et al. 2008, 2010) instrument at the 6.5 m Walter Baade Telescope on Cerro Manqui at the Las Campanas Observatory, Chile. FIRE reductions in this paper make use of the FIREHOSE package for low-dispersion data following the procedure in the online “cookbook.”<sup>21</sup> The FIREHOSE package uses NeAr arc lines for the calibrator, and OH sky emission lines for target wavelength solutions. For our faintest objects, pair subtraction of the 2-D spectra prior to insertion into the pipeline greatly improved the accuracy of the bspline sky-line fitting procedure. Although the automated continuum fitting worked well for most of our targets, the faint sources required manual selection of the continuum position when sky-lines were poorly subtracted. Spectra were extracted using the optimal spectral extraction process, where an iterative, local background model is fit to improve estimates of the sky flux for subtraction. The combined spectrum was then corrected for telluric absorption and flux calibrated using the observations

<sup>21</sup> See [http://www.mit.edu/people/rsimcoe/FIRE/ob\\_data.htm](http://www.mit.edu/people/rsimcoe/FIRE/ob_data.htm) for details.

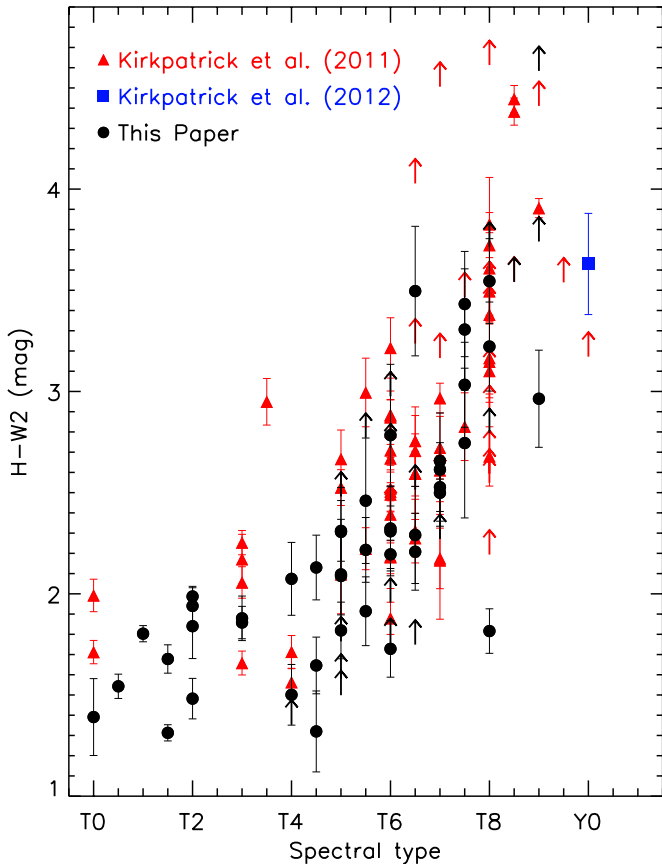




**Figure 5.**  $J - W2$  color vs. spectral type. Same symbols as in Figure 1. (A color version of this figure is available in the online journal.)



**Figure 7.** *Spitzer*  $ch1 - ch2$  vs. spectral type. Same symbols as in Figure 1. These colors can nearly be fit by a straight line, but the early-type T dwarfs are all bluer than the fit. (A color version of this figure is available in the online journal.)



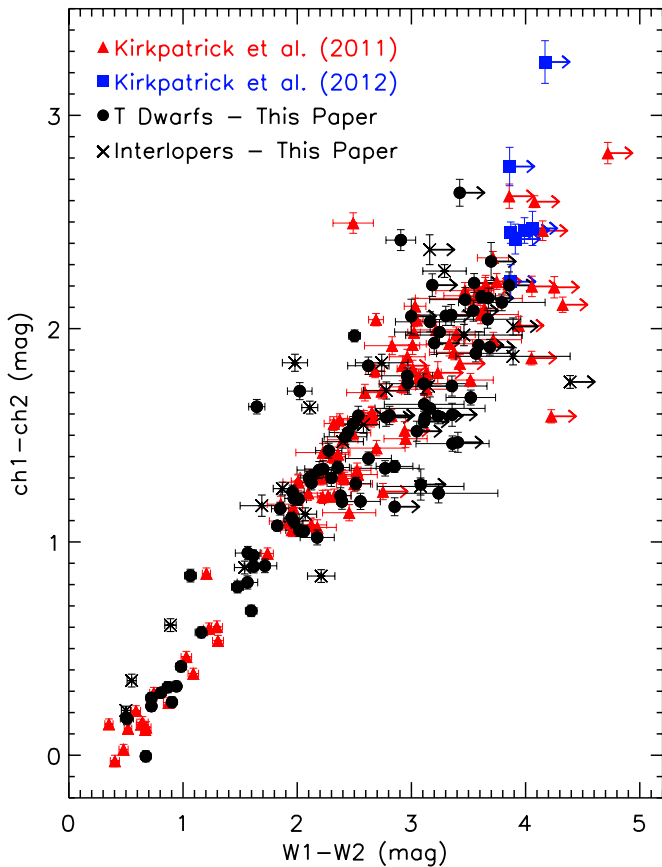
**Figure 6.**  $H - W2$  color vs. spectral type. Same symbols as in Figure 1. (A color version of this figure is available in the online journal.)

of an A0 V star and the technique described in Vacca et al. (2003) and the XTELLCOR program from SpeXtool (see Cushing et al. 2004). FIRE spectra are presented in Figure 10 and are colored red to differentiate them from the other instruments.

Observations with the Near-Infrared Spectrometer (NIRSPEC; McLean et al. 1998, 2000) at the 10 m W. M. Keck Observatory on Mauna Kea, HI, were made with slit widths of  $0''.38$ ,  $0''.57$ , or  $0''.76$  to reduce slit-loss for specific seeing conditions. These slit widths result in spectral resolutions at  $1.27 \mu\text{m}$  of  $R \sim 2250$ , 1500, and 1100, respectively. After being confirmed in our  $J$ -band (N3) observations, two of our new T dwarfs were observed with the  $H$ -band (N5) filter with a  $0''.76$  slit ( $R \sim 1400$  at  $1.58 \mu\text{m}$ ). Observations from multiple epochs used the same instrument configurations and were combined into a single spectrum. Data reduction made use of the publicly available REDSPEC package, with modifications to remove residuals from the sky-subtracted pairs prior to 1-D spectral extraction. Normalized Keck/NIRSPEC  $J$ -band spectra are shown in Figure 12, and objects with both  $J$ - and  $H$ -band observations are shown in Figure 13. The  $H$ -band spectra were scaled relative to the  $J$ -band data using the ratio of peak fluxes produced by REDSPEC (McLean et al. 2003).

#### 4. T DWARF SPECTRAL ANALYSIS

After collecting near-IR spectra for each candidate we determined spectral types through comparison to the spectral standards (Burgasser et al. 2006b; Cushing et al. 2011). Some of the objects are noteworthy for their peculiarity. Fourteen of our candidates have been published by others since we first identified



**Figure 8.** *Spitzer*  $ch1 - ch2$  vs. *WISE*  $W1 - W2$  color-color diagram. Same symbols as in Figure 1. Interlopers are marked by black x's and limits. (A color version of this figure is available in the online journal.)

or confirmed them, and we discuss each one individually. For all the T dwarfs presented here and in Kirkpatrick et al. (2011), as well as the Y dwarfs from Cushing et al. (2011) and Kirkpatrick et al. (2012), we derive spectral indices using the median flux method.

#### 4.1. Spectral Classification

We derived the spectral types for each of our near-IR spectra by visual comparison to the T0-to-T8 spectral standards of Burgasser et al. (2006b) and the T9 and Y0 standards defined by Cushing et al. (2011). Classifications are based on the complete near-infrared flux when it is available. Normalization at  $\sim 1.27 \mu\text{m}$  makes the *J*-band morphology the easiest to compare to the standards and emphasizes peculiarities in the *Y*, *H*, and *K* bands. Half spectral types are assigned where the spectrum falls consistently between two adjacent spectral standards. In cases where the spectrum deviates from the standards in a way that is inconsistent with the spectral sequence (e.g., the *J* band is narrower than a T7 and wider than a T8, but the *H*- and *K*-band fluxes are consistent with a T6) we have identified these objects as peculiar. We identify spectral types of low S/N spectra with “:” to indicate that they are more uncertain than the standard  $\pm 0.5$  type uncertainty. The extremely red brown dwarfs defy classification and are discussed in detail in Section 4.2. Our binary candidates are given spectral types and marked as “sb” to denote that they are peculiar and best matched with combined spectral templates. Assigned spectral types for all the objects in Table 2 are listed in column 2 of Tables 5 and 6.

#### 4.2. Are the Extremely Red Brown Dwarfs L or T Type?

The T dwarf spectral standards from Burgasser et al. (2006b) were chosen for their progressively stronger  $\text{H}_2\text{O}$  and  $\text{CH}_4$  absorption features throughout the near-infrared. It is the  $\text{CH}_4$  features in T dwarfs like the prototype Gl 229B (Geballe et al. 1996) that makes these objects stand apart from L dwarfs. Kirkpatrick et al. (2010) outlined the procedure for defining a near-infrared L dwarf sequence that varies smoothly between spectral types and is tied closely with the optical spectral types. For this L dwarf sequence, spectra are normalized at the *J*-band flux peak ( $\sim 1.27 \mu\text{m}$ ) and the type is determined from only the  $0.9\text{--}1.4 \mu\text{m}$  spectral shape. From this initial classification, the spectral morphology from  $1.4\text{--}2.5 \mu\text{m}$  identifies the source as either “red” or “blue” relative to the spectral standard. Based on these systems, we have identified three objects (WISE J064205.58+410155.5, WISE J075430.95+790957.8, and WISE J173859.27+614242.1) that defy classification.

As the number of red L dwarfs with near-IR spectra has increased, classification and physical interpretation of the spectra has become more complicated. Many of the known red L dwarfs are early-type and have accompanying optical spectra to facilitate classification and analysis (Looper et al. 2008; Kirkpatrick et al. 2006, 2010). At later spectral types, L dwarf *J - K* colors redden by nearly 1.5 mag relative to L0's (as cloud opacity increasingly dominates at shorter wavelengths) and the red L dwarfs mark the upper boundary of these colors (Gizis et al. 2012, Figure 4). Recently, as a result of 2MASS proper motion surveys and the *WISE* mission, the sample of red, late-type L dwarfs has been expanded (Kirkpatrick et al. 2011; Gizis et al. 2012). Since the reddest L dwarfs are a few magnitudes fainter at visible wavelengths, high-quality optical spectra of these objects are rare.

Infrared spectra of red L dwarfs are primarily influenced by temperature, metallicity, and gravity differences, but also by possible binarity and cloud morphology. Looper et al. (2008) discuss the influence of low surface gravity and high metallicity on reddening near-IR colors, and the unlikely reddening from binarity and interstellar extinction. Allers et al. (2010, Figure 3) show how dust and low surface gravity alters near-IR spectra for adjacent spectral types. Other extremely red objects, like 2MASS J035523.37+113343.7 (Faherty et al. 2013), 2MASS 1207b (Patience et al. 2010; Barman et al. 2011a) and the HR 8799 planets (Bowler et al. 2010; Barman et al. 2011b; Marley et al. 2012) have low surface gravity, appear to be dusty, resemble the L dwarf standards, and lack the methane features of T dwarfs. Gizis et al. (2012) present an extremely red L dwarf (WISEP J004701.06+680352.1) that they can best classify as an L7.5pec based on rough comparison to the spectral standards and other red L dwarfs in the literature, but they also discuss the difficulty in determining spectral types and estimating surface gravities for such red sources, which may not be very young. The extremely red objects shown in this paper do not show the “peakiness” associated with youth, but instead display a broader plateau in the *H* band, and are most similar to WISEP J0047+6803 and 2MASSW J2244316+204343 (Dahn et al. 2002; McLean et al. 2003; Looper et al. 2008).

WISE J0754+7909 is the least red of the three new objects. Figure 14 shows the Palomar/TSpec spectrum of this object along with the L9 and T2 spectral standards. Comparison to the L9 standard produces the best match to the integrated flux, but poorly matches the  $\text{H}_2\text{O}$  and  $\text{CH}_4$  absorption depths. Classification based solely on the *J*-band peak, as was done by Kirkpatrick et al. (2010), pushes the classification of this

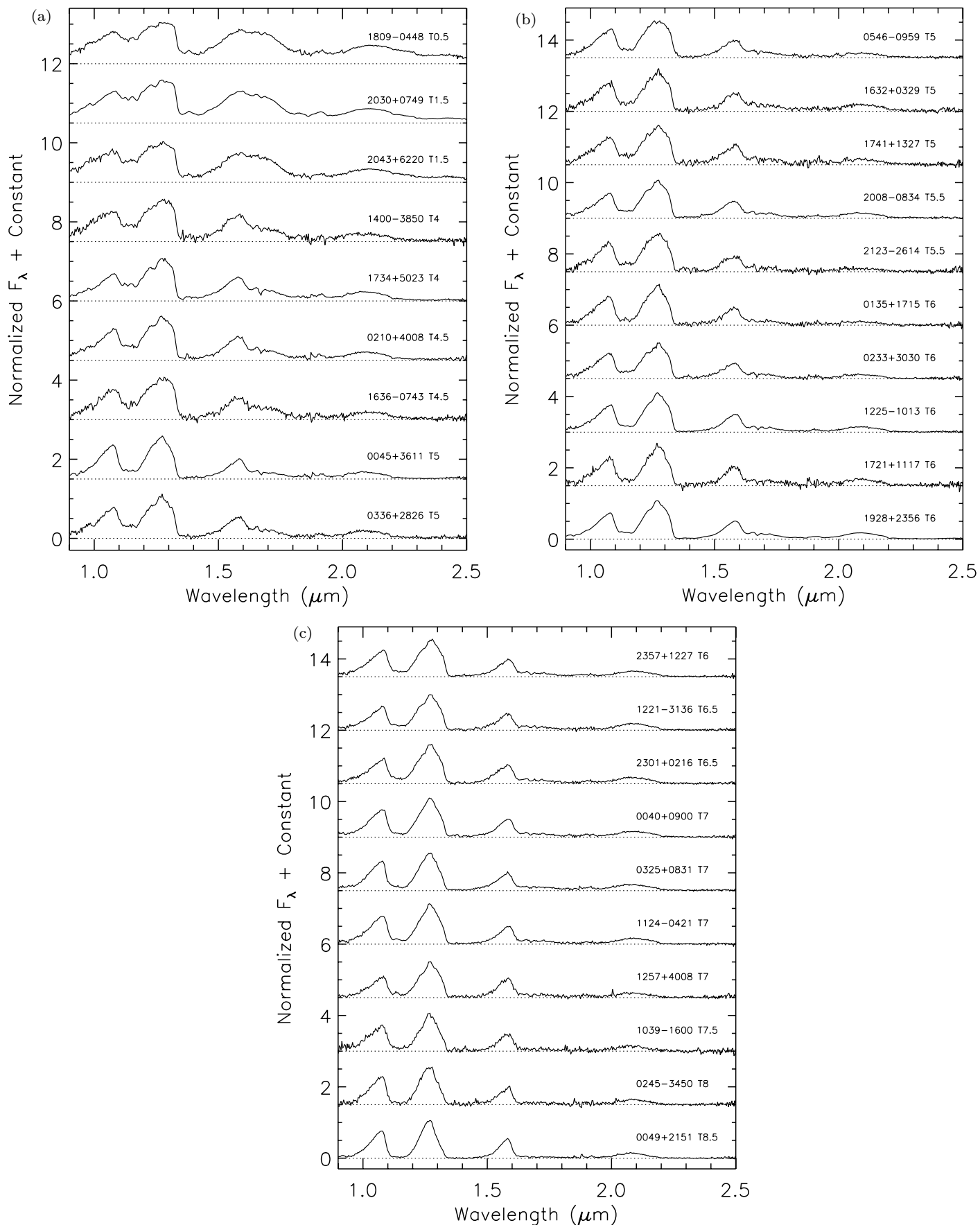
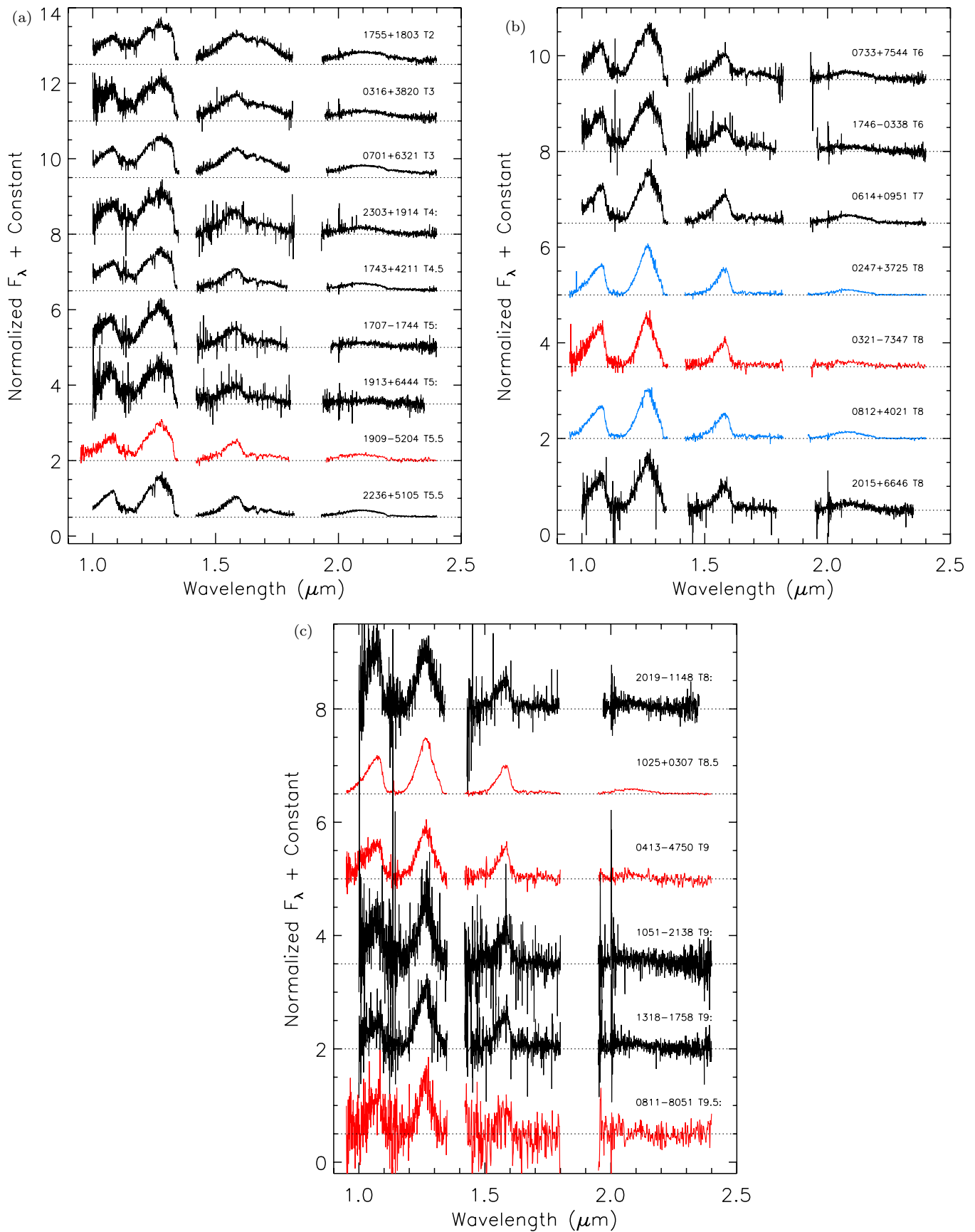
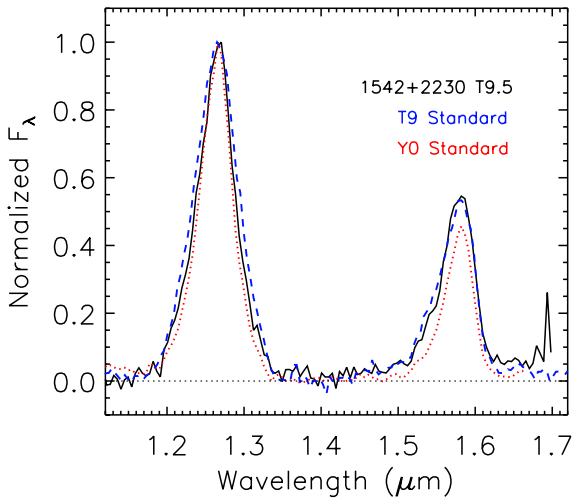


Figure 9. IRTF/SpEx spectra of confirmed *WISE* brown dwarfs with spectral types from T0.5 to T8.5. Spectra have been normalized at  $1.27 \mu\text{m}$  and offset vertically.



**Figure 10.** Other spectra of confirmed *WISE* brown dwarfs with spectral types from T2 to T9.5. Spectra have been normalized at  $1.27 \mu\text{m}$  and offset vertically. Palomar/TSpec spectra are shown in black, Magellan/FIRE spectra in red, and Gemini/GNIRS spectra in blue.

(A color version of this figure is available in the online journal.)



**Figure 11.** The *HST*/WFC3 spectrum of WISE J154214.00+223005.2 (T9.5). The T9 (UGPS J072227.51–054031.2) and Y0 (WISEP J173835.52+273258.9) spectral standards (Cushing et al. 2011) are included for comparison. Spectra have been normalized at 1.27  $\mu\text{m}$ .  
(A color version of this figure is available in the online journal.)

object into the T sequence. However, given the noise of this spectrum it is difficult to fully identify  $\text{CH}_4$  features, ruling out its classification as a T dwarf using the scheme of Burgasser et al. (2006b). Near-IR colors for this object are consistent with the T2 classification and *WISE* colors are similar to sources at the L/T transition. However, this object is blended in the *Spitzer* images with a source that is not visible in our near-IR imaging, so *WISE* and *Spitzer* colors should be used cautiously.

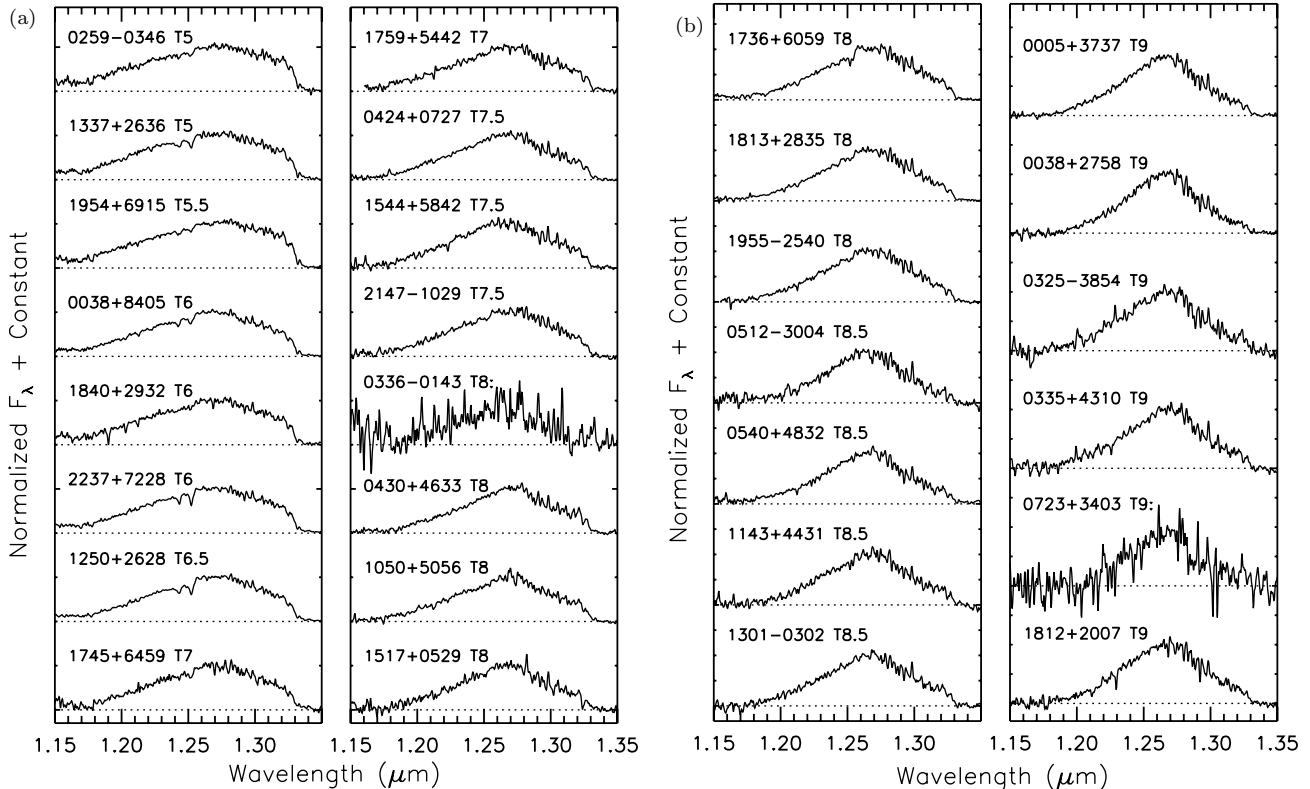
Burgasser et al. (2010) used the SpeX Prism Library to identify possible binary systems based on the composite of L

and T dwarf spectra. Using the same analysis, we find that WISE J0754+7909 is poorly matched by composite spectra and is likely not a binary. The spectrum of SDSS J1516+3053 is also included in Figure 14 since it matches the spectrum of WISE J0754+7909 well at shorter wavelengths. SDSS J151643.01+305344.4 has been classified as a  $\text{T}0.5 \pm 1$  (Chiu et al. 2006) and  $\text{T}1.5 \pm 2$  (Burgasser et al. 2010), and is a weak binary candidate based on their analysis. The large uncertainties in the SDSS J1516+3053 classifications are due to the difficulty in classifying this source using the methods in the literature.

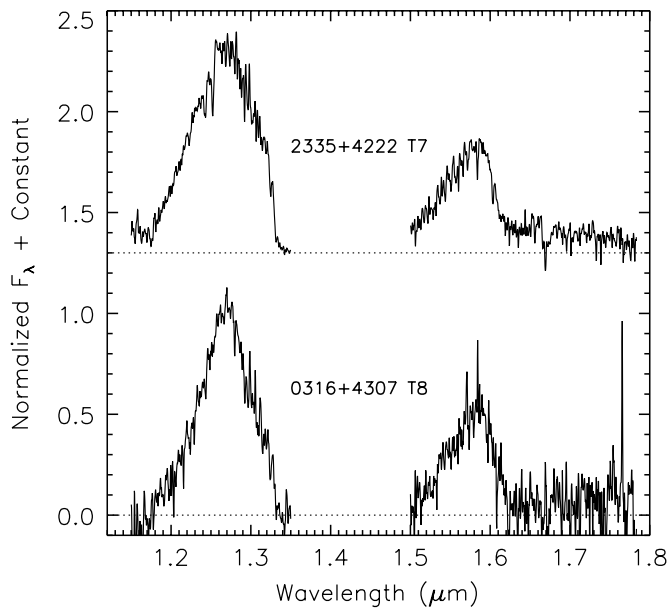
The Palomar/TSpec spectrum of WISE J0642+4101 is shown in Figure 15 with the L9 and T2 spectral standards. Just like WISE J0754+7909, classification of this object based on the *J* band only requires that we classify this object as a T dwarf. However, there is a clear absence of  $\text{CH}_4$  in this spectrum. Compared to SDSS J1516+3053, WISE J0642+4101 is significantly redder. The red  $\text{L}7.5 \pm 2$  dwarf 2MASS J2244+2043 is one of the reddest late-type L dwarfs and is very similar to WISEP J0047+6803 (L7.5pec; Gizis et al. 2012). Figure 15 shows that WISE J0642+4101 is nearly as red as 2MASS J2244+2043 in the *H* band, but has a significantly lower *K*-band flux.

The reddest object that we have identified, WISE J1738+6142, is shown in Figure 16. We observed this object with Palomar/TSpec on 2011 July 13 (UT) and with IRTF/SpeX on 2012 July 23 (UT). Although the Palomar/TSpec spectrum is noisy, comparison of these two spectra reveals that the near-infrared flux of WISE J1738+6142 is extremely variable.<sup>22</sup> Photometry of this object from PAIRITEL produces  $J - K_s = 2.55 \pm 0.16$ , which is equivalent with the extremely red L

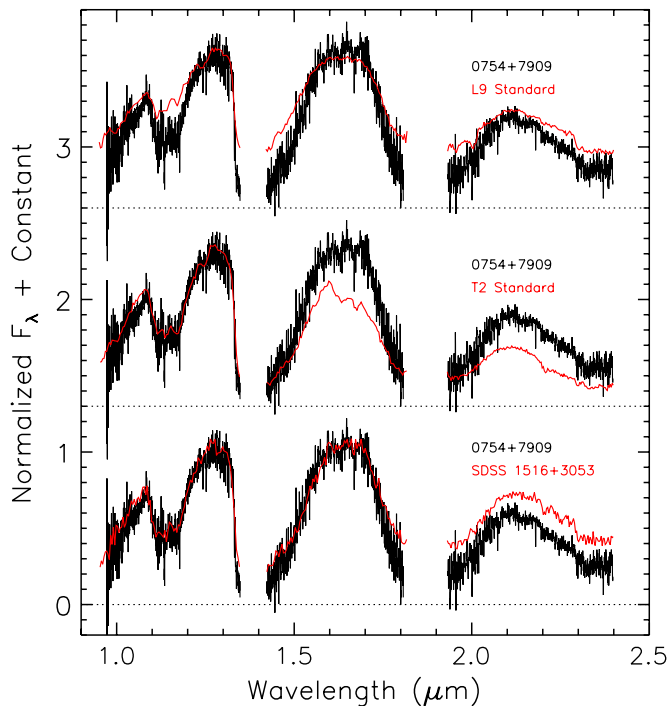
<sup>22</sup> The airmass of each A0 standard was less than 0.05 away from the mean value for WISE J1738+6142.



**Figure 12.** Keck/NIRSPEC *J*-band spectra of confirmed *WISE* brown dwarfs with spectral types from T5 to T9. Spectra have been normalized at 1.27  $\mu\text{m}$  and offset vertically.



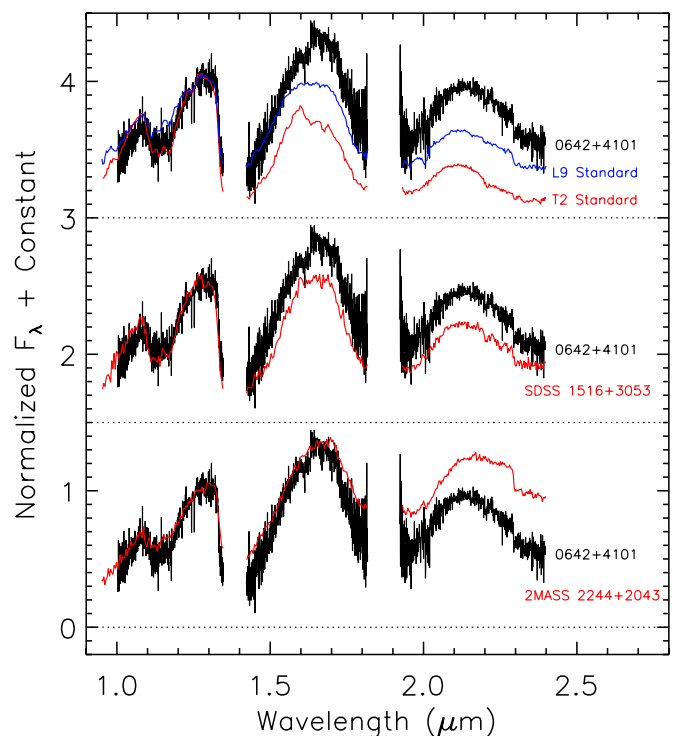
**Figure 13.** Keck/NIRSPEC *J*- and *H*-band spectra of confirmed *WISE* brown dwarfs WISE J233543.79+422255.2 (T7) and WISE J031624.35+430709.1 (T8). Spectra have been normalized at 1.27  $\mu\text{m}$  and offset vertically. The *H*-band spectra were scaled relative to the *J*-band data using the ratio of peak fluxes produced by REDSPEC (McLean et al. 2003).



**Figure 14.** This Palomar/TSpec spectrum of WISE 0754+7909 is not easily classified as a L or T dwarf. SDSS J1516+3053 has been classified as a T0.5  $\pm$  1 (Chiu et al. 2006) and T1.5  $\pm$  2 (Burgasser et al. 2010) and is a better match in the *J* and *H* bands than the spectral standards. Spectra have been normalized at 1.27  $\mu\text{m}$  and offset vertically.

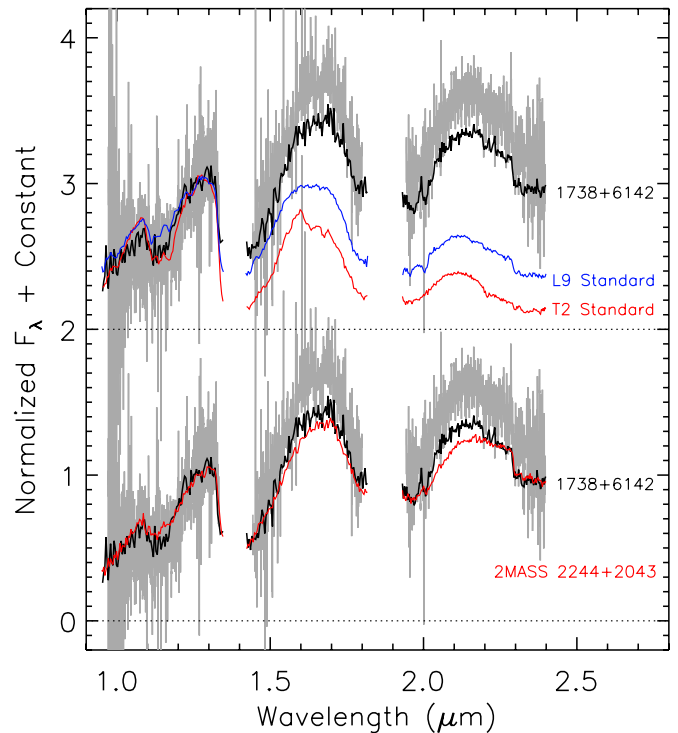
(A color version of this figure is available in the online journal.)

dwarf WISE J0047+6803. The *WISE*  $W1 - W2 = 0.72 \pm 0.04$  color for this source is slightly redder than the similar red L dwarfs WISEP J0047+6803 ( $W1 - W2 = 0.65 \pm 0.03$ ) and 2MASS J2244+2043 ( $W1 - W2 = 0.67 \pm 0.03$ ). Comparison of the WISE J1738+6142 IRTF/SpeX spectrum to 2MASS J2244+2043 reveals excess flux on the blue side of the *H* and



**Figure 15.** This Palomar/TSpec spectrum of WISE 0642+4101 is not easily classified as a L or T dwarf. It is redder than SDSS J1516+3053 (T1.5  $\pm$  2; Burgasser et al. 2010) and bluer than 2MASSW J2244+2043 (L7.5  $\pm$  2;Looper et al. 2008). Spectra have been normalized at 1.27  $\mu\text{m}$  and offset vertically.

(A color version of this figure is available in the online journal.)



**Figure 16.** WISE 1738+6142 was observed with both Palomar/TSpec (gray) and IRTF/SpeX (black). If it is actually an L dwarf, it is the reddest one known and shows substantial variability. 2MASSW J2244+2043 (L7.5  $\pm$  2; Looper et al. 2008) is similar to this object, but not as red. Excess flux in the *H* and *K* bands may hint at a T dwarf companion or the presence of CH<sub>4</sub> in this extremely red object. Spectra have been normalized at 1.27  $\mu\text{m}$  and offset vertically.

(A color version of this figure is available in the online journal.)

*K* bands, possibly hinting at the presence of a T dwarf secondary. Since the red L dwarf phenomenon is not entirely understood, having a coeval T dwarf companion with similar metallicity or low gravity indicators will help reveal the cause of the cloudiness in the L dwarfs, should any of these extremely red objects prove to be an L+T binary.

Although gravity, metallicity, and temperature changes are the primary variables in modeling these red objects, the variability seen in WISE J1738+6142 hints at considerably rapid changes in atmospheric conditions. If we assume that the source of reddening is common to all these objects, then surface gravity and metallicity are not likely the mechanisms at work. The proper motions of these three objects, determined by comparing 2MASS and WISE coordinates [WISE J0642+4101 ( $0''.37 \pm 0''.03 \text{ yr}^{-1}$ ), WISE J0754+7909 ( $0''.43 \pm 0''.04 \text{ yr}^{-1}$ ), and WISE J1738+6142 ( $0''.28 \pm 0''.04 \text{ yr}^{-1}$ )] are consistent with the red L dwarfs from Kirkpatrick et al. (2010) that are likely part of an older field population. This is inconsistent with either high metallicity or low gravity. Although analysis of the underlying physical mechanisms will require detailed analysis and modeling of higher resolution optical and near-IR spectroscopy, identifying companions to these red objects and disentangling their spectral features are good initial tests. We believe that further analysis (i.e., optical spectroscopy, high-resolution imaging, and time domain observations) are warranted before final classifications are made for these extremely red objects at the L/T transition.

#### 4.3. Comments on Interesting T Dwarf Discoveries

In the following subsection we discuss the peculiar objects individually, along with noteworthy objects that warrant separate discussion.

##### 4.3.1. WISE J0336–0143—T8

This object is a clear outlier in Figure 7 ( $ch1 - ch2 = 2.64 \pm 0.06$ ) and is undetected in the WISE W1 filter ( $W1 - W2 > 3.42$ ). These colors are more consistent with a Y dwarf than a T8, but the Keck/NIRSPEC *J*-band spectrum is broad. WISE J0336–0143 may be a T+Y binary, with the Y dwarf contributing more flux at the WISE passbands than in the near-IR bands. Follow-up photometry and broader near-IR spectroscopy of this source are warranted.

##### 4.3.2. WISE J0413–4750—T9

The A nod position of the pair subtracted 2-D spectra for this source was contaminated by a galaxy. The spectrum of the galaxy was extracted from the B-position images and fit with a line. This linear fit was then subtracted from the final extracted spectrum of WISE J0413–4750, which is shown in Figure 10.

##### 4.3.3. WISE J0629+2418—T2 sb

The IRTF/Spex spectrum for this object is presented in Figure 17 along with the T2 standard, which is the best overall match to the CH<sub>4</sub> and H<sub>2</sub>O absorption troughs. Relative to the T2 standard, the *H* band is wider and displays greater CH<sub>4</sub> absorption redward of the flux peak and the *K*-band flux is high. Using the statistical method described by Burgasser et al. (2010) we identify WISE J0629+2418 as a strong binary candidate with a  $L7 \pm 1$  primary and  $T5.5 \pm 0.5$  secondary ( $\Delta J_{\text{MKO}} = 0.47 \pm 0.28$ ,  $\Delta H_{\text{MKO}} = 1.67 \pm 0.30$ ). The best composite match to WISE J0629+2418 is also shown in Figure 17.

##### 4.3.4. WISE J1523+3125—T6.5 pec

Figure 18 shows the Gemini/GNIRS spectrum for this object. Comparison to the T6 standard produces the best match to the *H*-band flux, while the *J* band is better matched by the T7 standard. The *Y*- and *K*-band fluxes are inconsistent with the standards. These features are similar to the metal-poor T dwarfs 2MASS J0937347+293142 (T6pec; Burgasser et al. 2002) and BD +01° 2920B (T8pec; Pinfield et al. 2012). However, we also observed BD +01° 2920B (Section 4.4.5) and find that, other than a suppressed *K* band, it matches the T8 standard well and we do not classify it as peculiar.

##### 4.3.5. WISE J1542+2230—T9.5

The *HST*/WFC3 spectrum for this object is shown in Figure 11, compared to the T9 and Y0 spectral standards from Cushing et al. (2011). WISE J1542+2230 has a measured F140W(Vega) magnitude of 20.3. Located 2'' west is a neighbor that has a measured F140W(Vega) magnitude of 22.8. The slitless grism image of this field revealed that the neighbor has a flux peak coincident with the *H*-band flux peak in cool brown dwarfs, however we detect no flux in the *J*-band opacity window at 1.27  $\mu\text{m}$ . Additional high-resolution images of WISE J1542+2230 were obtained using the Keck II LGS-AO system (Wizinowich et al. 2006; van Dam et al. 2006) with NIRC2 on 2012 April 14 (UT). Very good seeing ( $\approx 0''.3$ ) and clear skies allowed us to use the relatively faint ( $R = 18.5$ ) USNO-B star 1124-0287738 (Monet et al. 2003) as the tip-tilt reference star. Observations were obtained in the MKO *H* filter with the wide camera (nominal plate scale 40 mas pixel<sup>-1</sup>) on NIRC2. Twenty-one frames with durations of 120 s each were collected using a 3 point dither pattern that was repeated seven times with position offsets 1''.5–5''. The images were dark subtracted, flat-fielded, shifted to a common grid, and median averaged to make a single mosaic image with a total exposure time of 42 minutes in the central region. From this imaging we measured the proper motion of WISE J1542+2230 to be  $\mu_{\alpha} = -0.82 \pm 0.07 \text{ arcsec yr}^{-1}$  and  $\mu_{\delta} = -0.41 \pm 0.06 \text{ arcsec yr}^{-1}$ , while the neighbor remained stationary, thus ruling out binarity.

##### 4.3.6. WISE J1730+4207—T0 sb

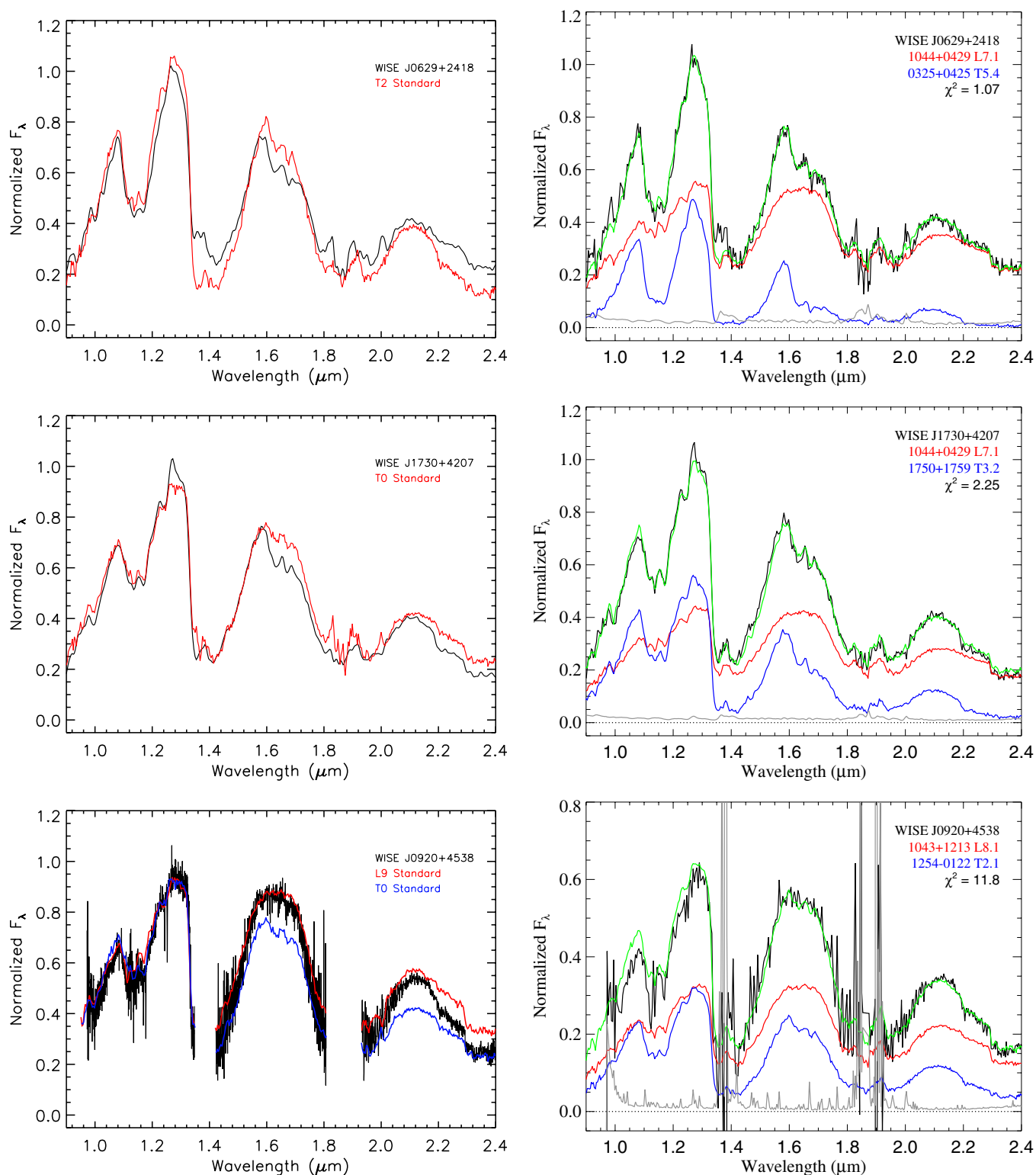
This object's spectrum is very similar to WISE 0629+2418 (Section 4.3.3), with the integrated flux most similar to the T0 standard (see Figure 17). This source is matched well by a composite of  $L7.5 \pm 1$  and  $T3 \pm 1$  spectra. With  $\Delta J_{\text{MKO}} = -0.31 \pm 0.27$  and  $\Delta H_{\text{MKO}} = 0.38 \pm 0.36$ , this system is likely a flux-reversal binary. The best composite match to WISE J1730+4207 is also shown in Figure 17, and is well within the uncertainties of the average fit  $L7.5+T3$ .

##### 4.3.7. WISE J2014+0424—T6.5 pec

Much like WISE J1523+3125 (Section 4.3.4), comparison to the T6 standard produces the best match to the *H*-band flux, while the *J* band is better matched by the T7 standard. The *Y*- and *K*-band fluxes are inconsistent with the standards. Figure 18 shows the Gemini/GNIRS spectrum for this object.

#### 4.4. Comments on Known and Candidate Brown Dwarfs in the Literature

Some of our candidates were identified and/or confirmed but subsequently published by others as independent discoveries. Table 6 lists these objects along with their discovery papers and



**Figure 17.** Binary candidates identified using the method of Burgasser et al. (2010). The left side shows the best matching spectral standard and the right side shows the best composite spectrum (green), along with the constituent templates. Spectra have been normalized at  $1.27 \mu\text{m}$  and offset vertically.

(A color version of this figure is available in the online journal.)

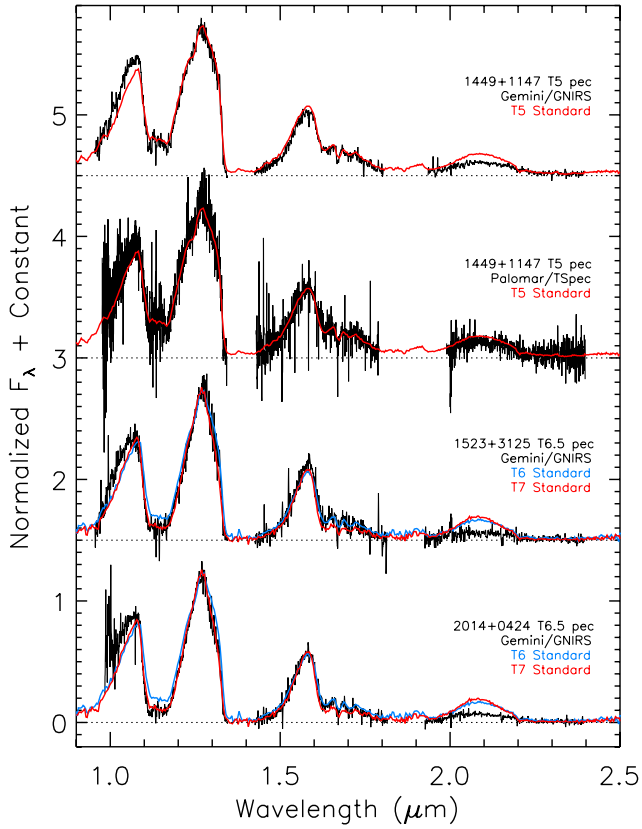
previous spectral classifications. Spectra for these objects are shown in Figure 19 unless noted otherwise.

#### 4.4.1. WISE J0920+4538—L9 sb?

Aberasturi et al. (2011) performed a cross correlation of the 2MASS Point Source, SDSS Data Release 7, and WISE

Preliminary Release Catalogs to identify six brown dwarf candidates based on photometric colors and proper motion. Based on a temperature derived from spectral energy distribution fitting, they estimated the spectral type of this object as L4 or L5. However, comparison to spectral standards reveals that this object is best classified as an L9 and a weak binary candidate.





**Figure 18.** Spectra of peculiar early-type T dwarfs, shown in black, along with spectral standards. Two different observations of the peculiar T5, WISE J1449+1147, from Gemini/GNIRS and Palomar/TSpec are shown. Spectra have been normalized at  $1.27 \mu\text{m}$  and offset vertically. (A color version of this figure is available in the online journal.)

Figure 17 shows the Palomar/TSpec spectrum for this source and the best-fitting composite spectrum with a  $L7.5 \pm 1.5$  primary and a  $T1.5 \pm 1.5$  secondary ( $\Delta J_{\text{MKO}} = -0.17 \pm 0.33$  and  $\Delta H_{\text{MKO}} = 0.22 \pm 0.33$ ). The composite fit to WISE J0920+4538 is highly uncertain, but fitting to a single object spectrum is also a poor fit and binarity may be the source of the discrepant photometric colors and spectral features of this source.

4.4.2. ULAS J095047.28+011734.3—T8

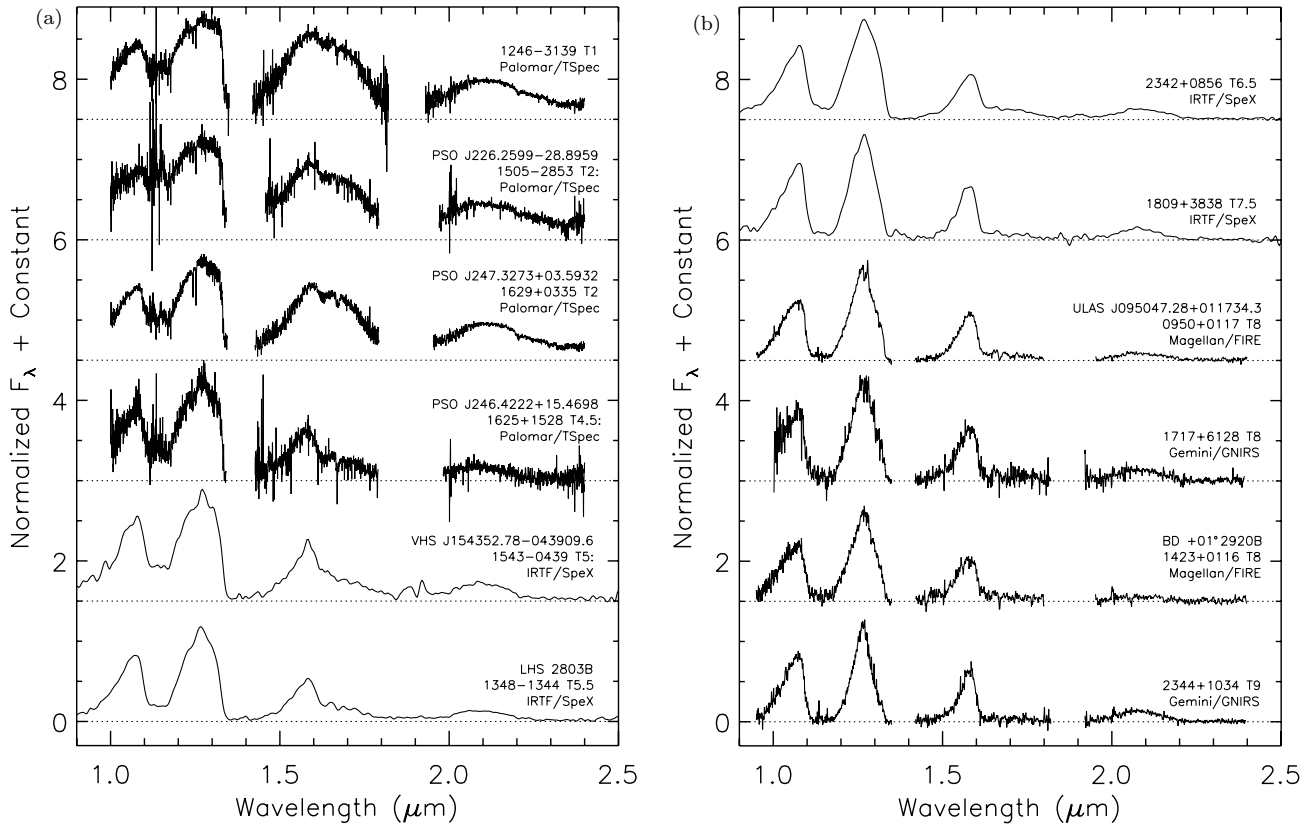
Photometry, and a T8 spectral type, for this object were reported by Leggett et al. (2012). Our Magellan/FIRE spectrum for this source is consistent with the T8 standard, but displays a slightly higher flux in the *Y* and *H* band, and is slightly suppressed in the *K* band. However, these deviations are within our noise estimates and so we do not classify this object as peculiar.

4.4.3. WISE J1246–3139—T1

This source was first identified in the literature by Andrei et al. (2011) as one of the targets in their parallax program. Based on preliminary photometry they estimated the spectral type as T1.0. The Palomar/TSpec spectrum for this source is shown in Figure 19 and we classify this object as a T1.

4.4.4. LHS 2803B—T5.5

This wide separation, common proper motion companion to the  $M4.5 \pm 0.5$  dwarf LHS 2803 was reported by Deacon et al. (2012) and classified as a T5.5. We produce the same T5.5 classification from our IRTF/SpEx spectrum.



**Figure 19.** Spectra of previously identified T dwarfs from the literature. Spectra have been normalized at  $1.27 \mu\text{m}$  and offset vertically.

4.4.5. *BD +01° 2920B—T8*

Pinfield et al. (2012) identify BD +01° 2920B as a T8pec dwarf companion to BD +01° 2920 (HIP 70319), a metal-poor ([Fe/H] =  $-0.38 \pm 0.06$ ) G1 dwarf at a distance of 17.2 pc. We observed BD +01° 2920B and find that, other than a suppressed *K* band, the object matches the T8 standard. Since our analysis (Section 4.5.5) shows that suppressed *K*-band flux is fairly common in late-type T dwarfs we do not classify it as peculiar.

4.4.6. *WISE J1449+1147—T5 pec*

In a search for high proper motion T dwarf candidates between the UKIDSS DR6 and SDSS DR7 databases, Scholz (2010) identified this source as a candidate T7  $\pm$  2 (ULAS J144901.90+114711.3). This object was observed with two instruments, Gemini/GNIRS and Palomar/TSpec. Figure 18 shows the near-IR spectra from each instrument along with the T5 spectral standard. The *J*- and *H*-band flux match the T5 standard, but the *Y* band displays a flux excess and the *K* band is more heavily suppressed than the standard. These are the same low-metallicity features seen in the other peculiar objects.

4.4.7. *Repeats from Deacon et al. (2011)*

Deacon et al. (2011) identified four new T dwarfs by their proper motions between the PanSTARRS 1 commissioning data and 2MASS. We independently identified three of these objects in the *WISE* catalog and they were observed prior to publication by Deacon et al. (2011): PSO J226.2599–28.8959 (*WISE* J1505–2853), PSO J246.4222+15.4698 (*WISE* J1625+1528), and PSO J247.3273+03.5932 (*WISE* J1629+0335). Our derived spectral types are consistent with their visually derived types, but with higher uncertainties. The fourth object observed by Deacon et al. (2011), PSO J201.0320+19.1072, is not included in the partial sky coverage of the *WISE* Preliminary Release Source Catalog and was not observed by us after it was published by Deacon et al. (2011).

4.4.8. *VHS J154352.78–043909.6—T5*

Our IRTF/SpEx spectrum for this source is fairly low S/N. Lodieu et al. (2012) photometrically selected this object from the first data release of the VISTA Hemisphere Survey and the *WISE* Preliminary Data Release. They derive a spectral type of T4.5 based on a Magellan/FIRE spectrum of the source, which is constant with the uncertain T5: classification that we produce.

4.4.9. *Repeats from Kirkpatrick et al. (2011)*

Two objects from Kirkpatrick et al. (2011), *WISE* J1717+6129 and *WISE* J2344+1034, were observed again with Gemini/GNIRS to provide more wavelength coverage than the original Keck/NIRSPEC observations. The classifications from Kirkpatrick et al. (2011) remain unchanged at T8 and T9, respectively.

4.4.10. *WISE J1809+3838—T7.5*

Luhman et al. (2012) used the *WISE* All-Sky Source Catalog along with the 2MASS Point Source Catalog to search for proper motion companions. From their IRTF/SpEx spectrum they produce a type of T7  $\pm$  1, while we classify the object as T7.5  $\pm$  0.5.

4.4.11. *WISE J2342+0856—T6.5*

This object was also identified by Scholz (2010) as a candidate T7  $\pm$  2 (ULAS J234228.96+085620.1). We classify this object as a T6.5 based on the IRTF/SpEx spectrum for this object.

4.5. *Median Derived Spectral Indices*

Burgasser et al. (2006b) defined a number of primary spectral indices that compare the ratio of the integrated *J*- and *H*-band flux peaks to the blueward H<sub>2</sub>O and redward CH<sub>4</sub> absorption features; H<sub>2</sub>O–J, CH<sub>4</sub>–J, H<sub>2</sub>O–H, and CH<sub>4</sub>–H. *K*-band indices were also defined, but *K*-band fluxes reduced by H<sub>2</sub> CIA results in low S/N *K*-band spectra and highly uncertain *K*-band indices. The *Y*/*J* and *K*/*J* color ratios, defined by Burgasser et al. (2004, 2006a), serve as proxies for the broadband *Y*–*J* and *J*–*K* colors. Two additional indices that correlate well with the T dwarf spectral sequence are *W<sub>J</sub>* (Warren et al. 2007) and NH<sub>3</sub>–H (Delorme et al. 2008a) which approximate the slope of the *J*- and *H*-band flux peaks, respectively.

In addition to these indices, we have derived an *H*/*J* color ratio as a proxy for the *J*–*H* color,

$$H/J = \frac{\tilde{F}_{1.560-1.600 \mu\text{m}}}{\tilde{F}_{1.250-1.290 \mu\text{m}}}, \quad (1)$$

and the *J*-narrow index which is designed to differentiate Y dwarfs from T dwarfs based on their narrow *J*-band flux peaks,

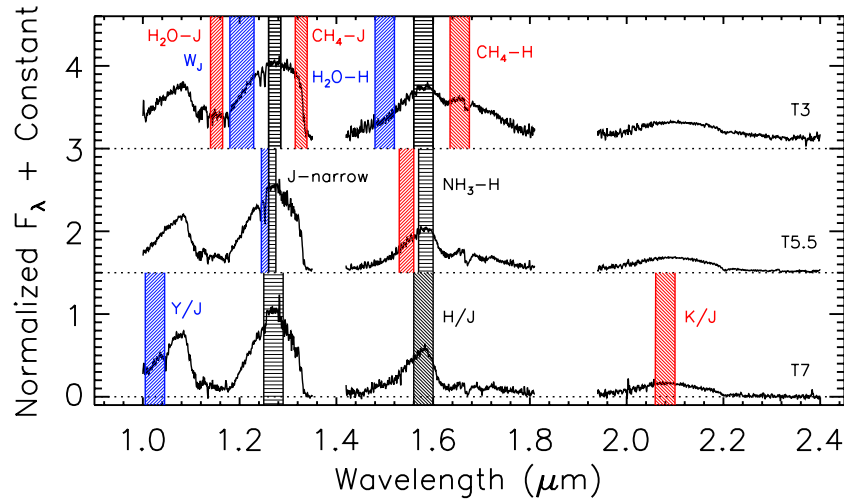
$$J - \text{narrow} = \frac{\tilde{F}_{1.245-1.260 \mu\text{m}}}{\tilde{F}_{1.260-1.275 \mu\text{m}}}, \quad (2)$$

where  $\tilde{F}$  is the *median* flux between the subscripted wavelengths in microns. Figure 20 depicts the wavelengths over which these indices are derived for a series of Palomar/TSpec spectra from this paper.

Although indices in the literature are defined as the integrated flux over the desired wavelength range, this method is unreliable when trying to compute indices for low-S/N spectra. Even with moderate S/N spectra, the flux in the numerator of most indices is minuscule for late-type T dwarfs and easily modulated by noisy pixels and poor telluric correction. For this reason, we have computed all of our indices *over the classical wavelengths* but use the *median* flux instead of the integrated flux. This method reduces the scatter in index values as a function of spectral type, especially at later types. Further discussion about using median fluxes to compute indices is deferred to the Appendix, where we also include the integrated flux indices for all our *WISE* discoveries.

We computed the index values using a Monte Carlo model of each spectrum. This was accomplished by randomly drawing from a normal distribution with means given by the flux densities at each wavelength and standard deviations given by the uncertainty in the flux densities. For 1000 realizations of each spectrum, the index is given as the mean and standard deviation of the distribution of index values. Table 7 lists the index values for the T and Y dwarf spectra in Kirkpatrick et al. (2011, 2012) and Cushing et al. (2011), the new *WISE* T dwarf discoveries in this paper, and for objects from Table 6.

Spectral indices for the *WISE*-discovered T and Y dwarfs are shown in Figures 21–25 along with the T0-to-Y0 spectral standards. Because our sample is mostly T dwarfs later than T5, indices for the T dwarfs in the SpEx Prism Library (A. J. Burgasser et al., in preparation) are also included in our figures.



**Figure 20.** The wavelengths that define the spectral indices derived in Equations (1)–(10) are depicted for a series of Palomar/TSpec T dwarf spectra. (A color version of this figure is available in the online journal.)

The average index value and standard deviation for the  $\sim 320$  unique T and Y dwarfs shown in the figures are listed in Table 8 for each half spectral type from T0 to Y0. In the subsections below we discuss each index in detail.

#### 4.5.1. Primary Indices from Burgasser et al. (2006b)

The primary classification indices for T dwarfs were designed by Burgasser et al. (2002) and Geballe et al. (2002), and then revised by Burgasser et al. (2006b). We modify these as follows to incorporate median fluxes:

$$\text{H}_2\text{O} - \text{J} = \frac{\tilde{F}_{1.140-1.165 \mu\text{m}}}{\tilde{F}_{1.260-1.285 \mu\text{m}}} \quad (3)$$

$$\text{CH}_4 - \text{J} = \frac{\tilde{F}_{1.315-1.340 \mu\text{m}}}{\tilde{F}_{1.260-1.285 \mu\text{m}}} \quad (4)$$

$$\text{H}_2\text{O} - \text{H} = \frac{\tilde{F}_{1.480-1.520 \mu\text{m}}}{\tilde{F}_{1.560-1.600 \mu\text{m}}} \quad (5)$$

$$\text{CH}_4 - \text{H} = \frac{\tilde{F}_{1.635-1.675 \mu\text{m}}}{\tilde{F}_{1.560-1.600 \mu\text{m}}} \quad (6)$$

These indices each show a general trend of having a maximum value at the earliest T spectral type and a steady decrease at later spectral types. However, by the end of the T sequence these indices have saturated and are less useful for classification. For Y dwarfs, these indices have highly uncertain and spurious values since the numerator in each case has essentially no flux and is dominated by background noise.

#### 4.5.2. $W_J$ and $\text{NH}_3 - \text{H}$ Indices for Late-type T Dwarfs

The  $W_J$  index was defined by Warren et al. (2007) to characterize the  $J$ -band width. The original integrated flux definition required that the denominator be multiplied by a factor of two in order to compensate for the larger width numerator. When modified to use the median flux, the index becomes

$$W_J = \frac{\tilde{F}_{1.180-1.230 \mu\text{m}}}{\tilde{F}_{1.260-1.285 \mu\text{m}}}, \quad (7)$$

and it is no longer necessary to keep this factor in the denominator. We have chosen to remove it in our analysis. This produces

index values between 0.0 and 0.9, which is consistent with the integrated flux results in the literature. The flux from 1.180 to 1.230  $\mu\text{m}$  gradually and consistently decreases with spectral type, producing unique index values all the way to the T/Y boundary, as seen by Cushing et al. (2011).

Delorme et al. (2008a) defined the  $\text{NH}_3 - \text{H}$  index to probe the blue wing of the  $H$  band in later T dwarfs. We modify this index to incorporate median fluxes,

$$\text{NH}_3 - \text{H} = \frac{\tilde{F}_{1.530-1.560 \mu\text{m}}}{\tilde{F}_{1.570-1.600 \mu\text{m}}}. \quad (8)$$

This index is not useful at identifying T dwarfs earlier than T7, but has a large dynamic range for the latest T dwarfs and the Y0s. Cushing et al. (2011) identified the break in the  $\text{NH}_3 - \text{H}$  index at Y0, suggesting that near-infrared  $\text{NH}_3$  absorption begins at the T/Y boundary. This break is still clearly identified in our median flux index.

#### 4.5.3. $Y/J$ Ratio

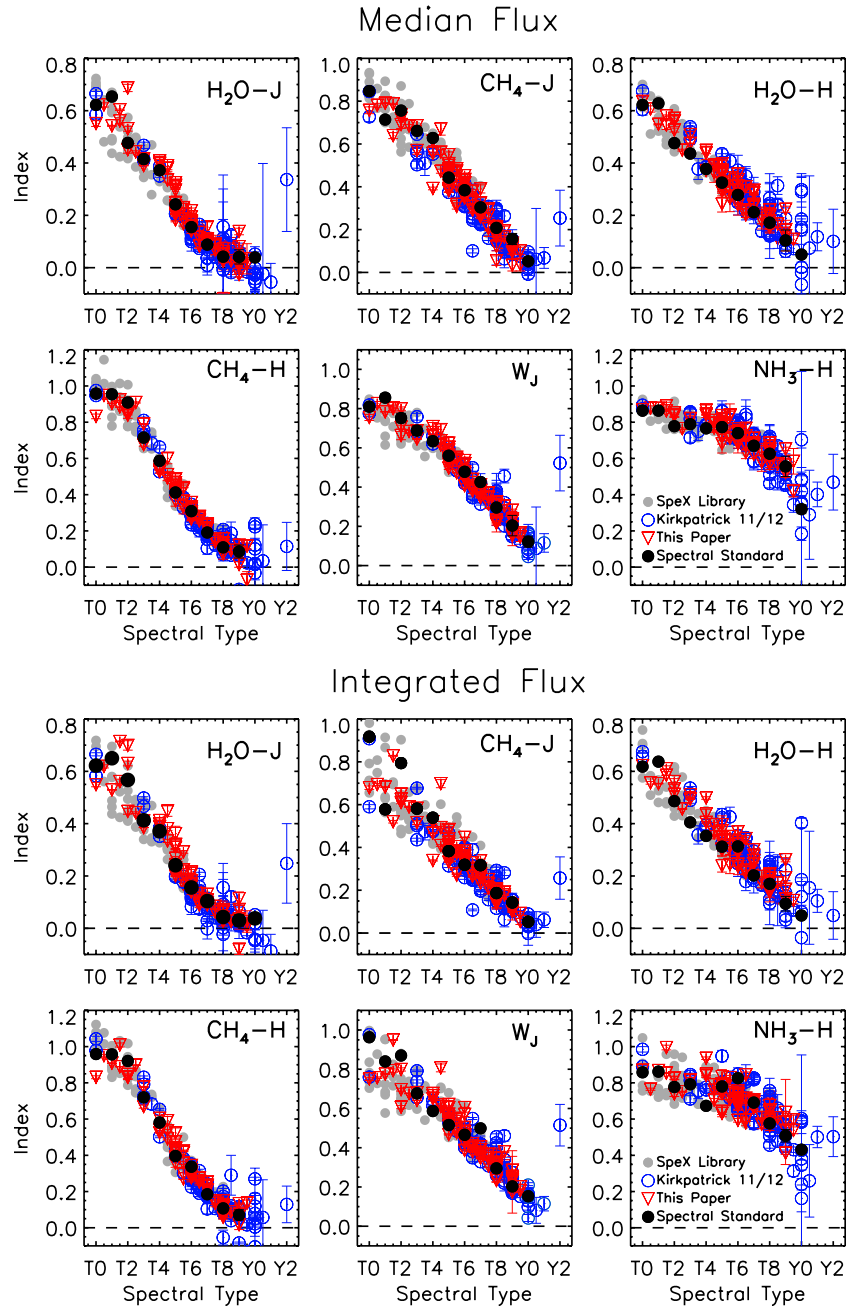
The  $Y/J$  index was defined by Burgasser et al. (2006b) as a possible tracer of variations in metallicity. We modify this index to incorporate median fluxes,

$$Y/J = \frac{\tilde{F}_{1.005-1.045 \mu\text{m}}}{\tilde{F}_{1.250-1.290 \mu\text{m}}}. \quad (9)$$

The  $Y$ -band spectra that we have acquired are from the low-resolution, multi-band spectrographs IRTF/SpeX, Palomar/TripleSpec, Magellan/FIRE, and Gemini/GNIRS. From lower-resolution spectra we derive indices with larger uncertainties. This index shows significant scatter compared to the  $H/J$  and  $K/J$  ratios and the spectral standards produce a trend with redder  $Y/J$  flux ratios relative to the rest of the population. The dispersion in this index is smallest for T4s and later objects show the largest scatter.

#### 4.5.4. $H/J$ Ratio

Burgasser et al. (2002) defined a broader version of the  $H/J$  index that encompasses most of the T dwarf flux contributing to the broadband  $J - H$  color, and noted a possible reversal at later types. It is not one of the indices revised in Burgasser et al.



**Figure 21.** Six spectral indices from Burgasser et al. (2006b), Warren et al. (2007), and Delorme et al. (2008a), computed using the median flux and the integrated flux. The T dwarfs in this paper are marked by red triangles, and the T and Y dwarfs of Kirkpatrick et al. (2011, 2012) and Cushing et al. (2011) are marked as blue hollow circles. Also included are the T dwarfs from the SpeX Prism Library as gray filled circles, and spectral standards as black filled circles.

(A color version of this figure is available in the online journal.)

(2006b) and so we have constructed the  $H/J$  index, presented in Equation (1), employing the wavelengths used by Burgasser et al. (2006b) to define other indices. This index shows a tight trend with an average dispersion of 0.1 and shows a similar reversal as the 2MASS  $J-H$  colors in Figure 4. As discussed in Section 3.1, the turnaround of the  $J-H$  color is evident before the T/Y boundary, and appears to occur around  $T6 \pm 1$  for the  $H/J$  index. However, Y dwarfs show a significant scatter in  $H/J$ . The Y0s break the trend of the T dwarfs, and the  $H/J$  index drops, possibly due to the onset of  $\text{NH}_3$  absorption. WISE J182831.08+265037.8 has been typed as  $\geq Y2$  (Kirkpatrick et al. 2012) based on the near-equal heights of the  $J$ - and  $H$ -band flux peaks and has an index value equivalent

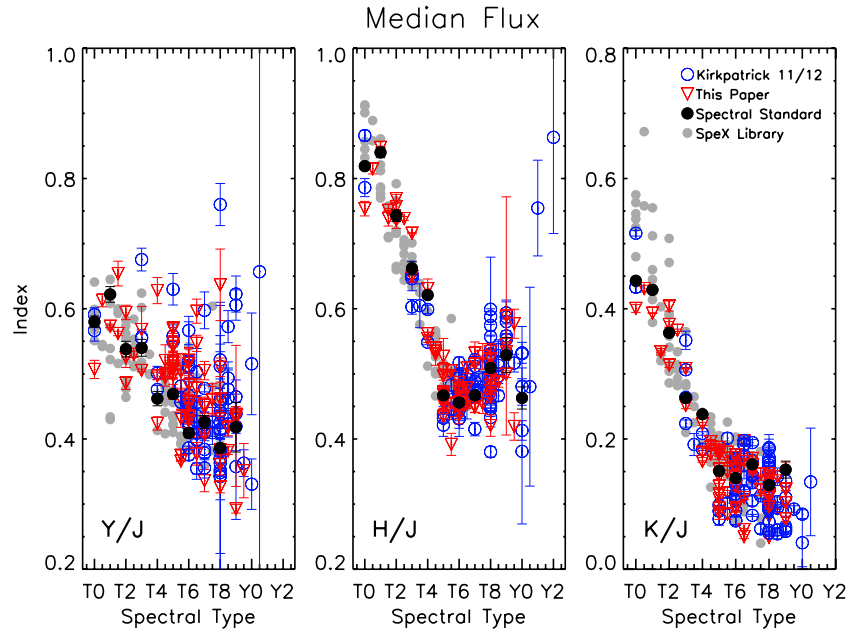
to the earliest T dwarfs. This dichotomy of  $H/J$  flux ratios hints at drastically different atmospheric conditions for Y0s and later type Y dwarfs.

#### 4.5.5. $K/J$ Ratio

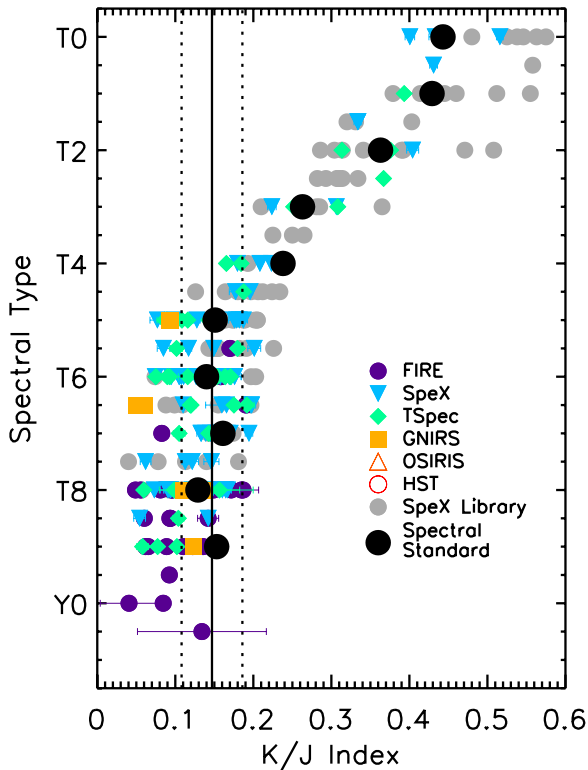
The wavelengths used for the  $K/J$  ratio were initially defined by Burgasser et al. (2002) to compare the  $K$ -band flux peak to the  $J$ -band flux peak, and modified here to incorporate median fluxes,

$$K/J = \frac{\tilde{F}_{2.060-2.100\mu\text{m}}}{\tilde{F}_{1.250-1.290\mu\text{m}}}. \quad (10)$$

Models have long predicted dominant  $\text{H}_2$  CIA of the  $K$ -band flux in cool brown dwarf atmospheres (Saumon et al. 1994,



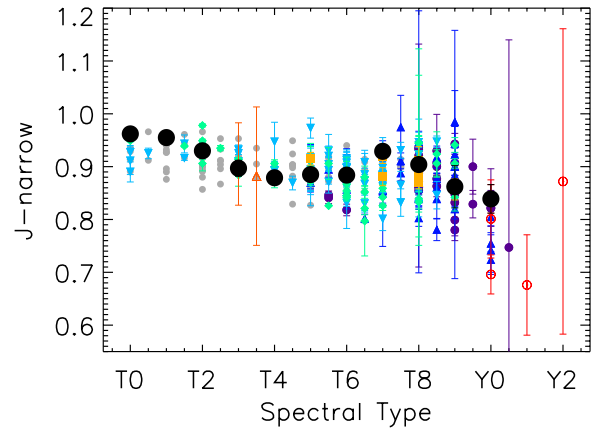
**Figure 22.** The peak flux ratios defined by Burgasser et al. (2004, 2006b), computed using the median flux instead of the integrated flux. Same symbols as in Figure 21. (A color version of this figure is available in the online journal.)



**Figure 23.** Spectral type vs.  $K/J$  ratio for the same objects in Figure 22, sorted by spectrograph. The average  $K/J$  index for the T5-T9 spectral standards is  $0.147 \pm 0.013$ , and the  $3\sigma$  limits are shown here. We find that 54 out of 170 (about one third) of T5 or later dwarfs are below this limit, while only 18 out of 170 are above this limit.

(A color version of this figure is available in the online journal.)

2012; Marley et al. 1996; Allard et al. 1996) which has been observationally verified and is evident in Figure 22. The large dispersion in the late-type T  $K/J$  index was pointed out by Burgasser et al. (2006b) and we find that the dispersion is

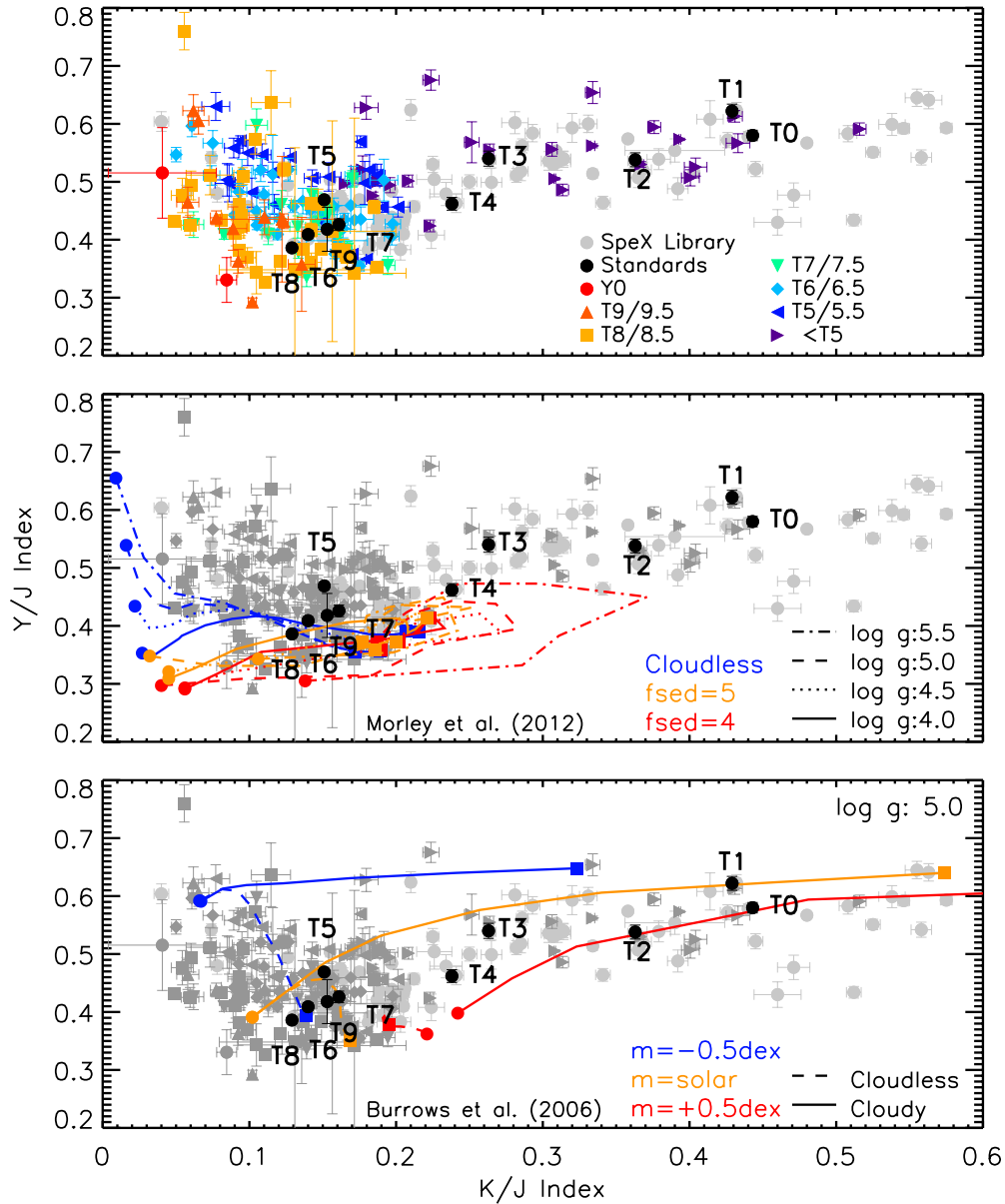


**Figure 24.** The  $J$ -narrow index for T and Y dwarfs in Figure 22. Undulation in the T dwarfs is due to changes in the  $1.254 \mu\text{m}$   $K_1$  line. Y dwarfs have smaller indices because of a narrowing of the  $J$ -band flux peak.

(A color version of this figure is available in the online journal.)

smallest at T4 and flares at both earlier and later types. Although the early-type T dwarf standards fall near the mean of each spectral bin, the late-type T spectral standards are on the redder side of the mean. Figure 23 shows the  $K/J$  indices for T dwarfs, sorted by instrument. We find that the average  $K/J$  index for the T5-T9 spectral standards is  $0.147 \pm 0.013$  and only  $\sim 11\%$  (18 out of 170; 8 *WISE* discoveries and 10 from the SpeX Prism Library) are redder than the  $3\sigma$  upper limit. However, 47 of the 126 *WISE*-discovered and 7 of the 44 SpeX Prism Library late-type T dwarfs are below the  $3\sigma$  lower limit (shown in Figure 23). In total, 54 out of 170, approximately one third, of the T5 or later dwarfs are blue relative to the standards.

The largest dispersion ( $\sim 1.5$  mag) in the  $K/J$  ratio is in the T7-T8 spectral bins, in which the number of known T dwarfs has been quintupled by *WISE*. The T dwarf sample prior to *WISE* peaked at T5 (Kirkpatrick et al. 2011, Figure 28), and



**Figure 25.** The  $Y/J$  vs.  $K/J$  indices of late-type T dwarfs compared to models. Top: Index values sorted by spectral type. Middle: the Morley et al. (2012) sulfide cloud models (which do not include silicate clouds expected in early-type T dwarfs) are shown for  $\log g = 4, 4.5, 5, 5.5$  (solid, dotted, dashed, dot-dashed) and  $T_{\text{eff}} = 400 \text{ K}$  to  $1300 \text{ K}$ . Cloudless models are shown in blue,  $f_{\text{sed}} = 5$  in orange, and  $f_{\text{sed}} = 4$  in red. Bottom: the cloudy (solid lines) and clear (dashed lines) models from Burrows et al. (2006) with  $\log g = 5$  and metallicities of solar and  $\pm 0.5 \text{ dex}$  with  $T_{\text{eff}} = 800 \text{ K}$  to  $1700 \text{ K}$ . The highest temperature is marked with a square and the lowest temperature is marked with a circle.

(A color version of this figure is available in the online journal.)

*WISE* discoveries shift this peak to T6, with the number of T8s nearly as bountiful. Figure 23 shows that, although the spectral standards all have similar  $K/J$  ratios, the value of the index for late-type T dwarfs gradually decreases at later types. The small number of late-type T dwarfs in the SpeX Prism Library, and the steady decrease in the  $K/J$  index with spectral type, results in a smaller fraction of blue T dwarfs from the SpeX Prism Library ( $\sim 16\%$ ) relative to the *WISE* discoveries ( $\sim 37\%$ ).

Although  $\sim 32\%$  of the late-type T dwarfs are blue ( $K$  band suppressed) and  $\sim 11\%$  are red, the current spectral standards still provide the best overall match to the bulk of observed spectra. The spectral standards match the mean  $H/J$  indices very well. It is possible that the standards, which were chosen to be bright in order to be easily observed, are also younger. If younger

than the mean of the sample, the standards would generally be more luminous for their effective temperature (larger), have a lower surface gravity (reduced CIA), and be metal-rich. All of these factors would result in the redder colors seen in the  $K/J$  index and bluer  $Y/J$  index values. Objects with blue or red  $K/J$  index values, relative to the  $J$  band normalized standards, are most commonly called peculiar in the literature. Because this is fairly common in our sample, the objects we classify as peculiar deviate from the standards in more than one band.

#### 4.5.6. $J$ -narrow Index

The  $J$ -narrow index is defined in Equation (2) and also presented in Kirkpatrick et al. (2012). This index was derived empirically from the spectra presented in this paper in order

**Table 7**  
Modified Spectral Indices Based on Median Fluxes

| Object Name<br>J2000 Coordinates<br>(1)            | Instrument<br>(2)      | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) | J-narrow<br>(10) |
|--|------------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|------------------|
| T and Y Dwarf Standards                            |                        |                        |                           |                           |                           |                           |                       |                           |                  |
| SDSS J1207+0244                                    | IRTF/SpeX <sup>a</sup> | T0                     | 0.622 ± 0.005             | 0.847 ± 0.007             | 0.622 ± 0.008             | 0.958 ± 0.006             | 0.810 ± 0.016         | 0.864 ± 0.008             | 0.962 ± 0.008    |
| SDSS J0151+1244                                    | IRTF/SpeX <sup>a</sup> | T1                     | 0.654 ± 0.008             | 0.714 ± 0.015             | 0.628 ± 0.013             | 0.954 ± 0.010             | 0.856 ± 0.020         | 0.864 ± 0.014             | 0.955 ± 0.012    |
| SDSSp J1254–0122                                   | IRTF/SpeX <sup>a</sup> | T2                     | 0.477 ± 0.008             | 0.756 ± 0.012             | 0.476 ± 0.012             | 0.909 ± 0.010             | 0.752 ± 0.024         | 0.778 ± 0.016             | 0.930 ± 0.011    |
| 2MASS J1209–1004                                   | IRTF/SpeX <sup>a</sup> | T3                     | 0.415 ± 0.008             | 0.661 ± 0.014             | 0.436 ± 0.012             | 0.715 ± 0.011             | 0.688 ± 0.024         | 0.789 ± 0.017             | 0.897 ± 0.015    |
| 2MASSI J2254+3123                                  | IRTF/SpeX <sup>a</sup> | T4                     | 0.372 ± 0.005             | 0.628 ± 0.007             | 0.377 ± 0.007             | 0.587 ± 0.008             | 0.634 ± 0.008         | 0.766 ± 0.008             | 0.879 ± 0.006    |
| 2MASS J1503+2525                                   | IRTF/SpeX <sup>a</sup> | T5                     | 0.242 ± 0.003             | 0.443 ± 0.011             | 0.325 ± 0.010             | 0.412 ± 0.007             | 0.560 ± 0.012         | 0.773 ± 0.010             | 0.885 ± 0.005    |
| SDSSp J1624+0029                                   | IRTF/SpeX <sup>a</sup> | T6                     | 0.155 ± 0.002             | 0.384 ± 0.010             | 0.278 ± 0.012             | 0.309 ± 0.007             | 0.478 ± 0.016         | 0.740 ± 0.014             | 0.884 ± 0.009    |
| 2MASSI J0727+1710                                  | IRTF/SpeX <sup>a</sup> | T7                     | 0.088 ± 0.004             | 0.304 ± 0.006             | 0.212 ± 0.014             | 0.191 ± 0.008             | 0.426 ± 0.012         | 0.670 ± 0.019             | 0.929 ± 0.013    |
| 2MASSI J0415–0935                                  | IRTF/SpeX <sup>a</sup> | T8                     | 0.042 ± 0.002             | 0.208 ± 0.004             | 0.172 ± 0.007             | 0.109 ± 0.004             | 0.296 ± 0.012         | 0.626 ± 0.009             | 0.904 ± 0.006    |
| UGPS J0722–0540                                    | IRTF/SpeX              | T9                     | 0.041 ± 0.027             | 0.156 ± 0.026             | 0.104 ± 0.040             | 0.086 ± 0.036             | 0.204 ± 0.052         | 0.556 ± 0.056             | 0.862 ± 0.040    |
| WISEPA J1738+2732                                  | <i>HST</i> /WFC3       | Y0                     | 0.039 ± 0.009             | 0.052 ± 0.010             | 0.050 ± 0.011             | ...                       | 0.122 ± 0.028         | 0.320 ± 0.025             | 0.839 ± 0.027    |
| T Dwarf Discoveries from Kirkpatrick et al. (2011) |                        |                        |                           |                           |                           |                           |                       |                           |                  |
| WISE J0008–1739                                    | Keck/NIRSPEC-J         | T6                     | 0.142 ± 0.033             | 0.402 ± 0.042             | ...                       | ...                       | 0.466 ± 0.028         | ...                       | 0.877 ± 0.057    |
| WISE J0123+4142                                    | Keck/NIRSPEC-J         | T7                     | 0.038 ± 0.066             | 0.282 ± 0.066             | ...                       | ...                       | 0.418 ± 0.050         | ...                       | 0.849 ± 0.100    |
| WISE J0138–0322                                    | IRTF/SpeX              | T3                     | 0.410 ± 0.008             | 0.570 ± 0.009             | 0.539 ± 0.014             | 0.756 ± 0.010             | 0.674 ± 0.012         | 0.858 ± 0.014             | 0.925 ± 0.012    |
| WISE J0148–7202                                    | Magellan/FIRE          | T9.5                   | –0.016 ± 0.013            | 0.076 ± 0.013             | 0.073 ± 0.015             | 0.023 ± 0.015             | 0.124 ± 0.014         | 0.424 ± 0.024             | 0.829 ± 0.026    |
| WISE J0150+3827                                    | IRTF/SpeX              | T0                     | 0.665 ± 0.008             | 0.845 ± 0.010             | 0.675 ± 0.011             | 0.975 ± 0.007             | 0.818 ± 0.010         | 0.894 ± 0.011             | 0.927 ± 0.013    |
| WISE J0221+3842                                    | Palomar/TSpec          | T6.5                   | 0.106 ± 0.018             | 0.256 ± 0.022             | 0.213 ± 0.031             | 0.265 ± 0.017             | 0.346 ± 0.022         | 0.673 ± 0.034             | 0.797 ± 0.066    |
| WISE J0223–2932                                    | IRTF/SpeX              | T7.5                   | 0.041 ± 0.009             | 0.160 ± 0.011             | 0.139 ± 0.020             | 0.169 ± 0.014             | 0.372 ± 0.016         | 0.689 ± 0.031             | 0.931 ± 0.015    |
|  | Keck/NIRSPEC-H         | T7                     | ...                       | ...                       | 0.216 ± 0.048             | 0.178 ± 0.027             | ...                   | 0.585 ± 0.038             | ...              |
| WISE J0226–0211                                    | Keck/NIRSPEC-H         | T7                     | ...                       | ...                       | 0.260 ± 0.063             | 0.104 ± 0.033             | ...                   | 0.582 ± 0.045             | ...              |
| WISE J0254+0223                                    | IRTF/SpeX              | T8                     | 0.047 ± 0.004             | 0.209 ± 0.005             | 0.175 ± 0.012             | 0.114 ± 0.006             | 0.298 ± 0.006         | 0.627 ± 0.015             | 0.900 ± 0.008    |
| WISE J0305+3954                                    | Palomar/TSpec          | T6                     | 0.114 ± 0.011             | 0.351 ± 0.014             | 0.341 ± 0.016             | 0.245 ± 0.010             | 0.420 ± 0.012         | 0.724 ± 0.017             | 0.867 ± 0.023    |
| WISE J0307+2904                                    | IRTF/SpeX              | T6.5                   | 0.133 ± 0.043             | 0.361 ± 0.051             | 0.316 ± 0.070             | 0.227 ± 0.060             | 0.438 ± 0.040         | 0.822 ± 0.101             | 0.874 ± 0.057    |
| WISE J0313+7807                                    | Palomar/TSpec          | T8.5                   | 0.125 ± 0.017             | 0.108 ± 0.012             | 0.242 ± 0.020             | 0.147 ± 0.012             | 0.320 ± 0.012         | 0.598 ± 0.025             | 0.906 ± 0.026    |
| WISE J0323–6025                                    | Magellan/FIRE          | T8.5                   | 0.047 ± 0.018             | 0.170 ± 0.022             | 0.178 ± 0.021             | 0.120 ± 0.014             | 0.260 ± 0.018         | 0.587 ± 0.030             | 0.907 ± 0.025    |
| WISE J0333–5856                                    | SOAR/OSIRIS            | T3                     | ...                       | 0.558 ± 0.034             | 0.520 ± 0.021             | 0.729 ± 0.021             | ...                   | 0.714 ± 0.025             | 0.905 ± 0.078    |
| WISE J0410+1411                                    | IRTF/SpeX              | T6                     | 0.100 ± 0.036             | 0.351 ± 0.044             | 0.268 ± 0.067             | 0.288 ± 0.055             | 0.462 ± 0.042         | 0.742 ± 0.087             | 0.831 ± 0.048    |
| WISE J0448–1935                                    | IRTF/SpeX              | T5 pec                 | 0.206 ± 0.023             | 0.469 ± 0.028             | 0.368 ± 0.049             | 0.428 ± 0.037             | 0.588 ± 0.024         | 0.859 ± 0.059             | 0.908 ± 0.030    |
| WISE J0458+6434                                    | IRTF/SpeX              | T8.5                   | 0.038 ± 0.016             | 0.268 ± 0.023             | 0.136 ± 0.027             | 0.084 ± 0.026             | 0.238 ± 0.024         | 0.471 ± 0.044             | 0.846 ± 0.026    |
| WISE J0500–1223                                    | IRTF/SpeX              | T8                     | 0.045 ± 0.031             | 0.206 ± 0.033             | 0.121 ± 0.049             | 0.095 ± 0.040             | 0.332 ± 0.036         | 0.651 ± 0.070             | 0.946 ± 0.044    |
| WISE J0513+0608                                    | Palomar/TSpec          | T6.5                   | 0.165 ± 0.006             | 0.325 ± 0.010             | 0.282 ± 0.008             | 0.240 ± 0.007             | 0.414 ± 0.008         | 0.707 ± 0.013             | 0.821 ± 0.012    |
| WISE J0525+6739                                    | IRTF/SpeX              | T6 pec                 | 0.174 ± 0.012             | 0.368 ± 0.015             | 0.310 ± 0.032             | 0.316 ± 0.023             | 0.482 ± 0.018         | 0.808 ± 0.038             | 0.897 ± 0.018    |
| WISE J0528–3308                                    | Palomar/TSpec          | T7 pec                 | 0.009 ± 0.025             | 0.254 ± 0.019             | 0.230 ± 0.028             | 0.210 ± 0.017             | 0.350 ± 0.016         | 0.676 ± 0.032             | 0.842 ± 0.025    |
| WISE J0539–1034                                    | Palomar/TSpec          | T5.5                   | 0.195 ± 0.018             | 0.373 ± 0.023             | 0.408 ± 0.027             | 0.327 ± 0.018             | 0.484 ± 0.016         | 0.814 ± 0.029             | 0.906 ± 0.030    |
| WISE J0542–1628                                    | Palomar/TSpec          | T6.5                   | 0.143 ± 0.007             | 0.274 ± 0.010             | 0.230 ± 0.009             | 0.240 ± 0.008             | 0.398 ± 0.008         | 0.694 ± 0.013             | 0.852 ± 0.012    |
| WISE J0611–0410                                    | IRTF/SpeX              | T0                     | 0.586 ± 0.017             | 0.727 ± 0.022             | 0.604 ± 0.021             | 0.947 ± 0.018             | 0.776 ± 0.018         | 0.873 ± 0.020             | 0.911 ± 0.026    |
| WISE J0612–4920                                    | SOAR/OSIRIS            | T3.5                   | ...                       | 0.510 ± 0.057             | 0.377 ± 0.040             | 0.684 ± 0.038             | ...                   | 0.749 ± 0.050             | 0.882 ± 0.131    |
| WISE J0612–3036                                    | Palomar/TSpec          | T6                     | 0.108 ± 0.002             | 0.312 ± 0.005             | 0.291 ± 0.003             | 0.314 ± 0.002             | 0.446 ± 0.002         | 0.796 ± 0.005             | 0.874 ± 0.003    |
| WISE J0614+3912                                    | Palomar/TSpec          | T6                     | 0.137 ± 0.016             | 0.418 ± 0.020             | 0.346 ± 0.017             | 0.301 ± 0.013             | 0.462 ± 0.014         | 0.794 ± 0.025             | 0.889 ± 0.029    |
| WISE J0623–0456                                    | IRTF/SpeX              | T8                     | 0.015 ± 0.030             | 0.287 ± 0.035             | 0.178 ± 0.051             | 0.094 ± 0.039             | 0.380 ± 0.036         | 0.722 ± 0.065             | 0.880 ± 0.044    |

Table 7  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) | J-narrow<br>(10) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|------------------|
| WISE J0625+5646                         | Palomar/TSpec     | T6                     | 0.182 ± 0.012             | 0.310 ± 0.015             | 0.316 ± 0.016             | 0.296 ± 0.010             | 0.418 ± 0.012         | 0.705 ± 0.018             | 0.854 ± 0.019    |
| WISE J0627–1114                         | IRTF/Spex         | T6                     | 0.162 ± 0.005             | 0.359 ± 0.007             | 0.294 ± 0.014             | 0.310 ± 0.010             | 0.462 ± 0.008         | 0.733 ± 0.018             | 0.871 ± 0.009    |
| WISE J0656+4205                         | IRTF/Spex         | T3                     | 0.467 ± 0.012             | 0.503 ± 0.016             | 0.491 ± 0.020             | 0.810 ± 0.018             | 0.758 ± 0.018         | 0.851 ± 0.024             | 0.907 ± 0.021    |
| WISE J0744+5628                         | Palomar/TSpec     | T8                     | 0.156 ± 0.028             | 0.256 ± 0.022             | 0.186 ± 0.038             | 0.069 ± 0.024             | 0.380 ± 0.020         | 0.630 ± 0.044             | 0.917 ± 0.040    |
| WISE J0750+2725                         | Keck/NIRSPEC-JH   | T8.5                   | –0.019 ± 0.016            | 0.117 ± 0.015             | 0.239 ± 0.027             | 0.066 ± 0.008             | 0.246 ± 0.012         | 0.576 ± 0.012             | 0.781 ± 0.021    |
| WISE J0751–7634                         | Magellan/FIRE     | T9                     | 0.025 ± 0.029             | 0.119 ± 0.017             | 0.188 ± 0.041             | 0.121 ± 0.031             | 0.148 ± 0.020         | 0.510 ± 0.048             | 0.848 ± 0.035    |
| WISE J0759–4904                         | Magellan/FIRE     | T8                     | 0.034 ± 0.004             | 0.160 ± 0.007             | 0.156 ± 0.008             | 0.122 ± 0.005             | 0.260 ± 0.008         | 0.608 ± 0.012             | 0.889 ± 0.010    |
| WISE J0819–0335                         | IRTF/Spex         | T4                     | 0.387 ± 0.006             | 0.553 ± 0.008             | 0.387 ± 0.012             | 0.663 ± 0.010             | 0.662 ± 0.010         | 0.781 ± 0.013             | 0.893 ± 0.011    |
| WISE J0821+1443                         | IRTF/Spex         | T5.5                   | 0.203 ± 0.013             | 0.401 ± 0.021             | 0.307 ± 0.025             | 0.385 ± 0.021             | 0.528 ± 0.022         | 0.715 ± 0.036             | 0.893 ± 0.026    |
| WISE J0836–1859                         | Magellan/FIRE     | T8 pec                 | 0.045 ± 0.017             | 0.145 ± 0.017             | 0.154 ± 0.017             | 0.124 ± 0.012             | 0.322 ± 0.016         | 0.606 ± 0.025             | 0.905 ± 0.021    |
| WISE J0857+5604                         | Palomar/TSpec     | T8                     | 0.069 ± 0.013             | 0.150 ± 0.013             | 0.125 ± 0.018             | 0.122 ± 0.011             | 0.296 ± 0.012         | 0.551 ± 0.023             | 0.892 ± 0.020    |
| WISE J0906+4735                         | Palomar/TSpec     | T8                     | 0.065 ± 0.186             | 0.245 ± 0.092             | 0.234 ± 0.125             | 0.125 ± 0.057             | 0.348 ± 0.074         | 0.642 ± 0.105             | 0.912 ± 0.161    |
| WISE J0929+0409                         | Palomar/TSpec     | T6.5                   | 0.082 ± 0.014             | 0.244 ± 0.018             | 0.273 ± 0.022             | 0.221 ± 0.014             | 0.364 ± 0.014         | 0.684 ± 0.026             | 0.880 ± 0.021    |
| WISE J0952+1955                         | IRTF/Spex         | T6                     | 0.159 ± 0.011             | 0.328 ± 0.014             | 0.285 ± 0.028             | 0.346 ± 0.022             | 0.476 ± 0.018         | 0.742 ± 0.038             | 0.915 ± 0.017    |
| WISE J1018–2445                         | Magellan/FIRE     | T8                     | 0.037 ± 0.005             | 0.151 ± 0.010             | 0.163 ± 0.006             | 0.092 ± 0.004             | 0.282 ± 0.008         | 0.613 ± 0.015             | 0.887 ± 0.008    |
| WISE J1019+6529                         | Palomar/TSpec     | T6                     | 0.134 ± 0.046             | 0.331 ± 0.029             | 0.293 ± 0.044             | 0.299 ± 0.024             | 0.472 ± 0.028         | 0.753 ± 0.045             | 0.877 ± 0.054    |
|   | IRTF/Spex         | T6                     | 0.126 ± 0.015             | 0.307 ± 0.020             | 0.249 ± 0.033             | 0.326 ± 0.025             | 0.450 ± 0.022         | 0.773 ± 0.056             | 0.887 ± 0.032    |
| WISE J1042–3842                         | Magellan/FIRE     | T8.5                   | 0.022 ± 0.012             | 0.147 ± 0.015             | 0.141 ± 0.014             | 0.116 ± 0.009             | 0.294 ± 0.016         | 0.561 ± 0.021             | 0.863 ± 0.020    |
| WISE J1122+2550                         | IRTF/Spex         | T6                     | 0.139 ± 0.014             | 0.350 ± 0.017             | 0.307 ± 0.031             | 0.234 ± 0.020             | 0.480 ± 0.022         | 0.770 ± 0.054             | 0.897 ± 0.032    |
| WISE J1150+6302                         | Palomar/TSpec     | T8                     | 0.020 ± 0.013             | 0.191 ± 0.013             | 0.133 ± 0.015             | 0.119 ± 0.011             | 0.286 ± 0.010         | 0.604 ± 0.023             | 0.833 ± 0.019    |
| WISE J1217+1626                         | Palomar/TSpec     | T9                     | 0.061 ± 0.017             | 0.083 ± 0.013             | 0.075 ± 0.022             | 0.099 ± 0.013             | 0.232 ± 0.012         | 0.539 ± 0.027             | 0.842 ± 0.026    |
| WISE J1311+0122                         | Keck/NIRSPEC-H    | T9:                    | ...                       | ...                       | 0.127 ± 0.038             | –0.123 ± 0.012            | ...                   | 0.581 ± 0.015             | ...              |
| WISE J1320+6034                         | IRTF/Spex         | T6.5                   | 0.107 ± 0.009             | 0.101 ± 0.010             | 0.350 ± 0.028             | 0.202 ± 0.017             | 0.498 ± 0.018         | 0.842 ± 0.045             | 0.908 ± 0.017    |
| WISE J1322–2340                         | IRTF/Spex         | T8                     | 0.088 ± 0.014             | 0.293 ± 0.017             | 0.266 ± 0.026             | 0.208 ± 0.021             | 0.366 ± 0.020         | 0.705 ± 0.037             | 0.829 ± 0.024    |
| WISE J1436–1814                         | Magellan/FIRE     | T8 pec                 | 0.061 ± 0.005             | 0.207 ± 0.009             | 0.238 ± 0.008             | 0.161 ± 0.006             | 0.292 ± 0.008         | 0.690 ± 0.014             | 0.855 ± 0.008    |
| WISE J1457+5815                         | IRTF/Spex         | T7                     | 0.102 ± 0.011             | 0.223 ± 0.014             | 0.257 ± 0.025             | 0.206 ± 0.017             | 0.412 ± 0.020         | 0.736 ± 0.036             | 0.931 ± 0.024    |
| WISE J1506+7027                         | Palomar/TSpec     | T6                     | 0.139 ± 0.001             | 0.336 ± 0.004             | 0.271 ± 0.003             | 0.293 ± 0.002             | 0.436 ± 0.002         | 0.720 ± 0.005             | 0.842 ± 0.003    |
|   | Keck/NIRSPEC-H    | T6                     | ...                       | ...                       | 0.353 ± 0.016             | 0.276 ± 0.009             | ...                   | 0.703 ± 0.014             | ...              |
| WISE J1519+7009                         | Palomar/TSpec     | T8                     | 0.101 ± 0.200             | 0.210 ± 0.108             | 0.181 ± 0.145             | 0.102 ± 0.069             | 0.350 ± 0.086         | 0.654 ± 0.127             | 0.945 ± 0.178    |
| WISE J1612–3420                         | Keck/NIRSPEC-H    | T6.5                   | ...                       | ...                       | 0.303 ± 0.022             | 0.227 ± 0.017             | ...                   | 0.722 ± 0.023             | ...              |
| WISE J1614+1739                         | Magellan/FIRE     | T9                     | 0.038 ± 0.031             | 0.116 ± 0.020             | 0.107 ± 0.037             | 0.094 ± 0.024             | 0.202 ± 0.034         | 0.513 ± 0.050             | 0.832 ± 0.032    |
| WISE J1617+1807                         | Magellan/FIRE     | T8                     | 0.113 ± 0.241             | 0.167 ± 0.133             | 0.211 ± 0.110             | 0.104 ± 0.063             | 0.336 ± 0.132         | 0.594 ± 0.108             | 0.921 ± 0.211    |
| WISE J1622–0959                         | IRTF/Spex         | T6                     | 0.177 ± 0.006             | 0.410 ± 0.009             | 0.290 ± 0.018             | 0.328 ± 0.011             | 0.478 ± 0.012         | 0.743 ± 0.022             | 0.866 ± 0.013    |
| WISE J1627+3255                         | IRTF/Spex         | T6                     | 0.143 ± 0.005             | 0.386 ± 0.004             | 0.279 ± 0.012             | 0.289 ± 0.007             | 0.454 ± 0.006         | 0.746 ± 0.013             | 0.877 ± 0.006    |
|   | Keck/NIRSPEC-H    | T6                     | ...                       | ...                       | 0.372 ± 0.057             | 0.280 ± 0.035             | ...                   | 0.733 ± 0.049             | ...              |
| WISE J1653+4444                         | IRTF/Spex         | T8                     | 0.035 ± 0.011             | 0.244 ± 0.016             | 0.175 ± 0.022             | 0.160 ± 0.015             | 0.276 ± 0.018         | 0.589 ± 0.038             | 0.867 ± 0.021    |
| WISE J1711+3500                         | IRTF/Spex         | T8                     | –0.009 ± 0.018            | 0.260 ± 0.025             | 0.213 ± 0.034             | 0.181 ± 0.025             | 0.362 ± 0.026         | 0.700 ± 0.045             | 0.900 ± 0.046    |
| WISE J1717+6129                         | Keck/NIRSPEC-JH   | T8                     | 0.094 ± 0.038             | 0.174 ± 0.039             | 0.192 ± 0.042             | 0.114 ± 0.024             | 0.288 ± 0.030         | 0.511 ± 0.030             | 0.904 ± 0.063    |
| WISE J1728+5716                         | IRTF/Spex         | T6                     | 0.136 ± 0.015             | 0.412 ± 0.021             | 0.265 ± 0.031             | 0.284 ± 0.022             | 0.444 ± 0.024         | 0.714 ± 0.040             | 0.871 ± 0.025    |
| WISE J1741+2553                         | Magellan/FIRE     | T9                     | 0.023 ± 0.071             | 0.155 ± 0.045             | 0.123 ± 0.031             | 0.063 ± 0.019             | 0.230 ± 0.048         | 0.578 ± 0.047             | 0.907 ± 0.069    |
| WISE J1804+3117                         | Keck/NIRSPEC-H    | T9.5:                  | ...                       | ...                       | ...                       | ...                       | ...                   | 0.345 ± 0.042             | ...              |
| WISE J1812+2721                         | Magellan/FIRE     | T8.5:                  | 0.042 ± 0.042             | 0.099 ± 0.033             | 0.128 ± 0.055             | 0.188 ± 0.061             | 0.202 ± 0.030         | 0.583 ± 0.097             | 0.930 ± 0.069    |
| WISE J1841+7000                         | Palomar/TSpec     | T5                     | 0.237 ± 0.016             | 0.489 ± 0.020             | 0.436 ± 0.018             | 0.398 ± 0.010             | 0.564 ± 0.012         | 0.818 ± 0.018             | 0.919 ± 0.019    |
| WISE J1852+3537                         | IRTF/Spex         | T7                     | 0.070 ± 0.010             | 0.235 ± 0.011             | 0.219 ± 0.025             | 0.170 ± 0.012             | 0.382 ± 0.016         | 0.731 ± 0.029             | 0.868 ± 0.018    |
| WISE J1906+4508                         | IRTF/Spex         | T6                     | 0.184 ± 0.005             | 0.384 ± 0.006             | 0.316 ± 0.017             | 0.333 ± 0.010             | 0.516 ± 0.008         | 0.754 ± 0.019             | 0.907 ± 0.011    |
| WISE J1952+7240                         | Palomar/TSpec     | T4                     | 0.350 ± 0.005             | 0.567 ± 0.009             | 0.384 ± 0.007             | 0.527 ± 0.006             | 0.620 ± 0.006         | 0.788 ± 0.009             | 0.878 ± 0.009    |



Table 7  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) | J-narrow<br>(10) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|------------------|
| WISE J1959–3338                         | Palomar/TSpec     | T8                     | 0.049 ± 0.013             | 0.212 ± 0.011             | 0.245 ± 0.011             | 0.138 ± 0.005             | 0.308 ± 0.008         | 0.652 ± 0.013             | 0.894 ± 0.011    |
| WISE J2018–7423                         | Magellan/FIRE     | T7                     | 0.086 ± 0.004             | 0.307 ± 0.009             | 0.227 ± 0.008             | 0.241 ± 0.005             | 0.384 ± 0.008         | 0.692 ± 0.018             | 0.879 ± 0.008    |
| WISE J2134–7137                         | Magellan/FIRE     | T9 pec                 | 0.019 ± 0.015             | 0.094 ± 0.018             | 0.106 ± 0.020             | 0.070 ± 0.019             | 0.172 ± 0.016         | 0.452 ± 0.031             | 0.780 ± 0.020    |
| WISE J2157+2659                         | Palomar/TSpec     | T7                     | 0.036 ± 0.004             | 0.231 ± 0.006             | 0.206 ± 0.004             | 0.185 ± 0.002             | 0.314 ± 0.004         | 0.670 ± 0.007             | 0.859 ± 0.006    |
| WISE J2209–2734                         | Keck/NIRSPEC-H    | T7                     | ...                       | ...                       | 0.290 ± 0.055             | 0.240 ± 0.033             | ...                   | 0.705 ± 0.044             | ...              |
| WISE J2213+0911                         | IRTF/SpecX        | T7                     | 0.109 ± 0.006             | 0.313 ± 0.008             | 0.238 ± 0.016             | 0.219 ± 0.010             | 0.390 ± 0.012         | 0.690 ± 0.022             | 0.884 ± 0.011    |
| WISE J2226+0440                         | IRTF/SpecX        | T8                     | 0.053 ± 0.006             | 0.193 ± 0.008             | 0.217 ± 0.018             | 0.118 ± 0.009             | 0.352 ± 0.012         | 0.659 ± 0.024             | 0.923 ± 0.013    |
|   | Keck/NIRSPEC-JH   | T8.5                   | 0.062 ± 0.039             | 0.064 ± 0.042             | 0.314 ± 0.034             | 0.099 ± 0.018             | 0.456 ± 0.034         | 0.669 ± 0.027             | 1.018 ± 0.070    |
| WISE J2237–0614                         | IRTF/SpecX        | T5                     | 0.206 ± 0.015             | 0.374 ± 0.018             | 0.403 ± 0.033             | 0.415 ± 0.024             | 0.602 ± 0.020         | 0.863 ± 0.036             | 0.917 ± 0.023    |
| WISE J2239+1617                         | IRTF/SpecX        | T3                     | 0.417 ± 0.006             | 0.645 ± 0.007             | 0.510 ± 0.012             | 0.727 ± 0.007             | 0.682 ± 0.008         | 0.818 ± 0.013             | 0.932 ± 0.009    |
| WISE J2255–3118                         | IRTF/SpecX        | T8                     | 0.037 ± 0.011             | 0.300 ± 0.015             | 0.159 ± 0.022             | 0.101 ± 0.014             | 0.254 ± 0.014         | 0.597 ± 0.033             | 0.894 ± 0.017    |
|   | Keck/NIRSPEC-H    | T8                     | ...                       | ...                       | 0.205 ± 0.033             | 0.097 ± 0.019             | ...                   | 0.462 ± 0.024             | ...              |
| WISE J2313–8037                         | Magellan/FIRE     | T8                     | 0.041 ± 0.004             | 0.163 ± 0.010             | 0.155 ± 0.007             | 0.136 ± 0.006             | 0.268 ± 0.012         | 0.555 ± 0.017             | 0.861 ± 0.009    |
| WISE J2319–1844                         | IRTF/SpecX        | T7.5                   | 0.078 ± 0.019             | 0.309 ± 0.024             | 0.181 ± 0.038             | 0.122 ± 0.028             | 0.336 ± 0.024         | 0.587 ± 0.048             | 0.832 ± 0.026    |
| WISE J2325–4105                         | Magellan/FIRE     | T9 pec                 | 0.011 ± 0.017             | 0.146 ± 0.024             | 0.062 ± 0.022             | 0.118 ± 0.019             | 0.184 ± 0.016         | 0.461 ± 0.027             | 0.799 ± 0.030    |
| WISE J2340–0745                         | IRTF/SpecX        | T7                     | 0.115 ± 0.005             | 0.299 ± 0.007             | 0.255 ± 0.015             | 0.225 ± 0.008             | 0.422 ± 0.008         | 0.739 ± 0.017             | 0.883 ± 0.010    |
| WISE J2343–7418                         | Magellan/FIRE     | T6                     | 0.184 ± 0.007             | 0.411 ± 0.014             | 0.289 ± 0.010             | 0.320 ± 0.008             | 0.492 ± 0.010         | 0.726 ± 0.018             | 0.818 ± 0.011    |
| WISE J2344+1034                         | Keck/NIRSPEC-J    | T9                     | –0.001 ± 0.023            | 0.119 ± 0.019             | ...                       | ...                       | 0.148 ± 0.016         | ...                       | 0.944 ± 0.032    |
| WISE J2348–1028                         | IRTF/SpecX        | T7                     | 0.079 ± 0.006             | 0.226 ± 0.008             | 0.213 ± 0.016             | 0.153 ± 0.011             | 0.388 ± 0.010         | 0.714 ± 0.023             | 0.883 ± 0.012    |
| WISE J2359–7335                         | Magellan/FIRE     | T6.5                   | 0.074 ± 0.005             | 0.256 ± 0.010             | 0.260 ± 0.007             | 0.232 ± 0.005             | 0.346 ± 0.008         | 0.670 ± 0.015             | 0.846 ± 0.008    |
| New T Dwarf Discoveries                 |                   |                        |                           |                           |                           |                           |                       |                           |                  |
| WISE J0005+3737                         | Keck/NIRSPEC-J    | T9                     | 0.006 ± 0.019             | 0.130 ± 0.017             | ...                       | ...                       | 0.236 ± 0.014         | ...                       | 0.884 ± 0.024    |
| WISE J0038+2758                         | Keck/NIRSPEC-J    | T9                     | –0.026 ± 0.010            | 0.097 ± 0.011             | ...                       | ...                       | 0.164 ± 0.010         | ...                       | 0.869 ± 0.015    |
| WISE J0038+8405                         | Keck/NIRSPEC-J    | T6                     | 0.155 ± 0.006             | 0.417 ± 0.020             | ...                       | ...                       | 0.452 ± 0.008         | ...                       | 0.857 ± 0.011    |
| WISE J0040+0900                         | IRTF/SpecX        | T7                     | 0.091 ± 0.005             | 0.295 ± 0.007             | 0.242 ± 0.016             | 0.233 ± 0.010             | 0.380 ± 0.010         | 0.678 ± 0.021             | 0.885 ± 0.012    |
| WISE J0045+3611                         | IRTF/SpecX        | T5                     | 0.202 ± 0.004             | 0.382 ± 0.006             | 0.323 ± 0.013             | 0.405 ± 0.010             | 0.498 ± 0.008         | 0.716 ± 0.016             | 0.905 ± 0.010    |
| WISE J0049+2151                         | IRTF/SpecX        | T8.5                   | 0.026 ± 0.005             | 0.166 ± 0.006             | 0.167 ± 0.013             | 0.093 ± 0.007             | 0.304 ± 0.008         | 0.569 ± 0.018             | 0.947 ± 0.011    |
| WISE J0135+1715                         | IRTF/SpecX        | T6                     | 0.147 ± 0.015             | 0.353 ± 0.019             | 0.313 ± 0.033             | 0.284 ± 0.025             | 0.518 ± 0.024         | 0.737 ± 0.042             | 0.899 ± 0.028    |
| WISE J0210+4008                         | IRTF/SpecX        | T4.5                   | 0.335 ± 0.008             | 0.473 ± 0.010             | 0.388 ± 0.019             | 0.491 ± 0.014             | 0.636 ± 0.012         | 0.809 ± 0.021             | 0.869 ± 0.013    |
| WISE J0233+3030                         | IRTF/SpecX        | T6                     | 0.218 ± 0.010             | 0.382 ± 0.014             | 0.358 ± 0.024             | 0.332 ± 0.020             | 0.536 ± 0.018         | 0.750 ± 0.038             | 0.871 ± 0.021    |
| WISE J0245–3450                         | IRTF/SpecX        | T8                     | 0.050 ± 0.017             | 0.208 ± 0.021             | 0.196 ± 0.032             | 0.133 ± 0.024             | 0.324 ± 0.024         | 0.637 ± 0.048             | 0.940 ± 0.025    |
| WISE J0247+3725                         | Gemini/GNIRS      | T8                     | 0.025 ± 0.007             | 0.173 ± 0.010             | 0.154 ± 0.009             | 0.098 ± 0.008             | 0.272 ± 0.008         | 0.571 ± 0.022             | 0.870 ± 0.012    |
| WISE J0259–0346                         | Keck/NIRSPEC-J    | T5                     | 0.210 ± 0.031             | 0.438 ± 0.036             | ...                       | ...                       | 0.526 ± 0.024         | ...                       | 0.897 ± 0.045    |
| WISE J0316+3820                         | Palomar/TSpec     | T3                     | 0.415 ± 0.017             | 0.570 ± 0.018             | 0.509 ± 0.012             | 0.676 ± 0.009             | 0.686 ± 0.016         | 0.821 ± 0.014             | 0.884 ± 0.021    |
| WISE J0316+4307                         | Keck/NIRSPEC-JH   | T8                     | –0.119 ± 0.025            | 0.214 ± 0.017             | 0.179 ± 0.043             | 0.074 ± 0.030             | 0.230 ± 0.012         | 0.575 ± 0.036             | 0.840 ± 0.018    |
| WISE J0321–7347                         | Magellan/FIRE     | T8                     | 0.052 ± 0.013             | 0.166 ± 0.012             | 0.163 ± 0.014             | 0.101 ± 0.009             | 0.216 ± 0.010         | 0.685 ± 0.013             | 0.933 ± 0.015    |
| WISE J0325–3854                         | Keck/NIRSPEC-J    | T9                     | 0.019 ± 0.041             | 0.135 ± 0.025             | ...                       | ...                       | 0.228 ± 0.018         | ...                       | 0.861 ± 0.036    |
| WISE J0325+0831                         | IRTF/SpecX        | T7                     | 0.097 ± 0.007             | 0.260 ± 0.009             | 0.295 ± 0.015             | 0.240 ± 0.012             | 0.412 ± 0.012         | 0.687 ± 0.026             | 0.897 ± 0.012    |
| WISE J0335+4310                         | Keck/NIRSPEC-J    | T9                     | 0.051 ± 0.013             | 0.138 ± 0.015             | ...                       | ...                       | 0.231 ± 0.011         | ...                       | 0.820 ± 0.019    |
| WISE J0336–0143                         | Keck/NIRSPEC-J    | T8:                    | ...                       | 0.055 ± 0.022             | ...                       | ...                       | 0.216 ± 0.044         | ...                       | 0.947 ± 0.248    |
| WISE J0336+2826                         | IRTF/SpecX        | T5                     | 0.311 ± 0.011             | 0.464 ± 0.016             | 0.371 ± 0.020             | 0.487 ± 0.021             | 0.588 ± 0.018         | 0.784 ± 0.030             | 0.867 ± 0.020    |
| WISE J0413–4750                         | Magellan/FIRE     | T9                     | 0.007 ± 0.009             | 0.034 ± 0.027             | 0.123 ± 0.059             | 0.015 ± 0.015             | 0.154 ± 0.052         | 0.564 ± 0.038             | 0.943 ± 0.020    |
| WISE J0424+0727                         | Keck/NIRSPEC-J    | T7.5                   | 0.048 ± 0.009             | 0.225 ± 0.016             | ...                       | ...                       | 0.356 ± 0.010         | ...                       | 0.911 ± 0.015    |
| WISE J0430+4633                         | Keck/NIRSPEC-J    | T8                     | 0.045 ± 0.008             | 0.210 ± 0.017             | ...                       | ...                       | 0.278 ± 0.008         | ...                       | 0.839 ± 0.013    |
| WISE J0512–3004                         | Keck/NIRSPEC-J    | T8.5                   | 0.092 ± 0.015             | 0.106 ± 0.014             | ...                       | ...                       | 0.231 ± 0.013         | ...                       | 0.918 ± 0.021    |
| WISE J0540+4832                         | Keck/NIRSPEC-J    | T8.5                   | 0.078 ± 0.008             | 0.144 ± 0.010             | ...                       | ...                       | 0.249 ± 0.007         | ...                       | 0.877 ± 0.011    |
| WISE J0546–0959                         | IRTF/SpecX        | T5                     | 0.234 ± 0.008             | 0.550 ± 0.013             | 0.355 ± 0.022             | 0.402 ± 0.015             | 0.602 ± 0.014         | 0.763 ± 0.029             | 0.973 ± 0.019    |
| WISE J0614+0951                         | Palomar/TSpec     | T7                     | 0.109 ± 0.001             | 0.287 ± 0.002             | 0.285 ± 0.002             | 0.212 ± 0.002             | 0.348 ± 0.002         | 0.712 ± 0.003             | 0.826 ± 0.003    |

Table 7  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) | J-narrow<br>(10) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|------------------|
| WISE J0629+2418                         | IRTF/Spex         | T2 sb                  | 0.451 ± 0.013             | 0.691 ± 0.019             | 0.561 ± 0.021             | 0.839 ± 0.017             | 0.662 ± 0.022         | 0.852 ± 0.024             | 0.925 ± 0.020    |
| WISE J0642+4101                         | Palomar/TSpec     | extr. red              | 0.539 ± 0.003             | 0.881 ± 0.003             | 0.606 ± 0.002             | 1.202 ± 0.003             | 0.738 ± 0.002         | 0.834 ± 0.002             | 0.949 ± 0.003    |
| WISE J0701+6321                         | Palomar/TSpec     | T3                     | 0.390 ± 0.001             | 0.685 ± 0.002             | 0.475 ± 0.001             | 0.790 ± 0.001             | 0.646 ± 0.002         | 0.819 ± 0.002             | 0.914 ± 0.002    |
| WISE J0723+3403                         | Keck/NIRSPEC-J    | T9:                    | ...                       | ...                       | ...                       | ...                       | 0.142 ± 0.063         | ...                       | 0.885 ± 0.101    |
| WISE J0733+7544                         | Palomar/TSpec     | T6                     | 0.141 ± 0.002             | 0.366 ± 0.003             | 0.309 ± 0.003             | 0.323 ± 0.003             | 0.444 ± 0.002         | 0.746 ± 0.004             | 0.845 ± 0.004    |
| WISE J0754+7909                         | Palomar/TSpec     | extr. red              | 0.476 ± 0.003             | 0.800 ± 0.004             | 0.443 ± 0.003             | 1.081 ± 0.002             | 0.774 ± 0.002         | 0.815 ± 0.003             | 0.978 ± 0.003    |
| WISE J0811–8051                         | Magellan/FIRE     | T9.5:                  | 0.034 ± 0.058             | 0.037 ± 0.030             | –0.198 ± 0.067            | –0.072 ± 0.047            | 0.146 ± 0.024         | 0.584 ± 0.071             | 0.900 ± 0.052    |
| WISE J0812+4021                         | Gemini/GNIRS      | T8                     | 0.054 ± 0.005             | 0.204 ± 0.009             | 0.221 ± 0.009             | 0.118 ± 0.008             | 0.308 ± 0.008         | 0.671 ± 0.016             | 0.881 ± 0.011    |
| WISE J1025+0307                         | Magellan/FIRE     | T8.5                   | 0.025 ± 0.003             | 0.118 ± 0.004             | 0.111 ± 0.003             | 0.079 ± 0.002             | 0.242 ± 0.004         | 0.547 ± 0.005             | 0.877 ± 0.006    |
| WISE J1039–1600                         | IRTF/Spex         | T7.5                   | 0.090 ± 0.015             | 0.296 ± 0.021             | 0.180 ± 0.032             | 0.141 ± 0.022             | 0.314 ± 0.024         | 0.637 ± 0.046             | 0.865 ± 0.026    |
| WISE J1050+5056                         | Keck/NIRSPEC-J    | T8                     | 0.041 ± 0.013             | 0.210 ± 0.017             | ...                       | ...                       | 0.321 ± 0.010         | ...                       | 0.842 ± 0.017    |
| WISE J1051–2138                         | Palomar/TSpec     | T9:                    | 0.138 ± 0.012             | 0.122 ± 0.008             | 0.223 ± 0.012             | 0.081 ± 0.007             | 0.282 ± 0.006         | 0.543 ± 0.014             | 0.941 ± 0.014    |
| WISE J1124–0421                         | IRTF/Spex         | T7                     | 0.108 ± 0.006             | 0.324 ± 0.008             | 0.235 ± 0.018             | 0.229 ± 0.011             | 0.366 ± 0.010         | 0.623 ± 0.023             | 0.862 ± 0.011    |
| WISE J1143+4431                         | Keck/NIRSPEC-J    | T8.5                   | 0.071 ± 0.034             | 0.165 ± 0.024             | ...                       | ...                       | 0.238 ± 0.019         | ...                       | 0.839 ± 0.038    |
| WISE J1221–3136                         | IRTF/Spex         | T6.5                   | 0.139 ± 0.008             | 0.341 ± 0.011             | 0.285 ± 0.026             | 0.262 ± 0.016             | 0.424 ± 0.016         | 0.633 ± 0.034             | 0.830 ± 0.016    |
| WISE J1225–1013                         | IRTF/Spex         | T6                     | 0.161 ± 0.006             | 0.417 ± 0.008             | 0.276 ± 0.016             | 0.303 ± 0.012             | 0.466 ± 0.010         | 0.744 ± 0.023             | 0.875 ± 0.011    |
| WISE J1250+2628                         | Keck/NIRSPEC-J    | T6.5                   | 0.131 ± 0.004             | 0.349 ± 0.010             | ...                       | ...                       | 0.412 ± 0.008         | ...                       | 0.802 ± 0.008    |
| WISE J1257+4008                         | IRTF/Spex         | T7                     | 0.100 ± 0.013             | 0.390 ± 0.019             | 0.217 ± 0.029             | 0.188 ± 0.020             | 0.385 ± 0.021         | 0.668 ± 0.044             | 0.801 ± 0.022    |
| WISE J1301–0302                         | Keck/NIRSPEC-J    | T8.5                   | –0.002 ± 0.024            | 0.194 ± 0.022             | ...                       | ...                       | 0.265 ± 0.015         | ...                       | 0.861 ± 0.026    |
| WISE J1318–1758                         | Palomar/TSpec     | T9:                    | 0.080 ± 0.006             | 0.115 ± 0.005             | 0.146 ± 0.007             | 0.121 ± 0.005             | 0.236 ± 0.006         | 0.652 ± 0.010             | 0.906 ± 0.009    |
| WISE J1337+2636                         | Keck/NIRSPEC-J    | T5                     | 0.182 ± 0.007             | 0.407 ± 0.013             | ...                       | ...                       | 0.518 ± 0.010         | ...                       | 0.870 ± 0.012    |
| WISE J1400–3850                         | IRTF/Spex         | T4                     | 0.402 ± 0.018             | 0.614 ± 0.022             | 0.439 ± 0.026             | 0.553 ± 0.021             | 0.708 ± 0.020         | 0.867 ± 0.028             | 0.910 ± 0.022    |
| WISE J1517+0529                         | Keck/NIRSPEC-J    | T8                     | 0.079 ± 0.032             | 0.177 ± 0.026             | ...                       | ...                       | 0.297 ± 0.018         | ...                       | 0.870 ± 0.036    |
| WISE J1523+3125                         | Gemini/GNIRS      | T6.5 pec               | 0.084 ± 0.010             | 0.334 ± 0.020             | 0.219 ± 0.014             | 0.280 ± 0.020             | 0.380 ± 0.012         | 0.669 ± 0.027             | 0.881 ± 0.017    |
| WISE J1542+2230                         | HST/WFC3          | T9.5                   | 0.015 ± 0.016             | 0.100 ± 0.017             | 0.108 ± 0.016             | 0.116 ± 0.017             | 0.166 ± 0.022         | 0.419 ± 0.031             | 0.782 ± 0.034    |
| WISE J1544+5842                         | Keck/NIRSPEC-J    | T7.5                   | 0.086 ± 0.038             | 0.205 ± 0.037             | ...                       | ...                       | 0.370 ± 0.028         | ...                       | 0.975 ± 0.060    |
| WISE J1632+0329                         | IRTF/Spex         | T5                     | 0.222 ± 0.017             | 0.421 ± 0.022             | 0.243 ± 0.031             | 0.452 ± 0.030             | 0.536 ± 0.024         | 0.795 ± 0.050             | 0.894 ± 0.041    |
| WISE J1636–0743                         | IRTF/Spex         | T4.5                   | 0.390 ± 0.024             | 0.670 ± 0.029             | 0.363 ± 0.037             | 0.601 ± 0.030             | 0.694 ± 0.028         | 0.794 ± 0.050             | 0.947 ± 0.037    |
| WISE J1707–1744                         | Palomar/TSpec     | T5:                    | 0.228 ± 0.014             | 0.393 ± 0.019             | 0.307 ± 0.017             | 0.425 ± 0.013             | 0.540 ± 0.014         | 0.789 ± 0.022             | 0.891 ± 0.023    |
| WISE J1721+1117                         | IRTF/Spex         | T6                     | 0.149 ± 0.019             | 0.435 ± 0.026             | 0.240 ± 0.039             | 0.294 ± 0.032             | 0.444 ± 0.026         | 0.688 ± 0.058             | 0.876 ± 0.034    |
| WISE J1730+4207                         | IRTF/Spex         | T0 sb                  | 0.551 ± 0.011             | 0.758 ± 0.016             | 0.636 ± 0.017             | 0.832 ± 0.013             | 0.754 ± 0.016         | 0.869 ± 0.019             | 0.890 ± 0.019    |
| WISE J1734+5023                         | IRTF/Spex         | T4                     | 0.398 ± 0.007             | 0.392 ± 0.006             | 0.449 ± 0.013             | 0.528 ± 0.010             | 0.678 ± 0.010         | 0.840 ± 0.014             | 0.892 ± 0.011    |
| WISE J1736+6059                         | Keck/NIRSPEC-J    | T8                     | 0.075 ± 0.010             | 0.195 ± 0.015             | ...                       | ...                       | 0.274 ± 0.009         | ...                       | 0.803 ± 0.016    |
| WISE J1738+6142                         | Palomar/TSpec     | extr. red              | 0.553 ± 0.040             | 0.882 ± 0.045             | 0.647 ± 0.017             | 1.139 ± 0.016             | 0.700 ± 0.036         | 0.829 ± 0.017             | 0.955 ± 0.066    |
|   | IRTF/Spex         | extr. red              | 0.572 ± 0.026             | 0.892 ± 0.036             | 0.632 ± 0.024             | 1.087 ± 0.023             | 0.847 ± 0.031         | 0.822 ± 0.024             | 0.992 ± 0.038    |
| WISE J1741+1327                         | IRTF/Spex         | T5                     | 0.249 ± 0.020             | 0.486 ± 0.024             | 0.362 ± 0.036             | 0.366 ± 0.030             | 0.564 ± 0.024         | 0.726 ± 0.047             | 0.884 ± 0.029    |
| WISE J1743+4211                         | Palomar/TSpec     | T4.5                   | 0.380 ± 0.006             | 0.562 ± 0.011             | 0.392 ± 0.007             | 0.511 ± 0.006             | 0.614 ± 0.008         | 0.768 ± 0.010             | 0.871 ± 0.011    |
| WISE J1745+6459                         | Keck/NIRSPEC-J    | T7                     | 0.155 ± 0.020             | 0.297 ± 0.023             | ...                       | ...                       | 0.393 ± 0.015         | ...                       | 0.854 ± 0.026    |
| WISE J1746–0338                         | Palomar/TSpec     | T6                     | 0.180 ± 0.012             | 0.348 ± 0.016             | 0.337 ± 0.015             | 0.303 ± 0.011             | 0.470 ± 0.012         | 0.764 ± 0.020             | 0.893 ± 0.017    |
| WISE J1755+1803                         | Palomar/TSpec     | T2                     | 0.531 ± 0.009             | 0.720 ± 0.012             | 0.526 ± 0.008             | 0.857 ± 0.006             | 0.706 ± 0.010         | 0.835 ± 0.008             | 0.906 ± 0.014    |
| WISE J1759+5442                         | Keck/NIRSPEC-J    | T7                     | 0.111 ± 0.016             | 0.247 ± 0.019             | ...                       | ...                       | 0.363 ± 0.012         | ...                       | 0.894 ± 0.021    |
| WISE J1809–0448                         | IRTF/Spex         | T0.5                   | 0.622 ± 0.008             | 0.781 ± 0.009             | 0.607 ± 0.012             | 0.948 ± 0.010             | 0.826 ± 0.010         | 0.878 ± 0.012             | 0.925 ± 0.010    |

Table 7  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1)                           | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) | J-narrow<br>(10) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|------------------|
| WISE J1812+2007   | Keck/NIRSPEC-J    | T9                     | 0.014 ± 0.023             | 0.135 ± 0.021             | ...                       | ...                       | 0.204 ± 0.016         | ...                       | 0.900 ± 0.035    |
| WISE J1813+2835   | Keck/NIRSPEC-J    | T8                     | 0.044 ± 0.005             | 0.170 ± 0.010             | ...                       | ...                       | 0.267 ± 0.007         | ...                       | 0.859 ± 0.009    |
| WISE J1840+2932   | Keck/NIRSPEC-J    | T6                     | 0.194 ± 0.018             | 0.339 ± 0.027             | ...                       | ...                       | 0.467 ± 0.015         | ...                       | 0.895 ± 0.028    |
| WISE J1909–5204   | Magellan/FIRE     | T5.5                   | 0.222 ± 0.007             | 0.484 ± 0.011             | 0.330 ± 0.009             | 0.329 ± 0.007             | 0.504 ± 0.009         | 0.761 ± 0.012             | 0.841 ± 0.011    |
| WISE J1913+6444   | Palomar/TSpec     | T5:                    | 0.296 ± 0.023             | 0.509 ± 0.027             | 0.367 ± 0.027             | 0.426 ± 0.020             | 0.538 ± 0.020         | 0.837 ± 0.033             | 0.911 ± 0.033    |
| WISE J1928+2356   | IRTF/SpEx         | T6                     | 0.175 ± 0.001             | 0.431 ± 0.002             | 0.294 ± 0.003             | 0.357 ± 0.003             | 0.520 ± 0.002         | 0.695 ± 0.004             | 0.912 ± 0.003    |
| WISE J1954+6915   | Keck/NIRSPEC-J    | T5.5                   | 0.189 ± 0.011             | 0.473 ± 0.018             | ...                       | ...                       | 0.500 ± 0.010         | ...                       | 0.895 ± 0.015    |
| WISE J1955–2540   | Keck/NIRSPEC-J    | T8                     | 0.005 ± 0.013             | 0.151 ± 0.015             | ...                       | ...                       | 0.266 ± 0.010         | ...                       | 0.875 ± 0.017    |
| WISE J2008–0834   | IRTF/SpEx         | T5.5                   | 0.205 ± 0.006             | 0.318 ± 0.007             | 0.344 ± 0.022             | 0.364 ± 0.013             | 0.552 ± 0.012         | 0.835 ± 0.025             | 0.904 ± 0.013    |
| WISE J2014+0424   | Gemini/GNIRS      | T6.5 pec               | 0.083 ± 0.006             | 0.291 ± 0.013             | 0.202 ± 0.010             | 0.275 ± 0.010             | 0.400 ± 0.008         | 0.726 ± 0.018             | 0.919 ± 0.013    |
| WISE J2015+6646   | Palomar/TSpec     | T8                     | 0.072 ± 0.013             | 0.191 ± 0.014             | 0.167 ± 0.015             | 0.156 ± 0.010             | 0.324 ± 0.012         | 0.604 ± 0.020             | 0.839 ± 0.019    |
| WISE J2019–1148   | Palomar/TSpec     | T8:                    | 0.062 ± 0.036             | 0.122 ± 0.021             | 0.162 ± 0.030             | 0.135 ± 0.020             | 0.234 ± 0.020         | 0.649 ± 0.037             | 0.924 ± 0.042    |
| WISE J2030+0749   | IRTF/SpEx         | T1.5                   | 0.603 ± 0.003             | 0.787 ± 0.003             | 0.580 ± 0.003             | 0.885 ± 0.003             | 0.806 ± 0.004         | 0.863 ± 0.004             | 0.916 ± 0.004    |
| WISE J2043+6220   | IRTF/SpEx         | T1.5                   | 0.561 ± 0.012             | 0.639 ± 0.014             | 0.545 ± 0.017             | 0.923 ± 0.014             | 0.800 ± 0.017         | 0.890 ± 0.020             | 0.943 ± 0.017    |
| WISE J2123–2614   | IRTF/SpEx         | T5.5                   | 0.230 ± 0.022             | 0.452 ± 0.027             | 0.266 ± 0.051             | 0.334 ± 0.040             | 0.542 ± 0.030         | 0.840 ± 0.061             | 0.930 ± 0.031    |
| WISE J2147–1029   | Keck/NIRSPEC-J    | T7.5                   | 0.071 ± 0.011             | 0.212 ± 0.016             | ...                       | ...                       | 0.339 ± 0.010         | ...                       | 0.888 ± 0.015    |
| WISE J2236+5105   | Palomar/TSpec     | T5.5                   | 0.186 ± 0.001             | 0.406 ± 0.001             | 0.296 ± 0.001             | 0.439 ± 0.001             | 0.474 ± 0.000         | 0.712 ± 0.002             | 0.826 ± 0.001    |
| WISE J2237+7228   | Keck/NIRSPEC-J    | T6                     | 0.172 ± 0.006             | 0.389 ± 0.014             | ...                       | ...                       | 0.478 ± 0.010         | ...                       | 0.881 ± 0.012    |
| WISE J2301+0216   | IRTF/SpEx         | T6.5                   | 0.135 ± 0.008             | 0.308 ± 0.012             | 0.309 ± 0.021             | 0.256 ± 0.014             | 0.440 ± 0.014         | 0.766 ± 0.029             | 0.867 ± 0.018    |
| WISE J2303+1914   | Palomar/TSpec     | T4:                    | 0.409 ± 0.004             | 0.557 ± 0.005             | 0.372 ± 0.005             | 0.538 ± 0.003             | 0.664 ± 0.004         | 0.847 ± 0.005             | 0.906 ± 0.007    |
| WISE J2335+4222   | Keck/NIRSPEC-JH   | T7                     | 0.101 ± 0.011             | 0.275 ± 0.020             | 0.295 ± 0.018             | 0.215 ± 0.014             | 0.384 ± 0.012         | 0.674 ± 0.019             | 0.891 ± 0.019    |
| WISE J2357+1227   | IRTF/SpEx         | T6                     | 0.145 ± 0.007             | 0.452 ± 0.010             | 0.257 ± 0.017             | 0.267 ± 0.012             | 0.408 ± 0.010         | 0.682 ± 0.025             | 0.838 ± 0.013    |
| T Dwarfs from Table 6   |                   |                        |                           |                           |                           |                           |                       |                           |                  |
| WISE J0920+4538   | Palomar/TSpec     | L9 sb?                 | 0.603 ± 0.001             | 0.865 ± 0.002             | 0.613 ± 0.002             | 0.998 ± 0.001             | 0.774 ± 0.002         | 0.876 ± 0.002             | 0.949 ± 0.002    |
| ULAS J0950+0117   | Magellan/FIRE     | T8                     | 0.050 ± 0.003             | 0.220 ± 0.006             | 0.159 ± 0.003             | 0.160 ± 0.003             | 0.344 ± 0.005         | 0.592 ± 0.007             | 0.936 ± 0.007    |
| WISE J1246–3139   | Palomar/TSpec     | T1                     | 0.542 ± 0.002             | 0.791 ± 0.002             | 0.548 ± 0.002             | 0.905 ± 0.001             | 0.784 ± 0.002         | 0.877 ± 0.002             | 0.939 ± 0.002    |
| LHS 2803B   | IRTF/SpEx         | T5.5                   | 0.168 ± 0.009             | 0.308 ± 0.012             | 0.285 ± 0.029             | 0.432 ± 0.021             | 0.540 ± 0.017         | 0.726 ± 0.037             | 0.920 ± 0.019    |
| BD +01° 2920B   | Magellan/FIRE     | T8                     | 0.052 ± 0.007             | 0.206 ± 0.007             | 0.218 ± 0.010             | 0.156 ± 0.008             | 0.321 ± 0.007         | 0.686 ± 0.016             | 0.862 ± 0.009    |
| WISE J1449+1147   | Gemini/GNIRS      | T5 pec                 | 0.223 ± 0.006             | 0.436 ± 0.012             | 0.292 ± 0.008             | 0.415 ± 0.010             | 0.552 ± 0.010         | 0.781 ± 0.015             | 0.915 ± 0.012    |
|   | Palomar/TSpec     | T5 pec                 | 0.236 ± 0.015             | 0.392 ± 0.019             | 0.310 ± 0.018             | 0.423 ± 0.013             | 0.550 ± 0.014         | 0.792 ± 0.023             | 0.893 ± 0.023    |
| PSOJ226.25–28.89  | Palomar/TSpec     | T2:                    | 0.687 ± 0.014             | 0.736 ± 0.015             | 0.571 ± 0.009             | 0.847 ± 0.007             | 0.798 ± 0.010         | 0.842 ± 0.009             | 0.926 ± 0.012    |
| VHS J1543–0439  | IRTF/SpEx         | T5:                    | 0.325 ± 0.024             | 0.477 ± 0.029             | 0.372 ± 0.040             | 0.486 ± 0.037             | 0.624 ± 0.034         | 0.681 ± 0.051             | 0.876 ± 0.050    |
| PSOJ246.42+15.46  | Palomar/TSpec     | T4.5:                  | 0.315 ± 0.014             | 0.500 ± 0.017             | 0.396 ± 0.014             | 0.465 ± 0.011             | 0.602 ± 0.012         | 0.818 ± 0.018             | 0.883 ± 0.019    |
| PSOJ247.32+03.59  | Palomar/TSpec     | T2                     | 0.443 ± 0.004             | 0.684 ± 0.007             | 0.449 ± 0.003             | 0.909 ± 0.004             | 0.684 ± 0.004         | 0.764 ± 0.005             | 0.935 ± 0.005    |
| WISE J1717+6128   | Gemini/GNIRS      | T8                     | 0.036 ± 0.014             | 0.198 ± 0.017             | 0.203 ± 0.015             | 0.134 ± 0.018             | 0.306 ± 0.014         | 0.655 ± 0.033             | 0.912 ± 0.026    |
| WISE J1809+3838   | IRTF/SpEx         | T7.5                   | 0.069 ± 0.018             | 0.266 ± 0.025             | 0.199 ± 0.032             | 0.154 ± 0.024             | 0.348 ± 0.026         | 0.582 ± 0.053             | 0.892 ± 0.036    |
| WISE J2342+0856   | IRTF/SpEx         | T6.5                   | 0.115 ± 0.006             | 0.380 ± 0.009             | 0.221 ± 0.016             | 0.276 ± 0.010             | 0.408 ± 0.010         | 0.672 ± 0.023             | 0.885 ± 0.012    |
| WISE J2344+1034   | Gemini/GNIRS      | T9                     | 0.028 ± 0.009             | 0.095 ± 0.010             | 0.144 ± 0.012             | 0.070 ± 0.014             | 0.196 ± 0.010         | 0.522 ± 0.027             | 0.857 ± 0.020    |
| Y Dwarfs from Cushing et al. (2011) and Kirkpatrick et al. (2012) |                   |                        |                           |                           |                           |                           |                       |                           |                  |
| WISE J0146+4234   | Keck/NIRSPEC-JH   | Y0                     | –0.115 ± 0.032            | 0.070 ± 0.021             | –0.019 ± 0.081            | –0.032 ± 0.038            | 0.150 ± 0.014         | 0.185 ± 0.037             | 0.805 ± 0.030    |
| WISE J0350–5658   | HST/WFC3          | Y1                     | –0.055 ± 0.071            | 0.068 ± 0.049             | 0.118 ± 0.054             | ...                       | 0.116 ± 0.096         | 0.401 ± 0.068             | 0.676 ± 0.095    |
| WISE J0359–5401   | HST/WFC3          | Y0                     | –0.020 ± 0.055            | 0.068 ± 0.037             | 0.144 ± 0.055             | 0.101 ± 0.058             | 0.170 ± 0.040         | 0.483 ± 0.067             | 0.801 ± 0.074    |
| WISE J0410+1502   | Magellan/FIRE     | Y0                     | –0.002 ± 0.082            | 0.026 ± 0.040             | –0.065 ± 0.424            | –0.160 ± 0.375            | 0.126 ± 0.042         | 0.349 ± 0.732             | 0.822 ± 0.074    |
| WISE J0713–2917   | Keck/NIRSPEC-J    | Y0                     | –0.029 ± 0.035            | 0.016 ± 0.019             | ...                       | ...                       | 0.046 ± 0.014         | ...                       | 0.724 ± 0.024    |
| WISE J0734–7157   | Magellan/FIRE     | Y0                     | –0.042 ± 0.044            | 0.037 ± 0.020             | 0.298 ± 0.047             | 0.020 ± 0.024             | 0.162 ± 0.024         | 0.484 ± 0.040             | 0.821 ± 0.034    |
| WISE J1405+5534   | HST/WFC3          | Y0 (pec?)              | –0.056 ± 0.035            | –0.008 ± 0.023            | 0.001 ± 0.020             | 0.121 ± 0.029             | 0.068 ± 0.028         | 0.356 ± 0.040             | 0.696 ± 0.037    |
| WISE J1541–2250   | Magellan/FIRE     | Y0.5                   | –0.024 ± 0.422            | 0.061 ± 0.238             | 0.075 ± 0.276             | 0.034 ± 0.199             | 0.088 ± 0.212         | 0.289 ± 0.246             | 0.747 ± 0.393    |

**Table 7**  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) | J-narrow<br>(10) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|------------------|
| WISE J1828+2650                         | <i>HST</i> /WFC3  | ≥Y2                    | 0.337 ± 0.198             | 0.254 ± 0.130             | 0.101 ± 0.123             | 0.114 ± 0.133             | 0.522 ± 0.142         | 0.469 ± 0.154             | 0.872 ± 0.289    |
| WISE J2056+1459                         | <i>HST</i> /WFC3  | Y0                     | 0.052 ± 0.009             | 0.096 ± 0.010             | 0.186 ± 0.011             | 0.223 ± 0.010             | 0.130 ± 0.014         | 0.481 ± 0.024             | 0.755 ± 0.016    |
| WISE J2220–3628                         | Keck/NIRSPEC-H    | Y0                     | ...                       | ...                       | 0.154 ± 0.032             | 0.015 ± 0.025             | ...                   | 0.420 ± 0.031             | 0.742 ± 0.046    |

**Note.** <sup>a</sup> Spectra from Adam Burgasser’s SpeX Prism Spectral Library.

**Table 8**  
Average Median-flux Spectral Indices for Each Half Spectral Type

| NIR Sp.<br>Type<br>(1) | H <sub>2</sub> O–J<br>(2) | CH <sub>4</sub> –J<br>(3) | H <sub>2</sub> O–H<br>(4) | CH <sub>4</sub> –H<br>(5) | W <sub>J</sub><br>(6) | NH <sub>3</sub> –H<br>(7) | J-narrow<br>(8) | Y/J<br>(9)    | H/J<br>(10)   | K/J<br>(11)   |
|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|-----------------|---------------|---------------|---------------|
| T0                     | 0.647 ± 0.054             | 0.841 ± 0.063             | 0.651 ± 0.036             | 0.970 ± 0.054             | 0.803 ± 0.030         | 0.884 ± 0.021             | 0.928 ± 0.024   | 0.579 ± 0.033 | 0.846 ± 0.051 | 0.496 ± 0.060 |
| T0.5                   | 0.581 ± 0.087             | 0.802 ± 0.050             | 0.591 ± 0.074             | 1.035 ± 0.100             | 0.790 ± 0.036         | 0.850 ± 0.039             | 0.934 ± 0.028   | 0.567 ± 0.040 | 0.854 ± 0.037 | 0.554 ± 0.121 |
| T1                     | 0.572 ± 0.079             | 0.772 ± 0.064             | 0.582 ± 0.041             | 0.912 ± 0.068             | 0.766 ± 0.080         | 0.853 ± 0.018             | 0.922 ± 0.028   | 0.557 ± 0.076 | 0.814 ± 0.033 | 0.445 ± 0.053 |
| T1.5                   | 0.537 ± 0.068             | 0.728 ± 0.067             | 0.518 ± 0.045             | 0.924 ± 0.059             | 0.777 ± 0.040         | 0.840 ± 0.051             | 0.937 ± 0.017   | 0.585 ± 0.051 | 0.734 ± 0.023 | 0.344 ± 0.033 |
| T2                     | 0.490 ± 0.071             | 0.707 ± 0.077             | 0.522 ± 0.052             | 0.861 ± 0.064             | 0.712 ± 0.055         | 0.828 ± 0.045             | 0.916 ± 0.030   | 0.532 ± 0.039 | 0.732 ± 0.035 | 0.370 ± 0.060 |
| T2.5                   | 0.457 ± 0.037             | 0.679 ± 0.055             | 0.490 ± 0.033             | 0.813 ± 0.059             | 0.697 ± 0.040         | 0.813 ± 0.032             | 0.914 ± 0.007   | 0.537 ± 0.023 | 0.687 ± 0.030 | 0.314 ± 0.026 |
| T3                     | 0.410 ± 0.035             | 0.625 ± 0.061             | 0.485 ± 0.038             | 0.722 ± 0.047             | 0.685 ± 0.048         | 0.802 ± 0.042             | 0.911 ± 0.019   | 0.563 ± 0.053 | 0.660 ± 0.030 | 0.281 ± 0.046 |
| T3.5                   | 0.368 ± 0.096             | 0.604 ± 0.071             | 0.390 ± 0.042             | 0.702 ± 0.042             | 0.621 ± 0.072         | 0.759 ± 0.038             | 0.900 ± 0.026   | 0.510 ± 0.018 | 0.611 ± 0.027 | 0.233 ± 0.032 |
| T4                     | 0.378 ± 0.026             | 0.558 ± 0.075             | 0.393 ± 0.031             | 0.571 ± 0.045             | 0.648 ± 0.034         | 0.801 ± 0.039             | 0.894 ± 0.022   | 0.481 ± 0.062 | 0.583 ± 0.041 | 0.208 ± 0.029 |
| T4.5                   | 0.325 ± 0.041             | 0.557 ± 0.054             | 0.376 ± 0.023             | 0.503 ± 0.059             | 0.623 ± 0.036         | 0.788 ± 0.027             | 0.894 ± 0.032   | 0.476 ± 0.031 | 0.533 ± 0.030 | 0.191 ± 0.029 |
| T5                     | 0.238 ± 0.037             | 0.462 ± 0.047             | 0.336 ± 0.041             | 0.416 ± 0.038             | 0.552 ± 0.039         | 0.764 ± 0.050             | 0.887 ± 0.027   | 0.495 ± 0.054 | 0.476 ± 0.028 | 0.152 ± 0.038 |
| T5.5                   | 0.197 ± 0.040             | 0.427 ± 0.087             | 0.313 ± 0.037             | 0.365 ± 0.053             | 0.512 ± 0.050         | 0.738 ± 0.054             | 0.888 ± 0.028   | 0.444 ± 0.048 | 0.480 ± 0.041 | 0.160 ± 0.036 |
| T6                     | 0.155 ± 0.024             | 0.379 ± 0.039             | 0.297 ± 0.031             | 0.303 ± 0.028             | 0.467 ± 0.029         | 0.739 ± 0.030             | 0.877 ± 0.026   | 0.458 ± 0.047 | 0.461 ± 0.021 | 0.135 ± 0.035 |
| T6.5                   | 0.117 ± 0.023             | 0.320 ± 0.075             | 0.260 ± 0.044             | 0.250 ± 0.023             | 0.398 ± 0.062         | 0.706 ± 0.058             | 0.864 ± 0.038   | 0.448 ± 0.063 | 0.472 ± 0.018 | 0.137 ± 0.049 |
| T7                     | 0.090 ± 0.032             | 0.290 ± 0.048             | 0.241 ± 0.030             | 0.200 ± 0.033             | 0.387 ± 0.028         | 0.676 ± 0.042             | 0.880 ± 0.033   | 0.424 ± 0.062 | 0.477 ± 0.030 | 0.148 ± 0.026 |
| T7.5                   | 0.063 ± 0.017             | 0.243 ± 0.047             | 0.183 ± 0.023             | 0.157 ± 0.026             | 0.344 ± 0.023         | 0.637 ± 0.050             | 0.899 ± 0.037   | 0.450 ± 0.066 | 0.489 ± 0.025 | 0.111 ± 0.044 |
| T8                     | 0.056 ± 0.060             | 0.200 ± 0.047             | 0.182 ± 0.034             | 0.126 ± 0.033             | 0.303 ± 0.044         | 0.625 ± 0.054             | 0.890 ± 0.036   | 0.429 ± 0.089 | 0.498 ± 0.047 | 0.118 ± 0.038 |
| T8.5                   | 0.051 ± 0.035             | 0.188 ± 0.056             | 0.183 ± 0.045             | 0.122 ± 0.035             | 0.295 ± 0.047         | 0.610 ± 0.059             | 0.884 ± 0.044   | 0.432 ± 0.082 | 0.503 ± 0.045 | 0.116 ± 0.039 |
| T9                     | 0.032 ± 0.037             | 0.117 ± 0.030             | 0.127 ± 0.045             | 0.068 ± 0.067             | 0.203 ± 0.038         | 0.539 ± 0.054             | 0.879 ± 0.053   | 0.448 ± 0.095 | 0.555 ± 0.030 | 0.100 ± 0.032 |
| T9.5                   | 0.011 ± 0.025             | 0.071 ± 0.032             | 0.100 ± 0.253             | −0.021 ± 0.116            | 0.145 ± 0.021         | 0.443 ± 0.101             | 0.865 ± 0.071   | 0.357 ± 0.008 | 0.504 ± 0.080 | 0.033 ± 0.083 |
| Y0                     | −0.022 ± 0.050            | 0.045 ± 0.031             | 0.116 ± 0.132             | 0.066 ± 0.133             | 0.117 ± 0.043         | 0.385 ± 0.105             | 0.778 ± 0.050   | 0.423 ± 0.131 | 0.467 ± 0.061 | 0.063 ± 0.031 |

to produce a useful index for classifying Y dwarfs using a spectral index. As discussed above, many of the indices derived for T dwarfs have saturated before the T/Y boundary and are no longer useful for Y dwarfs. The K1 doublet at 1.243 and 1.254  $\mu\text{m}$  is a feature present in M though T dwarfs down to mid-type T. The numerator in this index encloses the red member of the *J*-band neutral potassium doublet and the denominator captures the *J*-band flux peak. Variations in the K1 feature are what produce the dispersion and undulation seen in Figure 24 for the T dwarf sequence. Most of our spectra are lower resolution IRTF/SpeX and Palomar/TSpec spectra and the K1 1.254  $\mu\text{m}$  line is barely resolved. In these data, there is no significant difference in the *J*-narrow index when using the median or the integrated flux. In higher-resolution spectra the integrated flux produces slightly lower index values than the median method while increasing the dispersion in each spectral bin by including more spectral variation. To minimize this variability we use the median flux to derive this index. McLean et al. (2003, Figure 15) shows how the K1 lines broaden toward later spectral types, before also decreasing in strength around T6 (McLean et al. 2007). It is this broadening that causes the *J*-narrow index to decrease from T0-T6, and the disappearance of the line in late-type T dwarfs that causes the slight increase in the index before falling for the Y dwarfs as a result of the narrowing *J*-band flux peak.

As discussed in Kirkpatrick et al. (2012), because our by-eye classification of Y dwarfs requires that the *J*-band peak be narrower than the Y0 standard, WISE J173835.52+273258.9, all the other Y0s have smaller *J*-narrow indices. Also, this index is only useful for distinguishing very early-type Y dwarfs from late-type T dwarfs since it does not appear to work well for WISE J1828+2650, which is either much later in type or spectroscopically peculiar. Future use of the *J*-narrow index for higher-resolution spectra may provide a means of sorting each spectral bin by surface gravity by employing the K1 feature (McLean et al. 2003), a pursuit that may be aided by computing the index using the integrated flux.

## 5. CLOUDS AND METALLICITY AT THE T/Y BOUNDARY

Burrows et al. (2006) developed a set of brown dwarf models that combined cloudy and cloudless models to reproduce the observed *J* – *K* colors of L and T dwarfs, respectively. Similar synthetic colors were derived by Saumon & Marley (2008) that matched the overall brown dwarf sequence. Both models failed to match the late-type T dwarf dispersion, which they could modulate through variations in metallicity and binarity (see Figure 15 in Saumon & Marley 2008). Burgasser et al. (2011) utilized the Saumon & Marley (2008) models to determine the best-fit parameters for their five *WISE*-discovered T dwarfs and found that cloudy, low surface gravity models provided the best match to observed spectra.

The addition of sulfide clouds to the brown dwarf models by Morley et al. (2012) reproduces the dispersion of the late-type T dwarf photometry. The flux reversal we see in the *J* – *H* color (and the *H*/*J* index) around T7 corresponds to the turn-off of the late-type T dwarfs from the cloudless models of Morley et al. (2012). Based on this turn-off, the spectral sequence beyond T7 ( $T_{\text{eff}} \leq 800$  K) is possibly dominated by cloudy atmospheres that have redder *H*/*J* and *K*/*J* indices. This includes the T dwarf spectral standards and the Y dwarfs later than Y0. The bluest *H*/*J* and *K*/*J* indices continue the trend of the early-type T dwarfs and are still consistent with cloudless atmospheres. The

Y0s in this case stand-out in the *H*/*J* index as breaking the trend, and may be less cloudy than the later Y dwarfs. Thus, the spectral sequence of the late-type T dwarfs and the early-type Y dwarfs may no longer be correlated directly to temperature, but also to the atmospheric conditions.

The top panel of Figure 25 shows the objects that we have computed indices for, sorted by spectral type. Early-type T dwarfs are uniquely identified by their *K*/*J* index, while late-type T dwarfs have a larger *Y*/*J* dispersion. The T5-T9 spectral standards all have similar index values, and the T8 dwarfs show the largest spread in index values.

The middle panel in Figure 25 depicts the index values for the Morley et al. (2012) sulfide cloud models with solar metallicity, and various gravity and condensate sedimentation efficiencies ( $f_{\text{sed}}$ ), between 400 K and 1300 K. These models do not include silicate clouds, and so they do not replicate the early-type T dwarfs. The cloudless models predict a range of *Y*/*J* index values for the coolest objects when gravity is varied, but relatively little difference for most T dwarfs. Both the *Y* and *J* bands are impacted by the alkali opacity and small variations to the broadening produces large changes in the *Y*/*J* index, so our interpretation here is limited. For  $f_{\text{sed}} = 5$ , the models predict a slight increase in both the *Y*/*J* and *K*/*J* indices before they both decrease, and this matches our measured index values. However, for  $f_{\text{sed}} = 4$  only the  $\log g = 4.5$  model remains consistent with our measurements. Smaller  $f_{\text{sed}}$  values have  $Y/J \leq 0.5$  and large *K*/*J* values that are inconsistent with our measurements.

In the bottom panel of Figure 25 we show the index values for the cloudy (Case E) and cloudless models presented in Burrows et al. (2006), for  $\log g = 5.0$ ,  $T_{\text{eff}}$ s from 800 K to 1700 K, and various metallicities. The highest temperature is marked with a square and the lowest temperature is marked with a circle in the figure. Here we see that the *K*/*J* index produced for the cloudless models, for a specific temperature, do not match the early-type T dwarfs. This figure shows that the cloudy models trace the early-type T dwarfs well and identifies a similar cloudy late-type T population as the Morley et al. (2012) models. Although both the cloudy and cloudless  $-0.5$  dex tracks enclose the increasing *Y*/*J* index values, the cloudless sub-solar metallicity model best matches our measurements.

Overall, the T dwarf spectral standards occupy a minimum in the *Y*/*J* index for the bulk of the late-type T dwarfs. Objects with *Y*/*J* indices below the spectral standards are best matched to cloudy models and possibly oversolar metallicities. Objects with a *Y*/*J* index greater than the standards are best matched to cloudless models and sub-solar metallicities. The *K*/*J* index can be modulated by temperature, metallicity, and surface gravity (Leggett et al. 2007). However, objects with the lowest *K*/*J* values also have the highest *Y*/*J* indices, which is consistent with many *K* band suppressed late-type T dwarfs that are best matched to low-metallicity models.

## 6. INTERLOPERS IN WISE COLOR SPACE

Some of the brown dwarf candidates survived the photometric selection process but were spectroscopically identified as contaminants in our sample. In cases where the acquired spectrum did not match a brown dwarf, we saved images at the telescope to later verify pointing. In the few cases where pointing was questioned, the candidate was added back to the candidate list and the observations were attempted again. If pointing was confirmed, and the observed flux was not that of a brown dwarf, we logged the object as an interloper.

**Table 9**  
*WISE* All-Sky Photometry for Interloper Sources

| Object Name              | W1<br>(mag)  | W2<br>(mag)  | W3<br>(mag)  | W4<br>(mag) | W1 – W2<br>(mag) | W2 – W3<br>(mag) |
|--------------------------|--------------|--------------|--------------|-------------|------------------|------------------|
| (1)                      | (2)          | (3)          | (4)          | (5)         | (6)              | (7)              |
| WISE J004733.81+671834.8 | 17.00 ± 0.15 | 14.21 ± 0.06 | >12.01       | >8.82       | 2.79 ± 0.16      | <2.20            |
| WISE J014837.57–104803.0 | 16.54 ± 0.09 | 14.56 ± 0.06 | 12.67 ± 0.40 | >9.38       | 1.98 ± 0.11      | 1.89 ± 0.41      |
| WISE J020110.08+483633.7 | 17.41 ± 0.22 | 14.67 ± 0.07 | 12.05 ± 0.27 | >9.13       | 2.74 ± 0.23      | 2.62 ± 0.28      |
| WISE J022058.58+620236.4 | >17.42       | 13.04 ± 0.03 | >11.88       | 7.18 ± 0.12 | >4.39            | <1.16            |
| WISE J022116.78+590337.7 | 16.14 ± 0.09 | 14.07 ± 0.06 | 11.01 ± 0.10 | 8.06 ± 0.17 | 2.07 ± 0.10      | 3.06 ± 0.11      |
| WISE J040450.69+261825.1 | 14.23 ± 0.03 | 13.32 ± 0.04 | >12.65       | 8.07 ± 0.22 | 0.91 ± 0.05      | <0.66            |
| WISE J042102.74+372125.2 | 13.72 ± 0.03 | 13.30 ± 0.04 | 11.63 ± 0.27 | 8.59 ± 0.45 | 0.42 ± 0.05      | 1.67 ± 0.27      |
| WISE J044627.93–072611.6 | 16.09 ± 0.06 | 14.22 ± 0.05 | ...          | ...         | 1.87 ± 0.08      | ...              |
| WISE J054319.50+465312.9 | 16.96 ± 0.19 | 13.67 ± 0.04 | 10.61 ± 0.08 | 8.59 ± 0.32 | 3.29 ± 0.19      | 3.06 ± 0.09      |
| WISE J054647.84+263946.4 | 13.11 ± 0.03 | 12.61 ± 0.03 | >12.47       | >8.43       | 0.50 ± 0.04      | <0.15            |
| WISE J055439.47+245728.8 | 16.40 ± 0.11 | 14.20 ± 0.06 | 11.14 ± 0.14 | 7.91 ± 0.17 | 2.21 ± 0.12      | 3.06 ± 0.15      |
| WISE J062748.89–140155.0 | 13.94 ± 0.03 | 13.36 ± 0.04 | 11.49 ± 0.15 | 8.04 ± 0.14 | 0.59 ± 0.05      | 1.87 ± 0.15      |
| WISE J071429.04–121239.5 | 15.67 ± 0.06 | 13.57 ± 0.04 | >12.56       | 8.31 ± 0.23 | 2.11 ± 0.07      | <1.01            |
| WISE J082009.59–761323.1 | 15.38 ± 0.04 | 14.50 ± 0.04 | 12.91 ± 0.34 | >9.76       | 0.89 ± 0.05      | 1.59 ± 0.34      |
| WISE J120854.51–484423.2 | 17.07 ± 0.13 | 14.49 ± 0.05 | 11.33 ± 0.09 | 8.98 ± 0.27 | 2.58 ± 0.14      | 3.16 ± 0.10      |
| WISE J150119.95–045329.7 | 13.87 ± 0.03 | 13.32 ± 0.03 | 12.18 ± 0.26 | >9.51       | 0.55 ± 0.04      | 1.14 ± 0.26      |
| WISE J153015.18–261753.5 | 18.11 ± 0.49 | 14.23 ± 0.06 | 10.47 ± 0.09 | >8.97       | 3.89 ± 0.50      | 3.76 ± 0.11      |
| WISE J154500.53–843159.0 | 17.59 ± 0.19 | 14.81 ± 0.07 | 11.16 ± 0.09 | 8.63 ± 0.26 | 2.78 ± 0.20      | 3.65 ± 0.11      |
| WISE J164312.53+371535.4 | 16.56 ± 0.08 | 13.72 ± 0.04 | 10.85 ± 0.07 | >8.74       | 2.84 ± 0.09      | 2.88 ± 0.08      |
| WISE J165031.12–001417.8 | 16.42 ± 0.10 | 13.88 ± 0.05 | 9.78 ± 0.05  | 8.03 ± 0.20 | 2.54 ± 0.11      | 4.10 ± 0.06      |
| WISE J172256.74+555031.7 | 16.34 ± 0.05 | 14.17 ± 0.04 | 10.85 ± 0.05 | >9.27       | 2.17 ± 0.06      | 3.32 ± 0.06      |
| WISE J175443.93+323332.5 | 17.22 ± 0.14 | 15.54 ± 0.12 | 12.17 ± 0.23 | >8.72       | 1.69 ± 0.19      | 3.37 ± 0.26      |
| WISE J185916.88+362732.5 | >18.42       | 14.53 ± 0.06 | 11.44 ± 0.12 | 9.30 ± 0.48 | >3.89            | 3.09 ± 0.13      |
| WISE J223204.75+384703.8 | 17.22 ± 0.16 | 14.82 ± 0.07 | 12.28 ± 0.27 | 9.37 ± 0.52 | 2.40 ± 0.18      | 2.55 ± 0.28      |
| WISE J224245.85–201511.0 | >18.32       | 15.15 ± 0.13 | 11.73 ± 0.24 | >9.02       | >3.16            | 3.42 ± 0.27      |
| WISE J224416.22+433724.7 | 15.89 ± 0.07 | 14.36 ± 0.05 | 12.57 ± 0.39 | >9.29       | 1.54 ± 0.09      | 1.79 ± 0.39      |
| WISE J225144.24+243034.9 | 16.40 ± 0.10 | 14.89 ± 0.09 | >12.54       | >9.05       | 1.51 ± 0.13      | <2.35            |
| WISE J233555.92+650621.2 | 17.44 ± 0.19 | 14.30 ± 0.05 | >13.01       | 8.67 ± 0.20 | 3.15 ± 0.20      | <1.28            |
| WISE J234847.41+335104.9 | 14.38 ± 0.03 | 13.24 ± 0.03 | 11.74 ± 0.15 | >8.82       | 1.14 ± 0.04      | 1.50 ± 0.16      |
| WISE J235135.76+735746.9 | 18.43 ± 0.50 | 14.97 ± 0.08 | 12.12 ± 0.26 | >9.33       | 3.46 ± 0.51      | 2.84 ± 0.28      |
| WISE J235329.88+801604.3 | 18.34 ± 0.37 | 15.26 ± 0.08 | >13.09       | >9.10       | 3.08 ± 0.38      | <2.18            |

*WISE* All-Sky photometry for the interlopers is listed in Table 9. Figure 3 shows where these sources encroach on the *WISE*  $W1 - W2$  versus  $W2 - W3$  color space of T and Y dwarfs. Although many are located on the periphery, some look like legitimate brown dwarf candidates because they fall squarely in the brown dwarf color-color space. Interlopers that were observed with *Spitzer* are logged in Table 10 and shown in Figure 8. Only a few of the interlopers are distinguishable from brown dwarfs in this figure.

Spectroscopic observations are listed in Table 11 along with descriptions of the spectra. In most cases we observe faint near-IR continuum and no discernible spectral features. However, some objects are unique and we discuss those sources in the following subsections.

### 6.1. Young Stellar Objects

Two of the interlopers, WISE J0421+3721 and WISE J0546+2639, were selected from candidates in our L-dwarf color selection process ( $W1 - W2 > 0.4$  mag and no association with a 2MASS source). Both objects are missing from the 2MASS All-Sky PSC, but are listed in the 2MASS Survey Point Source Reject Table. WISE J0421+3721 has 2MASS magnitudes  $J = 17.0 \pm 0.2$ ,  $H = 15.0 \pm 0.1$ , and  $K_s = 14.1 \pm 0.1$  mag. WISE J0546+2639 is flagged as an artifact contaminated source with  $J = 15.88 \pm 0.07$ ,  $H = 14.50 \pm 0.06$ , and  $K_s = 13.26 \pm 0.03$  mag. These two sources have very similar near-IR colors, and consistent  $W1 - W2$  colors. The IRTF/SpEx spectra

**Table 10**  
*Spitzer*/IRAC Photometry for Interloper Sources

| Object Name     | ch1<br>(mag) | ch2<br>(mag) | ch1 – ch2<br>(mag) |
|-----------------|--------------|--------------|--------------------|
| (1)             | (2)          | (3)          | (4)                |
| WISE J0148–1048 | 16.47 ± 0.04 | 14.63 ± 0.02 | 1.84 ± 0.04        |
| WISE J0201+4836 | 16.54 ± 0.04 | 14.70 ± 0.02 | 1.84 ± 0.04        |
| WISE J0220+6202 | 14.79 ± 0.02 | 13.05 ± 0.02 | 1.75 ± 0.03        |
| WISE J0221+5903 | 15.06 ± 0.02 | 13.93 ± 0.02 | 1.13 ± 0.03        |
| WISE J0446–0726 | 15.59 ± 0.03 | 14.35 ± 0.02 | 1.25 ± 0.03        |
| WISE J0543+4653 | 15.91 ± 0.03 | 13.64 ± 0.02 | 2.27 ± 0.03        |
| WISE J0546+2639 | 12.88 ± 0.02 | 12.67 ± 0.02 | 0.21 ± 0.02        |
| WISE J0554+2457 | 14.94 ± 0.02 | 14.10 ± 0.02 | 0.84 ± 0.03        |
| WISE J0714–1212 | 15.51 ± 0.03 | 13.89 ± 0.02 | 1.63 ± 0.03        |
| WISE J0820–7613 | 15.24 ± 0.02 | 14.63 ± 0.02 | 0.61 ± 0.03        |
| WISE J1208–4844 | 15.98 ± 0.03 | 14.43 ± 0.02 | 1.55 ± 0.04        |
| WISE J1501–0453 | 13.84 ± 0.02 | 13.49 ± 0.02 | 0.35 ± 0.03        |
| WISE J1530–2617 | 16.11 ± 0.03 | 14.24 ± 0.02 | 1.87 ± 0.04        |
| WISE J1545–8431 | 16.54 ± 0.04 | 14.83 ± 0.02 | 1.71 ± 0.04        |
| WISE J1754+3233 | 16.68 ± 0.04 | 15.51 ± 0.02 | 1.17 ± 0.05        |
| WISE J1859+3627 | 16.50 ± 0.04 | 14.49 ± 0.02 | 2.01 ± 0.04        |
| WISE J2232+3847 | 15.87 ± 0.03 | 14.39 ± 0.02 | 1.47 ± 0.03        |
| WISE J2242–2015 | 17.48 ± 0.07 | 15.11 ± 0.02 | 2.37 ± 0.07        |
| WISE J2244+4337 | 15.21 ± 0.02 | 14.33 ± 0.02 | 0.88 ± 0.03        |
| WISE J2335+6506 | 15.62 ± 0.03 | 13.89 ± 0.02 | 1.73 ± 0.03        |
| WISE J2351+7357 | 16.90 ± 0.05 | 14.93 ± 0.02 | 1.97 ± 0.05        |
| WISE J2353+8016 | 16.40 ± 0.04 | 15.13 ± 0.02 | 1.26 ± 0.04        |

**Table 11**  
Follow-up Near-IR Spectroscopy for Interloper Sources

| Object Name<br>J2000 Coordinates<br>(1) | Spectrograph<br>(2) | Obs. Date<br>(UT)<br>(3) | Description of Spectrum<br>(4)   |
|---|---------------------|--------------------------|--|
| WISE J0047+6718                         | Keck/NIRSPEC-H      | 2010 Jul 18              | Faint continuum throughout the <i>H</i> band   |
| WISE J0148−1048                         | Keck/NIRSPEC-J      | 2011 Aug 9               | Faint continuum; cluster of <i>Spitzer</i> sources within 0'.5   |
| WISE J0201+4836                         | Keck/NIRSPEC-J      | 2011 Oct 8/9             | Faint continuum; two blended <i>Spitzer</i> sources  |
| WISE J0220+6202                         | Palomar/TSpec       | 2012 Jan 7               | Faint <i>K</i> -band continuum   |
| WISE J0221+5903                         | Palomar/TSpec       | 2011 Nov 8               | Faint <i>K</i> -band continuum; no motion between <i>WISE</i> and <i>Spitzer</i> epochs                |
| WISE J0404+2618                         | Palomar/TSpec       | 2012 Jan 6               | <i>K</i> -band and faint <i>H</i> -band continuum  |
| WISE J0421+3721                         | IRTF/SpEX           | 2012 Feb 1               | YSO with high S/N hump throughout NIR; peak flux near 1.8 $\mu\text{m}$ (Figure 26)                    |
| WISE J0446−0726                         | Palomar/TSpec       | 2012 Jan 7               | Faint <i>H</i> - and <i>K</i> -band continuum; no motion between <i>WISE</i> and <i>Spitzer</i> epochs |
| WISE J0543+4653                         | Gemini/GNIRS        | 2012 Jan 3               | Faint continuum throughout near-IR, flux decreases as wavelength increases                             |
| WISE J0546+2639                         | IRTF/SpEX           | 2012 Jan 31              | YSO with high S/N hump throughout NIR; peak flux near 1.9 $\mu\text{m}$ (Figure 26)                    |
| WISE J0554+2457                         | Palomar/TSpec       | 2011 Nov 8               | Faint <i>K</i> -band continuum   |
| WISE J0627−1401                         | IRTF/SpEX           | 2012 Feb 13              | Extended object in the guider camera; very faint <i>K</i> -band flux                                   |
| WISE J0714−1212                         | IRTF/SpEX           | 2010 Dec 18              | Reddened star in Galactic plane - Upper Canis Major  |
| WISE J0820−7613                         | Magellan/FIRE       | 2010 Dec 23              | No near-IR flux measured; no motion between <i>WISE</i> and <i>Spitzer</i> epochs                      |
| WISE J1208−4844                         | <i>HST</i> /WFC2    | 2011 May 19              | Extended source in <i>HST</i> image  |
| WISE J1501−0453                         | IRTF/SpEX           | 2012 Feb 13              | Faint continuum throughout near-IR   |
| WISE J1530−2617                         | Keck/NIRSPEC-J      | 2012 Mar 30              | AGN with $H\alpha$ at 1.3136 $\mu\text{m}$ , $z \sim 1.00$ (Figure 27)                                 |
| WISE J1545−8431                         | <i>HST</i> /WFC3    | 2011 May 12              | Extended source in <i>HST</i> image  |
| WISE J1643+3715                         | IRTF/SpEX           | 2010 May 27              | No near-IR flux measured   |
| WISE J1650−0014                         | IRTF/SpEX           | 2010 May 26              | No near-IR flux measured   |
| WISE J1722+5550                         | IRTF/SpEX           | 2010 May 26              | No near-IR flux measured   |
| WISE J1754+3233                         | <i>HST</i> /WFC3    | 2011 Mar 19/20           | $H\beta$ and [O III] (500.7 nm) at 1.4192 and 1.4611 $\mu\text{m}$ for $z \sim 1.92$ AGN (Figure 28)   |
| WISE J1859+3627                         | Keck/NIRSPEC-J      | 2011 Aug 8               | Faint continuum; no motion between <i>WISE</i> and <i>Spitzer</i> epochs                               |
| WISE J2232+3847                         | <i>HST</i> /WFC3    | 2011 Sep 21/22           | Continuum throughout near-IR; no motion between <i>WISE</i> and <i>Spitzer</i> epochs                  |
| WISE J2242−2015                         | Keck/NIRSPEC-J      | 2012 Sep 25              | Faint continuum throughout the <i>J</i> band   |
| WISE J2244+4337                         | Palomar/TSpec       | 2012 Jan 7               | Faint continuum throughout near-IR   |
| WISE J2251+2430                         | Keck/NIRSPEC-J      | 2012 Jun 9               | Faint continuum; broad emission hump at 1.167 $\mu\text{m}$  |
| WISE J2335+6506                         | Keck/NIRSPEC-J      | 2011 Oct 9               | Faint continuum; no motion between <i>WISE</i> and <i>Spitzer</i> epochs                               |
| WISE J2348+3351                         | IRTF/SpEX           | 2010 Sep 14              | Faint continuum throughout near-IR   |
| WISE J2351+7357                         | Keck/NIRSPEC-J      | 2012 Sep 25              | Faint continuum throughout the <i>J</i> band   |
| WISE J2353+8016                         | Keck/NIRSPEC-J      | 2012 Sep 25              | Faint continuum throughout the <i>J</i> band   |

of these sources are shown in Figure 26 with prominent spectral features marked.

We identify these sources as YSOs based on comparisons to the survey of 110 young stellar objects by Connelley & Greene (2010). We find that a few of their YSO spectra have similar morphologies to our newly identified YSOs in that they that lack emission features, peak around 1.8  $\mu\text{m}$ , and show weak H and CO absorption features. The best spectral match Elias 2-25 (16:26:34.167−24:23:28.26 J2000) is a T Tauri star with similar near-IR colors to the new YSOs ( $J - H = 1.598$ ,  $H - K_s = 0.943$ , and  $J - K_s = 2.542$ ). The other T Tauri objects from Connelley & Greene (2010) with similar colors and spectral morphologies are V806 Tau, FS Tau A, and LZK 12.

Employing the  $\alpha$  spectral index, defined as the slope of  $\log(\lambda F_\lambda)$  versus  $\log(\lambda)$  (Lada 1987), over the *WISE* passbands we find  $\alpha = -1.63$  and  $-1.42$  for WISE J0421+3721 and WISE J0546+2639, respectively. Inclusion of the  $K_s$  and  $W3$  magnitudes for WISE J0421+3721 produces  $\alpha = -1.45$ . These values are consistent with evolved T Tauri stars between Class II and Class III in the proximity of Taurus-Auriga.

## 6.2. Active Galactic Nuclei

Although many of the interlopers show faint continuum flux, two of them show spectral features indicative of AGN. WISE J1530−2617 and WISE J1754+3233 have *Spitzer* and

*WISE* colors consistent with reddened extragalactic sources (Wright et al. 2010; Eisenhardt et al. 2012; Stern et al. 2012).

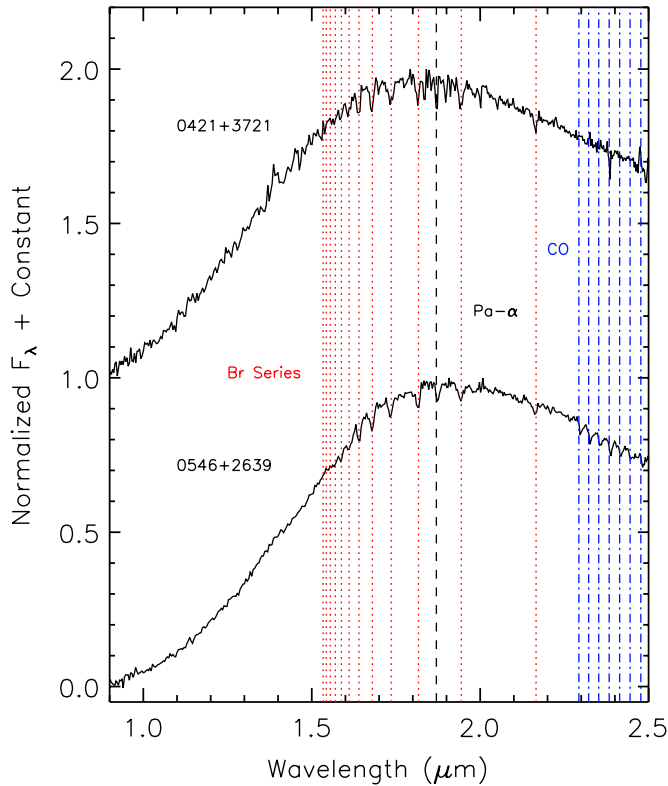
Figure 27 shows the Keck/NIRSPEC *J*-band spectrum of WISE J1530−2617. We identify  $H\alpha$ , [N II]  $\lambda\lambda 6583$ , and broad [S II]  $\lambda\lambda 6716, 6731$  at 1.3136, 1.3158 and 1.3313, 1.3334  $\mu\text{m}$ , respectively. This produces a redshift  $z = 1.00$  and line flux ratio  $N[\text{II}]/H\alpha = 1.314$ , which is typical for an AGN (Veilleux & Osterbrock 1987). Also,  $W1 - W2 = 3.89 \pm 0.50$  for this source, which is even redder than the *W1W2*-dropouts shown in Figure 1 of Eisenhardt et al. (2012).

The *HST*/WFC3 spectrum of WISE J1754+3233 is shown in Figure 28. We determine that  $z = 1.92$  for  $H\beta$  and [O III]  $\lambda\lambda 4959, 5007$  at 1.4192, 1.4471, and 1.4611  $\mu\text{m}$ , respectively. Although [O III]  $\lambda 5007/H\beta = 1.129$  is not unique to AGN, its *WISE* colors identify it as an AGN (Wright et al. 2010). This object is one that was initially identified as a candidate in the Preliminary Data Release, but its updated All-Sky Data Release photometry moved it outside our selection criteria (see Figure 3).

## 7. CONCLUSIONS

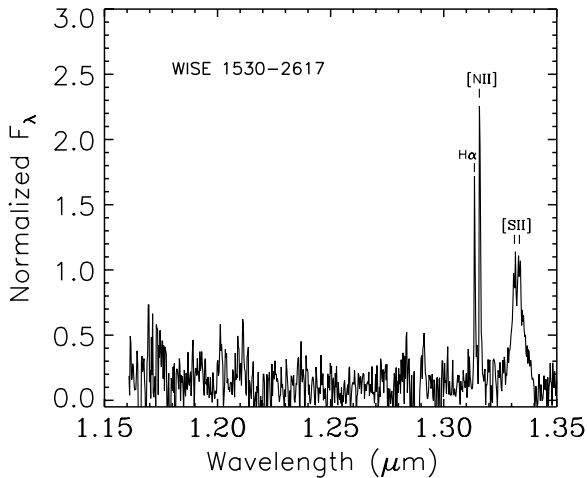
We present the spectra of  $\sim 100$  T dwarfs uncovered with *WISE*. Spectral types were derived by visual comparison to spectral standards, and modified median-flux spectral indices were computed for *WISE* brown dwarf discoveries. We also define the *J*-narrow index to help better identify future





**Figure 26.** IRTF/Spex spectra of two YSOs found in the same *WISE* color space as T dwarfs. Both sources lack clear emission features and display photospheric H (dotted and dashed lines) and CO (dash-dotted lines) absorption.

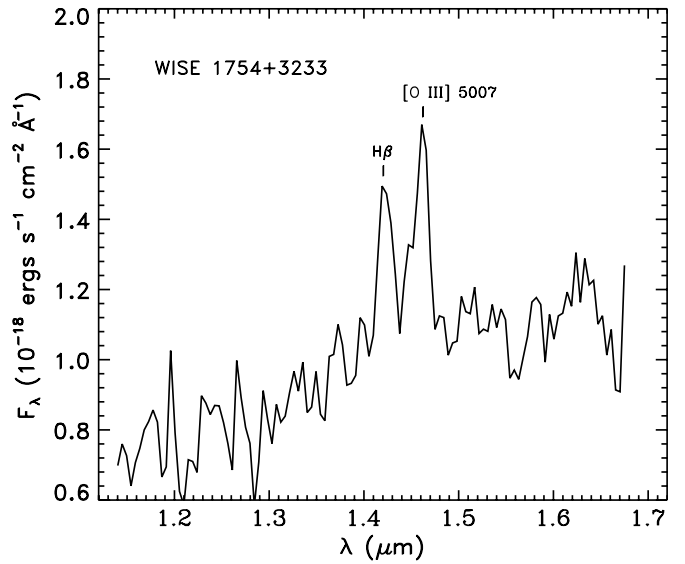
(A color version of this figure is available in the online journal.)



**Figure 27.** Keck/NIRSPEC spectrum of WISE J153015.18–261753.6, an AGN that is on the reddest edges of *WISE* brown dwarf color space. The  $H\alpha$ , [N II]  $\lambda$ 6583, and broad double-peaked [S II]  $\lambda$  $\lambda$ 6716, 6731 lines in the *J* band place this object at  $z = 1.00$ .

early-type Y dwarf discoveries. Along with the 89 T dwarfs reported by Kirkpatrick et al. (2011), our follow-up triples the number of known brown dwarfs with spectral types later than T5.

Using the classification schemes in the literature, we identify three extremely red brown dwarfs that cannot easily be classified as L or T type. These objects display *Y*- and *J*-band spectral morphologies most similar to T dwarfs, have red *J*–*K* colors, and lack distinct  $\text{CH}_4$  absorption features. Although gravity, metallicity, and temperature variations can all contribute to the



**Figure 28.** *HST*/WFC3 spectrum of WISE J175443.93+323332.5, an AGN interloper. The  $H\beta$  and [O III]  $\lambda$  $\lambda$ 4959, 5007 lines in the *H* band place this object at  $z = 1.92$ .

reddening in these objects, variability seen in WISE J1738+6242 hints at rapid (on the order of a year) atmospheric changes. Perhaps the discrepant features we see in these extremely red objects are due to an unresolved redL + T binary. If the T dwarf component of this system constrains other physical parameters, such as the age or metallicity of the system, this would shed light on the underlying cause of the red L dwarf phenomenon. Alternatively, these objects may bridge the L dwarf sequence to the HR 8799 planets and provide a greater understanding of both with further investigation.

Along with the spectral indices, we derive the *Y*/*J*, *H*/*J*, and *K*/*J* peak flux ratios for  $\sim 320$  T and Y dwarfs. The *H*/*J* ratio traces the *J*–*H* color and shows a reversal around T7. The Y0s stand-out in the *H*/*J* index as breaking the trend, and may be less cloudy than the later Y dwarfs. Thus, the spectral sequence of the late-type T dwarfs and the early-type Y dwarfs may no longer be correlated directly to temperature, but also to other atmospheric conditions like cloud fraction, metallicity, grain size, and surface gravity. The *K*/*J* index shows a large dispersion of  $\sim 1.5$  mag, which can be matched by the sulfide cloud models presented by Morley et al. (2012) and not by previous cloudless models used for late-type T dwarfs. We find that although most late-type T dwarfs match the *J*- and *H*-band morphology of the spectral standards, one-third show significantly suppressed *K*-band flux relative to the standards (smaller *K*/*J* values), which implies higher surface gravities, cloudless atmospheres, and/or low metallicities. Comparison to atmospheric models reveals that the small *Y*/*J* peak flux ratios of late-type T dwarfs are best matched to cloudy models and/or oversolar metallicities. Objects with a *Y*/*J* index greater than the standards are best matched to cloudless models and/or sub-solar metallicities. However, we cannot disentangle the physical parameters modulating T dwarf colors until model grids are extended to include various cloud species at lower temperatures and non-solar metallicities.

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## APPENDIX

### INTEGRATED FLUX INDICES FOR WISE-DISCOVERED BROWN DWARFS

Spectral indices from the literature are defined as integrated flux ratios such that

$$\text{integrated flux index} = \int F_{\lambda_1-\lambda_2} d\lambda / \int F_{\lambda_3-\lambda_4} d\lambda,$$

where the numerator, integrated between  $\lambda_1 - \lambda_2$ , covers a specified absorption region and the denominator, integrated between  $\lambda_3 - \lambda_4$ , includes the corresponding peak flux. This results in index values generally less than unity and greater than zero. In this paper we redefine the spectral indices using the median flux ratios which when defined as

$$\text{median flux index} = \tilde{F}_{\lambda_1-\lambda_2} / \tilde{F}_{\lambda_3-\lambda_4},$$

for the same wavelengths produce consistent index values with the integrated flux method, but decreased dispersion per spectral type bin.

For each of the *WISE*-discovered brown dwarfs listed in Table 7 we first derived the integrated flux ratios from Burgasser et al. (2006b), Warren et al. (2007), and Delorme et al. (2008a). These are listed in Table 12. Indices were derived as described in Section 4.5, using a Monte Carlo method with 1000 realizations of the spectrum. Figure 29 shows the median flux and integrated flux indices plotted as a function of spectral type, like Figure 21, but color coded by spectrograph. The  $Y/J$ ,  $H/J$ , and  $K/J$  flux ratios computed using the median flux and integrated flux methods are shown in Figure 30, also color coded by spectrograph.

The integrated flux indices show a clear instrumental bias, where the indices from IRTF/SpeX spectra sit distinctly above the others. This offset is the result of differences in spectral resolution between instruments, and between near-infrared bands

**Table 12**  
Spectral Indices Using Integrated (not Median) Fluxes

| Object Name<br>J2000 Coordinates<br>(1)            | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4)   | CH <sub>4</sub> –J<br>(5)  | H <sub>2</sub> O–H<br>(6)  | CH <sub>4</sub> –H<br>(7)  | W <sub>J</sub><br>(8)      | NH <sub>3</sub> –H<br>(9)  |
|--|-------------------|------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| T Dwarf Discoveries from Kirkpatrick et al. (2011) |                   |                        |                             |                            |                            |                            |                            |                            |
| WISE J0008–1739                                    | Keck/NIRSPEC-J    | T6                     | 0.141 ± 0.025               | 0.393 ± 0.028              | ...                        | ...                        | 0.463 ± 0.021              | ...                        |
| WISE J0123+4142                                    | Keck/NIRSPEC-J    | T7                     | ...                         | 0.285 ± 0.051              | ...                        | ...                        | 0.419 ± 0.041              | ...                        |
| WISE J0138–0322                                    | IRTF/SpeX         | T3                     | 0.409 ± 0.006               | 0.502 ± 0.004              | 0.536 ± 0.006              | 0.831 ± 0.007              | 0.655 ± 0.005              | 0.846 ± 0.008              |
| WISE J0148–7202                                    | Magellan/FIRE     | T9.5                   | –0.017 ± 0.011 <sup>a</sup> | 0.076 ± 0.006 <sup>a</sup> | 0.070 ± 0.013 <sup>a</sup> | 0.016 ± 0.012 <sup>a</sup> | 0.152 ± 0.006 <sup>a</sup> | 0.431 ± 0.015 <sup>a</sup> |
| WISE J0150+3827                                    | IRTF/SpeX         | T0                     | 0.665 ± 0.006               | 0.908 ± 0.006              | 0.675 ± 0.004              | 0.979 ± 0.005              | 0.976 ± 0.006              | 0.891 ± 0.006              |
| WISE J0221+3842                                    | Palomar/TSpec     | T6.5                   | 0.129 ± 0.019               | 0.247 ± 0.016              | 0.179 ± 0.035              | 0.255 ± 0.022              | 0.349 ± 0.020              | 0.660 ± 0.039              |
| WISE J0223–2932                                    | IRTF/SpeX         | T7.5                   | 0.040 ± 0.007               | 0.156 ± 0.004              | 0.165 ± 0.012              | 0.163 ± 0.010              | 0.383 ± 0.005              | 0.696 ± 0.016              |
|  | Keck/NIRSPEC-H    | T7                     | ...                         | ...                        | ...                        | 0.177 ± 0.022              | ...                        | 0.580 ± 0.027              |
| WISE J0226–0211                                    | Keck/NIRSPEC-H    | T7                     | ...                         | ...                        | ...                        | 0.104 ± 0.028              | ...                        | 0.574 ± 0.032              |
| WISE J0254+0223                                    | IRTF/SpeX         | T8                     | 0.047 ± 0.003               | 0.188 ± 0.002              | 0.167 ± 0.004              | 0.111 ± 0.004              | 0.295 ± 0.002              | 0.572 ± 0.005              |
| WISE J0305+3954                                    | Palomar/TSpec     | T6                     | 0.111 ± 0.012               | 0.334 ± 0.008              | 0.355 ± 0.018              | 0.225 ± 0.012              | 0.435 ± 0.009              | 0.719 ± 0.019              |
| WISE J0307+2904                                    | IRTF/SpeX         | T6.5                   | 0.142 ± 0.042               | 0.389 ± 0.029              | 0.302 ± 0.060              | 0.217 ± 0.045              | 0.486 ± 0.026              | 0.821 ± 0.079              |
| WISE J0313+7807                                    | Palomar/TSpec     | T8.5                   | 0.121 ± 0.021               | 0.114 ± 0.010              | 0.251 ± 0.030              | 0.097 ± 0.019              | 0.341 ± 0.011              | 0.608 ± 0.029              |
| WISE J0323–6025                                    | Magellan/FIRE     | T8.5                   | 0.052 ± 0.016               | 0.166 ± 0.008              | 0.179 ± 0.021              | 0.121 ± 0.013              | 0.283 ± 0.008              | 0.554 ± 0.018              |
| WISE J0333–5856                                    | SOAR/OSIRIS       | T3                     | ...                         | 0.511 ± 0.021              | 0.515 ± 0.018              | 0.714 ± 0.016              | ...                        | 0.711 ± 0.020              |
| WISE J0410+1411                                    | IRTF/SpeX         | T6                     | 0.083 ± 0.030               | 0.313 ± 0.022              | 0.247 ± 0.049              | 0.269 ± 0.042              | 0.416 ± 0.020              | 0.669 ± 0.055              |
| WISE J0448–1935                                    | IRTF/SpeX         | T5 pec                 | 0.196 ± 0.017               | 0.398 ± 0.013              | 0.324 ± 0.029              | 0.417 ± 0.029              | 0.532 ± 0.012              | 0.765 ± 0.039              |
| WISE J0458+6434                                    | IRTF/SpeX         | T8.5                   | 0.039 ± 0.015               | 0.281 ± 0.013              | 0.125 ± 0.019              | 0.080 ± 0.018              | 0.289 ± 0.009              | 0.477 ± 0.026              |
| WISE J0500–1223                                    | IRTF/SpeX         | T8                     | 0.034 ± 0.026               | 0.200 ± 0.018              | 0.112 ± 0.037              | 0.106 ± 0.034              | 0.315 ± 0.016              | 0.576 ± 0.045              |
| WISE J0513+0608                                    | Palomar/TSpec     | T6.5                   | 0.159 ± 0.006               | 0.315 ± 0.004              | 0.287 ± 0.009              | 0.232 ± 0.006              | 0.420 ± 0.004              | 0.698 ± 0.010              |
| WISE J0525+6739                                    | IRTF/SpeX         | T6 pec                 | 0.171 ± 0.009               | 0.323 ± 0.006              | 0.291 ± 0.017              | 0.314 ± 0.016              | 0.455 ± 0.006              | 0.722 ± 0.022              |
| WISE J0528–3308                                    | Palomar/TSpec     | T7 pec                 | –0.002 ± 0.039              | 0.272 ± 0.014              | 0.183 ± 0.048              | 0.233 ± 0.029              | 0.377 ± 0.013              | 0.631 ± 0.044              |
| WISE J0539–1034                                    | Palomar/TSpec     | T5.5                   | 0.177 ± 0.022               | 0.335 ± 0.013              | 0.426 ± 0.037              | 0.302 ± 0.023              | 0.485 ± 0.014              | 0.827 ± 0.038              |
| WISE J0542–1628                                    | Palomar/TSpec     | T6.5                   | 0.144 ± 0.009               | 0.266 ± 0.005              | 0.215 ± 0.012              | 0.226 ± 0.008              | 0.406 ± 0.004              | 0.686 ± 0.012              |
| WISE J0611–0410                                    | IRTF/SpeX         | T0                     | 0.583 ± 0.013               | 0.590 ± 0.010              | 0.657 ± 0.012              | 1.043 ± 0.014              | 0.760 ± 0.011              | 0.985 ± 0.015              |
| WISE J0612–4920                                    | SOAR/OSIRIS       | T3.5                   | ...                         | 0.474 ± 0.039              | 0.357 ± 0.035              | 0.683 ± 0.030              | ...                        | 0.755 ± 0.042              |
| WISE J0612–3036                                    | Palomar/TSpec     | T6                     | 0.117 ± 0.001               | 0.311 ± 0.001              | 0.317 ± 0.001              | 0.315 ± 0.001              | 0.443 ± 0.001              | 0.793 ± 0.001              |
| WISE J0614+3912                                    | Palomar/TSpec     | T6                     | 0.140 ± 0.023               | 0.401 ± 0.012              | 0.334 ± 0.023              | 0.273 ± 0.016              | 0.465 ± 0.012              | 0.789 ± 0.026              |
| WISE J0623–0456                                    | IRTF/SpeX         | T8                     | 0.002 ± 0.028               | 0.293 ± 0.020              | 0.166 ± 0.039              | 0.082 ± 0.032              | 0.425 ± 0.019              | 0.721 ± 0.052              |
| WISE J0625+5646                                    | Palomar/TSpec     | T6                     | 0.182 ± 0.012               | 0.312 ± 0.007              | 0.330 ± 0.020              | 0.275 ± 0.013              | 0.425 ± 0.007              | 0.686 ± 0.020              |
| WISE J0627–1114                                    | IRTF/SpeX         | T6                     | 0.163 ± 0.004               | 0.315 ± 0.003              | 0.277 ± 0.005              | 0.339 ± 0.005              | 0.454 ± 0.003              | 0.654 ± 0.007              |
| WISE J0656+4205                                    | IRTF/SpeX         | T3                     | 0.466 ± 0.010               | 0.436 ± 0.007              | 0.489 ± 0.011              | 0.792 ± 0.012              | 0.738 ± 0.008              | 0.836 ± 0.014              |
| WISE J0744+5628                                    | Palomar/TSpec     | T8                     | 0.156 ± 0.031               | 0.266 ± 0.018              | 0.196 ± 0.061              | –0.054 ± 0.041             | 0.404 ± 0.018              | 0.695 ± 0.061              |
| WISE J0750+2725                                    | Keck/NIRSPEC-JH   | T8.5                   | 0.036 ± 0.008               | 0.118 ± 0.008              | ...                        | 0.039 ± 0.004              | 0.231 ± 0.006              | 0.578 ± 0.005              |
| WISE J0751–7634                                    | Magellan/FIRE     | T9                     | 0.010 ± 0.023               | 0.132 ± 0.013              | 0.224 ± 0.042              | 0.117 ± 0.029              | 0.178 ± 0.012              | 0.511 ± 0.042              |
| WISE J0759–4904                                    | Magellan/FIRE     | T8                     | 0.036 ± 0.003               | 0.160 ± 0.002              | 0.154 ± 0.004              | 0.116 ± 0.004              | 0.279 ± 0.002              | 0.615 ± 0.006              |
| WISE J0819–0335                                    | IRTF/SpeX         | T4                     | 0.384 ± 0.004               | 0.474 ± 0.003              | 0.395 ± 0.005              | 0.654 ± 0.005              | 0.642 ± 0.003              | 0.761 ± 0.006              |
| WISE J0821+1443                                    | IRTF/SpeX         | T5.5                   | 0.199 ± 0.011               | 0.352 ± 0.009              | 0.317 ± 0.016              | 0.383 ± 0.015              | 0.506 ± 0.009              | 0.714 ± 0.020              |
| WISE J0836–1859                                    | Magellan/FIRE     | T8 pec                 | 0.046 ± 0.014               | 0.148 ± 0.005              | 0.153 ± 0.015              | 0.118 ± 0.010              | 0.310 ± 0.007              | 0.609 ± 0.014              |
| WISE J0857+5604                                    | Palomar/TSpec     | T8                     | 0.065 ± 0.015               | 0.171 ± 0.008              | 0.095 ± 0.025              | 0.094 ± 0.017              | 0.311 ± 0.008              | 0.534 ± 0.025              |

**Table 12**  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4)  | CH <sub>4</sub> –J<br>(5)  | H <sub>2</sub> O–H<br>(6)  | CH <sub>4</sub> –H<br>(7)  | W <sub>J</sub><br>(8)      | NH <sub>3</sub> –H<br>(9) |
|---|-------------------|------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|---------------------------|
| WISE J0906+4735                         | Palomar/TSpec     | T8                     | 0.048 ± 0.165              | 0.235 ± 0.072              | 0.220 ± 0.113              | 0.124 ± 0.044              | 0.336 ± 0.062              | 0.620 ± 0.081             |
| WISE J0929+0409                         | Palomar/TSpec     | T6.5                   | 0.074 ± 0.017              | 0.252 ± 0.010              | 0.317 ± 0.031              | 0.190 ± 0.019              | 0.380 ± 0.009              | 0.666 ± 0.033             |
| WISE J0952+1955                         | IRTF/SpeX         | T6                     | 0.156 ± 0.008              | 0.294 ± 0.006              | 0.260 ± 0.017              | 0.332 ± 0.016              | 0.444 ± 0.006              | 0.669 ± 0.021             |
| WISE J1018–2445                         | Magellan/FIRE     | T8                     | 0.037 ± 0.004              | 0.158 ± 0.002              | 0.163 ± 0.004              | 0.084 ± 0.003              | 0.302 ± 0.002              | 0.625 ± 0.005             |
| WISE J1019+6529                         | Palomar/TSpec     | T6                     | 0.131 ± 0.038              | 0.328 ± 0.021              | 0.280 ± 0.036              | 0.297 ± 0.019              | 0.472 ± 0.023              | 0.745 ± 0.033             |
|   | IRTF/SpeX         | T6                     | 0.122 ± 0.012              | 0.259 ± 0.008              | 0.269 ± 0.024              | 0.352 ± 0.022              | 0.443 ± 0.010              | 0.849 ± 0.034             |
| WISE J1042–3842                         | Magellan/FIRE     | T8.5                   | 0.026 ± 0.010              | 0.155 ± 0.005              | 0.146 ± 0.011              | 0.108 ± 0.007              | 0.297 ± 0.006              | 0.558 ± 0.011             |
| WISE J1122+2550                         | IRTF/SpeX         | T6                     | 0.135 ± 0.011              | 0.304 ± 0.008              | 0.299 ± 0.025              | 0.261 ± 0.018              | 0.448 ± 0.009              | 0.767 ± 0.028             |
| WISE J1150+6302                         | Palomar/TSpec     | T8                     | 0.017 ± 0.015              | 0.202 ± 0.008              | 0.161 ± 0.023              | 0.148 ± 0.015              | 0.308 ± 0.007              | 0.591 ± 0.026             |
| WISE J1217+1626                         | Palomar/TSpec     | T9                     | 0.066 ± 0.020              | 0.103 ± 0.010              | 0.032 ± 0.030              | 0.054 ± 0.019              | 0.247 ± 0.010              | 0.542 ± 0.030             |
| WISE J1311+0122                         | Keck/NIRSPEC-H    | T9:                    | ...                        | ...                        | ...                        | –0.084 ± 0.005             | ...                        | 0.610 ± 0.007             |
| WISE J1320+6034                         | IRTF/SpeX         | T6.5                   | 0.105 ± 0.008              | 0.108 ± 0.004              | 0.347 ± 0.015              | 0.212 ± 0.013              | 0.487 ± 0.006              | 0.805 ± 0.021             |
| WISE J1322–2340                         | IRTF/SpeX         | T8                     | 0.084 ± 0.011              | 0.240 ± 0.007              | 0.256 ± 0.018              | 0.202 ± 0.015              | 0.349 ± 0.008              | 0.708 ± 0.024             |
| WISE J1436–1814                         | Magellan/FIRE     | T8 pec                 | 0.062 ± 0.003              | 0.202 ± 0.002              | 0.244 ± 0.004              | 0.157 ± 0.003              | 0.318 ± 0.002              | 0.670 ± 0.005             |
| WISE J1457+5815                         | IRTF/SpeX         | T7                     | 0.100 ± 0.010              | 0.197 ± 0.005              | 0.282 ± 0.019              | 0.218 ± 0.015              | 0.411 ± 0.007              | 0.819 ± 0.024             |
| WISE J1506+7027                         | Palomar/TSpec     | T6                     | 0.140 ± 0.001              | 0.315 ± 0.001              | 0.280 ± 0.001              | 0.271 ± 0.001              | 0.443 ± 0.001              | 0.718 ± 0.002             |
|   | Keck/NIRSPEC-H    | T6                     | ...                        | ...                        | ...                        | 0.271 ± 0.006              | ...                        | 0.705 ± 0.009             |
| WISE J1519+7009                         | Palomar/TSpec     | T8                     | 0.081 ± 0.167              | 0.198 ± 0.085              | 0.152 ± 0.138              | 0.105 ± 0.053              | 0.341 ± 0.069              | 0.626 ± 0.098             |
| WISE J1612–3420                         | Keck/NIRSPEC-H    | T6.5                   | ...                        | ...                        | ...                        | 0.217 ± 0.013              | ...                        | 0.719 ± 0.016             |
| WISE J1614+1739                         | Magellan/FIRE     | T9                     | 0.037 ± 0.022              | 0.107 ± 0.009              | 0.124 ± 0.033              | 0.106 ± 0.022              | 0.187 ± 0.016              | 0.508 ± 0.037             |
| WISE J1617+1807                         | Magellan/FIRE     | T8                     | 0.020 ± 0.004 <sup>b</sup> | 0.170 ± 0.003 <sup>b</sup> | 0.159 ± 0.007 <sup>b</sup> | 0.108 ± 0.006 <sup>b</sup> | 0.275 ± 0.003 <sup>b</sup> | 0.724 ± 0.101             |
| WISE J1622–0959                         | IRTF/SpeX         | T6                     | 0.176 ± 0.005              | 0.353 ± 0.004              | 0.278 ± 0.007              | 0.325 ± 0.007              | 0.468 ± 0.004              | 0.649 ± 0.009             |
| WISE J1627+3255                         | IRTF/SpeX         | T6                     | 0.143 ± 0.003              | 0.332 ± 0.002              | 0.261 ± 0.004              | 0.277 ± 0.003              | 0.425 ± 0.002              | 0.756 ± 0.006             |
|   | Keck/NIRSPEC-H    | T6                     | ...                        | ...                        | ...                        | 0.278 ± 0.028              | ...                        | 0.744 ± 0.039             |
| WISE J1653+4444                         | IRTF/SpeX         | T8                     | 0.030 ± 0.009              | 0.213 ± 0.007              | 0.168 ± 0.012              | 0.153 ± 0.012              | 0.271 ± 0.006              | 0.602 ± 0.018             |
| WISE J1711+3500                         | IRTF/SpeX         | T8                     | –0.023 ± 0.017             | 0.255 ± 0.013              | 0.222 ± 0.022              | 0.173 ± 0.020              | 0.456 ± 0.015              | 0.698 ± 0.031             |
| WISE J1717+6129                         | Keck/NIRSPEC-JH   | T8                     | 0.092 ± 0.029              | 0.173 ± 0.030              | ...                        | 0.116 ± 0.018              | 0.292 ± 0.023              | 0.507 ± 0.023             |
| WISE J1728+5716                         | IRTF/SpeX         | T6                     | 0.132 ± 0.012              | 0.353 ± 0.009              | 0.268 ± 0.018              | 0.276 ± 0.018              | 0.400 ± 0.008              | 0.703 ± 0.027             |
| WISE J1741+2553                         | Magellan/FIRE     | T9                     | 0.021 ± 0.060              | 0.157 ± 0.029              | 0.136 ± 0.028              | 0.073 ± 0.018              | 0.274 ± 0.030              | 0.566 ± 0.025             |
| WISE J1804+3117                         | Keck/NIRSPEC-H    | T9.5:                  | ...                        | ...                        | ...                        | –0.133 ± 0.029             | ...                        | 0.313 ± 0.030             |
| WISE J1812+2721                         | Magellan/FIRE     | T8.5:                  | 0.040 ± 0.050 <sup>b</sup> | 0.120 ± 0.030 <sup>b</sup> | 0.140 ± 0.130 <sup>b</sup> | 0.290 ± 0.110 <sup>b</sup> | 0.220 ± 0.040 <sup>b</sup> | 0.631 ± 0.104             |
| WISE J1841+7000                         | Palomar/TSpec     | T5                     | 0.236 ± 0.013              | 0.467 ± 0.009              | 0.423 ± 0.015              | 0.394 ± 0.008              | 0.556 ± 0.008              | 0.805 ± 0.013             |
| WISE J1852+3537                         | IRTF/SpeX         | T7                     | 0.068 ± 0.007              | 0.207 ± 0.005              | 0.253 ± 0.012              | 0.184 ± 0.010              | 0.379 ± 0.005              | 0.825 ± 0.017             |
| WISE J1906+4508                         | IRTF/SpeX         | T6                     | 0.183 ± 0.004              | 0.332 ± 0.003              | 0.324 ± 0.007              | 0.330 ± 0.006              | 0.495 ± 0.003              | 0.754 ± 0.010             |
| WISE J1952+7240                         | Palomar/TSpec     | T4                     | 0.352 ± 0.006              | 0.480 ± 0.004              | 0.384 ± 0.007              | 0.502 ± 0.005              | 0.614 ± 0.004              | 0.776 ± 0.007             |
| WISE J1959–3338                         | Palomar/TSpec     | T8                     | 0.049 ± 0.013              | 0.207 ± 0.006              | 0.233 ± 0.010              | 0.137 ± 0.004              | 0.318 ± 0.004              | 0.649 ± 0.007             |
| WISE J2018–7423                         | Magellan/FIRE     | T7                     | 0.086 ± 0.006 <sup>b</sup> | 0.198 ± 0.004 <sup>b</sup> | 0.224 ± 0.011 <sup>b</sup> | 0.231 ± 0.010 <sup>b</sup> | 0.420 ± 0.005 <sup>b</sup> | 0.681 ± 0.006             |
| WISE J2134–7137                         | Magellan/FIRE     | T9 pec                 | 0.017 ± 0.014              | 0.100 ± 0.007              | 0.108 ± 0.018              | 0.055 ± 0.017              | 0.197 ± 0.008              | 0.436 ± 0.020             |
| WISE J2157+2659                         | Palomar/TSpec     | T7                     | 0.029 ± 0.003              | 0.255 ± 0.002              | 0.193 ± 0.002              | 0.185 ± 0.001              | 0.329 ± 0.001              | 0.658 ± 0.002             |
| WISE J2209–2734                         | Keck/NIRSPEC-H    | T7                     | ...                        | ...                        | ...                        | 0.240 ± 0.025              | ...                        | 0.692 ± 0.034             |
| WISE J2213+0911                         | IRTF/SpeX         | T7                     | 0.108 ± 0.005              | 0.274 ± 0.003              | 0.229 ± 0.008              | 0.210 ± 0.007              | 0.370 ± 0.003              | 0.708 ± 0.011             |
| WISE J2226+0440                         | IRTF/SpeX         | T8                     | 0.052 ± 0.005              | 0.172 ± 0.003              | 0.237 ± 0.009              | 0.125 ± 0.008              | 0.347 ± 0.004              | 0.757 ± 0.012             |
|   | Keck/NIRSPEC-JH   | T8.5                   | 0.060 ± 0.032              | 0.063 ± 0.034              | ...                        | 0.099 ± 0.015              | 0.461 ± 0.027              | 0.660 ± 0.020             |
| WISE J2237–0614                         | IRTF/SpeX         | T5                     | 0.200 ± 0.012              | 0.314 ± 0.008              | 0.435 ± 0.023              | 0.439 ± 0.021              | 0.576 ± 0.009              | 0.948 ± 0.031             |
| WISE J2239+1617                         | IRTF/SpeX         | T3                     | 0.498 ± 0.005              | 0.677 ± 0.004              | 0.511 ± 0.005              | 0.725 ± 0.004              | 0.792 ± 0.004              | 0.813 ± 0.006             |
| WISE J2255–3118                         | IRTF/SpeX         | T8                     | 0.031 ± 0.008              | 0.263 ± 0.006              | 0.164 ± 0.014              | 0.108 ± 0.012              | 0.260 ± 0.005              | 0.662 ± 0.017             |
|   | Keck/NIRSPEC-H    | T8                     | ...                        | ...                        | ...                        | 0.099 ± 0.016              | ...                        | 0.456 ± 0.017             |

**Table 12**  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4)  | CH <sub>4</sub> –J<br>(5)  | H <sub>2</sub> O–H<br>(6)  | CH <sub>4</sub> –H<br>(7)  | W <sub>J</sub><br>(8)      | NH <sub>3</sub> –H<br>(9) |
|---|-------------------|------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|---------------------------|
| WISE J2313–8037                         | Magellan/FIRE     | T8                     | 0.044 ± 0.008 <sup>b</sup> | 0.116 ± 0.004 <sup>b</sup> | 0.174 ± 0.012 <sup>b</sup> | 0.142 ± 0.011 <sup>b</sup> | 0.324 ± 0.005 <sup>b</sup> | 0.561 ± 0.005             |
| WISE J2319–1844                         | IRTF/Spex         | T7.5                   | 0.072 ± 0.015              | 0.268 ± 0.010              | 0.167 ± 0.023              | 0.106 ± 0.021              | 0.308 ± 0.008              | 0.599 ± 0.033             |
| WISE J2325–4105                         | Magellan/FIRE     | T9 pec                 | 0.011 ± 0.014              | 0.153 ± 0.009              | 0.047 ± 0.020              | 0.100 ± 0.015              | 0.222 ± 0.009              | 0.450 ± 0.021             |
| WISE J2340–0745                         | IRTF/Spex         | T7                     | 0.114 ± 0.004              | 0.253 ± 0.003              | 0.295 ± 0.007              | 0.242 ± 0.006              | 0.411 ± 0.003              | 0.827 ± 0.009             |
| WISE J2343–7418                         | Magellan/FIRE     | T6                     | 0.184 ± 0.005              | 0.371 ± 0.003              | 0.297 ± 0.006              | 0.306 ± 0.005              | 0.489 ± 0.003              | 0.697 ± 0.007             |
| WISE J2344+1034                         | Keck/NIRSPEC-J    | T9                     | ...                        | 0.126 ± 0.013              | ...                        | ...                        | 0.169 ± 0.009              | ...                       |
| WISE J2348–1028                         | IRTF/Spex         | T7                     | 0.078 ± 0.005              | 0.198 ± 0.003              | 0.252 ± 0.009              | 0.169 ± 0.008              | 0.373 ± 0.004              | 0.817 ± 0.012             |
| WISE J2359–7335                         | Magellan/FIRE     | T6.5                   | 0.206 ± 0.008 <sup>b</sup> | 0.261 ± 0.004 <sup>b</sup> | 0.343 ± 0.011 <sup>b</sup> | 0.315 ± 0.008 <sup>b</sup> | 0.549 ± 0.005 <sup>b</sup> | 0.653 ± 0.005             |
| T Dwarf Discoveries from This Paper     |                   |                        |                            |                            |                            |                            |                            |                           |
| WISE J0005+3737                         | Keck/NIRSPEC-J    | T9                     | ...                        | 0.130 ± 0.016              | ...                        | ...                        | 0.238 ± 0.019              | ...                       |
| WISE J0038+2758                         | Keck/NIRSPEC-J    | T9                     | –0.080 ± 0.020             | 0.102 ± 0.006              | ...                        | ...                        | 0.174 ± 0.004              | ...                       |
| WISE J0038+8405                         | Keck/NIRSPEC-J    | T6                     | ...                        | ...                        | ...                        | ...                        | 0.464 ± 0.003              | ...                       |
| WISE J0040+0900                         | IRTF/Spex         | T7                     | 0.090 ± 0.004              | 0.259 ± 0.003              | 0.246 ± 0.008              | 0.231 ± 0.006              | 0.372 ± 0.003              | 0.661 ± 0.009             |
| WISE J0045+3611                         | IRTF/Spex         | T5                     | 0.201 ± 0.003              | 0.332 ± 0.002              | 0.304 ± 0.005              | 0.389 ± 0.005              | 0.468 ± 0.003              | 0.631 ± 0.006             |
| WISE J0049+2151                         | IRTF/Spex         | T8.5                   | 0.027 ± 0.004              | 0.179 ± 0.003              | 0.173 ± 0.006              | 0.088 ± 0.005              | 0.379 ± 0.003              | 0.607 ± 0.008             |
| WISE J0135+1715                         | IRTF/Spex         | T6                     | 0.170 ± 0.014              | 0.360 ± 0.010              | 0.313 ± 0.021              | 0.277 ± 0.018              | 0.570 ± 0.011              | 0.735 ± 0.028             |
| WISE J0210+4008                         | IRTF/Spex         | T4.5                   | 0.334 ± 0.006              | 0.409 ± 0.004              | 0.366 ± 0.008              | 0.535 ± 0.007              | 0.619 ± 0.005              | 0.705 ± 0.009             |
| WISE J0233+3030                         | IRTF/Spex         | T6                     | 0.216 ± 0.009              | 0.335 ± 0.006              | 0.331 ± 0.014              | 0.319 ± 0.012              | 0.504 ± 0.006              | 0.672 ± 0.017             |
| WISE J0245–3450                         | IRTF/Spex         | T8                     | 0.042 ± 0.013              | 0.185 ± 0.009              | 0.182 ± 0.021              | 0.126 ± 0.018              | 0.316 ± 0.009              | 0.577 ± 0.025             |
| WISE J0247+3725                         | Gemini/GNIRS      | T8                     | 0.030 ± 0.007              | 0.164 ± 0.004              | 0.152 ± 0.008              | 0.089 ± 0.007              | 0.289 ± 0.004              | 0.574 ± 0.012             |
| WISE J0259–0346                         | Keck/NIRSPEC-J    | T5                     | ...                        | 0.414 ± 0.022              | ...                        | ...                        | 0.526 ± 0.018              | ...                       |
| WISE J0316+3820                         | Palomar/TSpec     | T3                     | 0.410 ± 0.015              | 0.516 ± 0.009              | 0.511 ± 0.012              | 0.669 ± 0.009              | 0.680 ± 0.011              | 0.817 ± 0.013             |
| WISE J0316+4307                         | Keck/NIRSPEC-JH   | T8                     | ...                        | 0.192 ± 0.013              | ...                        | 0.070 ± 0.023              | 0.233 ± 0.009              | 0.564 ± 0.027             |
| WISE J0321–7347                         | Magellan/FIRE     | T8                     | 0.072 ± 0.013              | 0.148 ± 0.004              | 0.192 ± 0.006              | 0.058 ± 0.003              | 0.302 ± 0.004              | 0.643 ± 0.005             |
| WISE J0325–3854                         | Keck/NIRSPEC-J    | T9                     | ...                        | 0.128 ± 0.022              | ...                        | ...                        | 0.245 ± 0.013              | ...                       |
| WISE J0325+0831                         | IRTF/Spex         | T7                     | 0.096 ± 0.005              | 0.234 ± 0.004              | 0.279 ± 0.008              | 0.235 ± 0.008              | 0.406 ± 0.004              | 0.707 ± 0.012             |
| WISE J0335+4310                         | Keck/NIRSPEC-J    | T9                     | ...                        | 0.138 ± 0.009              | ...                        | ...                        | 0.226 ± 0.016              | ...                       |
| WISE J0336–0143                         | Keck/NIRSPEC-J    | T8:                    | ...                        | 0.147 ± 0.034              | ...                        | ...                        | 0.344 ± 0.054              | ...                       |
| WISE J0336+2826                         | IRTF/Spex         | T5                     | 0.309 ± 0.009              | 0.403 ± 0.007              | 0.350 ± 0.011              | 0.474 ± 0.012              | 0.546 ± 0.007              | 0.789 ± 0.018             |
| WISE J0413–4750                         | Magellan/FIRE     | T9                     | 0.033 ± 0.036              | 0.102 ± 0.041              | 0.193 ± 0.069              | 0.017 ± 0.027              | 0.284 ± 0.072              | 0.584 ± 0.235             |
| WISE J0424+0727                         | Keck/NIRSPEC-J    | T7.5                   | ...                        | 0.220 ± 0.006              | ...                        | ...                        | 0.355 ± 0.005              | ...                       |
| WISE J0430+4633                         | Keck/NIRSPEC-J    | T8                     | ...                        | 0.229 ± 0.006              | ...                        | ...                        | 0.281 ± 0.004              | ...                       |
| WISE J0512–3004                         | Keck/NIRSPEC-J    | T8.5                   | ...                        | 0.110 ± 0.009              | ...                        | ...                        | 0.243 ± 0.007              | ...                       |
| WISE J0540+4832                         | Keck/NIRSPEC-J    | T8.5                   | ...                        | 0.161 ± 0.004              | ...                        | ...                        | 0.278 ± 0.003              | ...                       |
| WISE J0546–0959                         | IRTF/Spex         | T5                     | 0.232 ± 0.006              | 0.484 ± 0.006              | 0.347 ± 0.012              | 0.434 ± 0.012              | 0.571 ± 0.005              | 0.771 ± 0.016             |
| WISE J0614+0951                         | Palomar/TSpec     | T7                     | 0.130 ± 0.001              | 0.278 ± 0.001              | 0.300 ± 0.001              | 0.209 ± 0.001              | 0.347 ± 0.001              | 0.699 ± 0.001             |
| WISE J0629+2418                         | IRTF/Spex         | T2 sb                  | 0.447 ± 0.011              | 0.626 ± 0.009              | 0.512 ± 0.011              | 0.832 ± 0.013              | 0.607 ± 0.008              | 0.739 ± 0.014             |
| WISE J0642+4101                         | Palomar/TSpec     | extr. red              | 0.544 ± 0.001              | 0.793 ± 0.001              | 0.613 ± 0.001              | 1.197 ± 0.001              | 0.737 ± 0.001              | 0.844 ± 0.001             |
| WISE J0701+6321                         | Palomar/TSpec     | T3                     | 0.385 ± 0.001              | 0.583 ± 0.001              | 0.494 ± 0.001              | 0.777 ± 0.001              | 0.641 ± 0.001              | 0.814 ± 0.001             |
| WISE J0723+3403                         | Keck/NIRSPEC-J    | T9:                    | ...                        | ...                        | ...                        | ...                        | 0.081 ± 0.027              | ...                       |
| WISE J0733+7544                         | Palomar/TSpec     | T6                     | 0.139 ± 0.001              | 0.330 ± 0.001              | 0.322 ± 0.002              | 0.301 ± 0.001              | 0.452 ± 0.001              | 0.741 ± 0.001             |
| WISE J0754+7909                         | Palomar/TSpec     | extr. red              | 0.472 ± 0.001              | 0.651 ± 0.001              | 0.469 ± 0.002              | 1.071 ± 0.001              | 0.757 ± 0.001              | 0.792 ± 0.005             |
| WISE J0811–8051                         | Magellan/FIRE     | T9.5:                  | 0.026 ± 0.041              | 0.054 ± 0.014              | –0.449 ± 0.035             | –0.293 ± 0.018             | 0.201 ± 0.013              | 0.596 ± 0.026             |
| WISE J0812+4021                         | Gemini/GNIRS      | T8                     | 0.065 ± 0.006              | 0.183 ± 0.003              | 0.207 ± 0.008              | 0.110 ± 0.007              | 0.322 ± 0.004              | 0.649 ± 0.013             |
| WISE J1025+0307                         | Magellan/FIRE     | T8.5                   | 0.030 ± 0.002              | 0.112 ± 0.001              | 0.113 ± 0.001              | 0.069 ± 0.001              | 0.308 ± 0.001              | 0.551 ± 0.001             |
| WISE J1039–1600                         | IRTF/Spex         | T7.5                   | 0.084 ± 0.012              | 0.250 ± 0.009              | 0.175 ± 0.020              | 0.135 ± 0.019              | 0.308 ± 0.008              | 0.572 ± 0.025             |
| WISE J1050+5056                         | Keck/NIRSPEC-J    | T8                     | ...                        | 0.224 ± 0.007              | ...                        | ...                        | 0.332 ± 0.005              | ...                       |
| WISE J1051–2138                         | Palomar/TSpec     | T9:                    | 0.113 ± 0.026              | 0.132 ± 0.003              | 0.262 ± 0.008              | 0.075 ± 0.006              | 0.254 ± 0.002              | 0.412 ± 0.007             |
| WISE J1124–0421                         | IRTF/Spex         | T7                     | 0.108 ± 0.005              | 0.269 ± 0.003              | 0.259 ± 0.010              | 0.252 ± 0.008              | 0.366 ± 0.003              | 0.692 ± 0.012             |

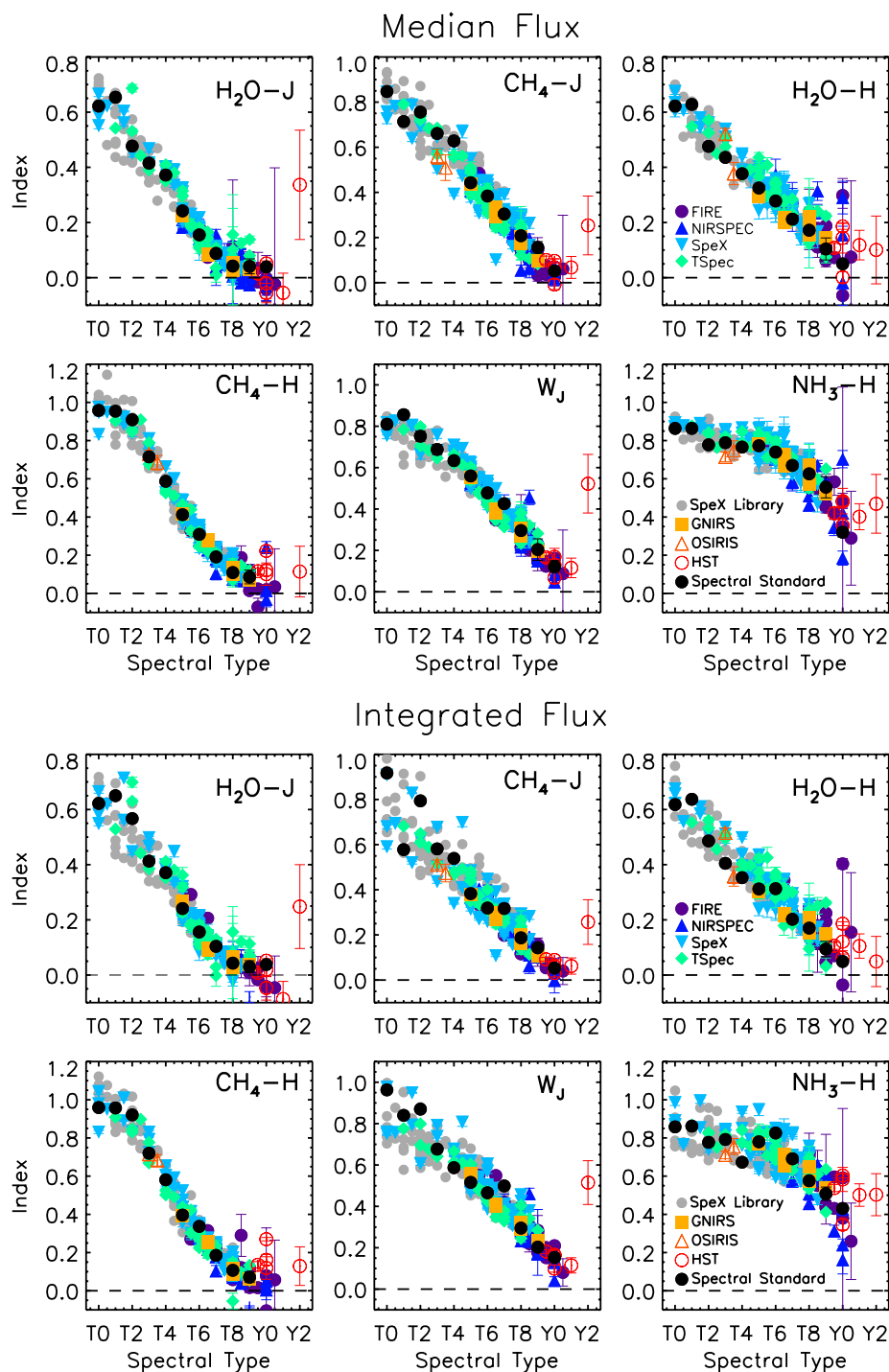
Table 12  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|
| WISE J1143+4431                         | Keck/NIRSPEC-J    | T8.5                   | ...                       | 0.170 ± 0.018             | ...                       | ...                       | 0.248 ± 0.014         | ...                       |
| WISE J1221–3136                         | IRTF/SpeX         | T6.5                   | 0.136 ± 0.007             | 0.298 ± 0.005             | 0.268 ± 0.013             | 0.258 ± 0.013             | 0.399 ± 0.005         | 0.579 ± 0.016             |
| WISE J1225–1013                         | IRTF/SpeX         | T6                     | 0.160 ± 0.004             | 0.358 ± 0.004             | 0.289 ± 0.008             | 0.301 ± 0.007             | 0.454 ± 0.003         | 0.717 ± 0.011             |
| WISE J1250+2628                         | Keck/NIRSPEC-J    | T6.5                   | ...                       | 0.312 ± 0.003             | ...                       | ...                       | 0.422 ± 0.002         | ...                       |
| WISE J1257+4008                         | IRTF/SpeX         | T7                     | 0.097 ± 0.010             | 0.337 ± 0.008             | 0.206 ± 0.018             | 0.177 ± 0.016             | 0.386 ± 0.007         | 0.670 ± 0.025             |
| WISE J1301–0302                         | Keck/NIRSPEC-J    | T8.5                   | ...                       | 0.191 ± 0.015             | ...                       | ...                       | 0.273 ± 0.009         | ...                       |
| WISE J1318–1758                         | Palomar/TSpec     | T9:                    | 0.072 ± 0.020             | 0.122 ± 0.002             | 0.113 ± 0.006             | 0.133 ± 0.004             | 0.285 ± 0.002         | 0.637 ± 0.005             |
| WISE J1337+2636                         | Keck/NIRSPEC-J    | T5                     | ...                       | 0.366 ± 0.004             | ...                       | ...                       | 0.524 ± 0.003         | ...                       |
| WISE J1400–3850                         | IRTF/SpeX         | T4                     | 0.399 ± 0.013             | 0.520 ± 0.010             | 0.437 ± 0.018             | 0.604 ± 0.017             | 0.677 ± 0.011         | 0.850 ± 0.021             |
| WISE J1517+0529                         | Keck/NIRSPEC-J    | T8                     | ...                       | 0.175 ± 0.027             | ...                       | ...                       | 0.294 ± 0.013         | ...                       |
| WISE J1523+3125                         | Gemini/GNIRS      | T6.5 pec               | 0.090 ± 0.011             | 0.298 ± 0.008             | 0.222 ± 0.013             | 0.256 ± 0.020             | 0.401 ± 0.007         | 0.652 ± 0.025             |
| WISE J1542+2230                         | <i>HST</i> /WFC3  | T9.5                   | 0.008 ± 0.014             | 0.092 ± 0.009             | 0.106 ± 0.013             | 0.136 ± 0.017             | 0.182 ± 0.009         | 0.539 ± 0.019             |
| WISE J1544+5842                         | Keck/NIRSPEC-J    | T7.5                   | ...                       | 0.210 ± 0.027             | ...                       | ...                       | 0.367 ± 0.021         | ...                       |
| WISE J1632+0329                         | IRTF/SpeX         | T5                     | 0.216 ± 0.013             | 0.365 ± 0.011             | 0.239 ± 0.024             | 0.439 ± 0.021             | 0.513 ± 0.013         | 0.741 ± 0.032             |
| WISE J1636–0743                         | IRTF/SpeX         | T4.5                   | 0.448 ± 0.020             | 0.698 ± 0.019             | 0.366 ± 0.024             | 0.591 ± 0.023             | 0.807 ± 0.020         | 0.789 ± 0.035             |
| WISE J1707–1744                         | Palomar/TSpec     | T5:                    | 0.226 ± 0.016             | 0.352 ± 0.009             | 0.301 ± 0.025             | 0.391 ± 0.018             | 0.535 ± 0.010         | 0.794 ± 0.028             |
| WISE J1721+1117                         | IRTF/SpeX         | T6                     | 0.144 ± 0.015             | 0.372 ± 0.011             | 0.236 ± 0.031             | 0.279 ± 0.026             | 0.425 ± 0.011         | 0.688 ± 0.040             |
| WISE J1730+4207                         | IRTF/SpeX         | T0 sb                  | 0.549 ± 0.008             | 0.679 ± 0.008             | 0.622 ± 0.008             | 0.831 ± 0.008             | 0.751 ± 0.008         | 0.870 ± 0.010             |
| WISE J1734+5023                         | IRTF/SpeX         | T4                     | 0.389 ± 0.004             | 0.339 ± 0.003             | 0.498 ± 0.005             | 0.543 ± 0.005             | 0.650 ± 0.004         | 0.936 ± 0.007             |
| WISE J1736+6059                         | Keck/NIRSPEC-J    | T8                     | ...                       | 0.196 ± 0.006             | ...                       | ...                       | 0.295 ± 0.005         | ...                       |
| WISE J1738+6142                         | Palomar/TSpec     | extr. red              | 0.527 ± 0.038             | 0.792 ± 0.035             | 0.629 ± 0.020             | 1.148 ± 0.019             | 0.719 ± 0.033         | 0.844 ± 0.022             |
|   | IRTF/SpeX         | extr. red              | 0.676 ± 0.026             | 0.998 ± 0.025             | 0.635 ± 0.015             | 1.095 ± 0.017             | 1.008 ± 0.024         | 0.821 ± 0.018             |
| WISE J1741+1327                         | IRTF/SpeX         | T5                     | 0.244 ± 0.015             | 0.425 ± 0.011             | 0.334 ± 0.026             | 0.357 ± 0.023             | 0.511 ± 0.011         | 0.643 ± 0.030             |
| WISE J1743+4211                         | Palomar/TSpec     | T4.5                   | 0.381 ± 0.007             | 0.493 ± 0.005             | 0.397 ± 0.007             | 0.491 ± 0.006             | 0.610 ± 0.005         | 0.759 ± 0.008             |
| WISE J1745+6459                         | Keck/NIRSPEC-J    | T7                     | ...                       | 0.298 ± 0.012             | ...                       | ...                       | 0.400 ± 0.010         | ...                       |
| WISE J1746–0338                         | Palomar/TSpec     | T6                     | 0.181 ± 0.015             | 0.338 ± 0.008             | 0.369 ± 0.022             | 0.305 ± 0.014             | 0.465 ± 0.008         | 0.755 ± 0.023             |
| WISE J1755+1803                         | Palomar/TSpec     | T2                     | 0.630 ± 0.009             | 0.610 ± 0.006             | 0.533 ± 0.006             | 0.847 ± 0.006             | 0.696 ± 0.007         | 0.827 ± 0.007             |
| WISE J1759+5442                         | Keck/NIRSPEC-J    | T7                     | ...                       | 0.252 ± 0.009             | ...                       | ...                       | 0.379 ± 0.007         | ...                       |
| WISE J1809–0448                         | IRTF/SpeX         | T0.5                   | 0.619 ± 0.006             | 0.694 ± 0.005             | 0.556 ± 0.005             | 0.950 ± 0.006             | 0.757 ± 0.004         | 0.765 ± 0.006             |
| WISE J1812+2007                         | Keck/NIRSPEC-J    | T9                     | ...                       | 0.138 ± 0.015             | ...                       | ...                       | 0.216 ± 0.011         | ...                       |
| WISE J1813+2835                         | Keck/NIRSPEC-J    | T8                     | ...                       | 0.172 ± 0.003             | ...                       | ...                       | 0.287 ± 0.002         | ...                       |
| WISE J1840+2932                         | Keck/NIRSPEC-J    | T6                     | ...                       | 0.325 ± 0.013             | ...                       | ...                       | 0.465 ± 0.010         | ...                       |
| WISE J1909–5204                         | Magellan/FIRE     | T5.5                   | 0.292 ± 0.005             | 0.335 ± 0.002             | 0.337 ± 0.003             | 0.270 ± 0.002             | 0.550 ± 0.003         | 0.737 ± 0.004             |
| WISE J1913+6444                         | Palomar/TSpec     | T5:                    | 0.362 ± 0.028             | 0.481 ± 0.016             | 0.338 ± 0.034             | 0.418 ± 0.027             | 0.550 ± 0.017         | 0.834 ± 0.039             |
| WISE J1928+2356                         | IRTF/SpeX         | T6                     | 0.210 ± 0.001             | 0.447 ± 0.001             | 0.300 ± 0.001             | 0.344 ± 0.001             | 0.605 ± 0.001         | 0.701 ± 0.001             |
| WISE J1954+6915                         | Keck/NIRSPEC-J    | T5.5                   | ...                       | 0.404 ± 0.007             | ...                       | ...                       | 0.494 ± 0.005         | ...                       |
| WISE J1955–2540                         | Keck/NIRSPEC-J    | T8                     | ...                       | 0.166 ± 0.007             | ...                       | ...                       | 0.288 ± 0.005         | ...                       |
| WISE J2008–0834                         | IRTF/SpeX         | T5.5                   | 0.205 ± 0.005             | 0.277 ± 0.003             | 0.351 ± 0.009             | 0.357 ± 0.008             | 0.543 ± 0.004         | 0.829 ± 0.012             |
| WISE J2014+0424                         | Gemini/GNIRS      | T6.5 pec               | 0.096 ± 0.006             | 0.268 ± 0.004             | 0.214 ± 0.009             | 0.253 ± 0.009             | 0.409 ± 0.004         | 0.715 ± 0.014             |
| WISE J2015+6646                         | Palomar/TSpec     | T8                     | 0.071 ± 0.015             | 0.207 ± 0.008             | 0.138 ± 0.019             | 0.149 ± 0.014             | 0.350 ± 0.008         | 0.594 ± 0.020             |
| WISE J2019–1148                         | Palomar/TSpec     | T8:                    | 0.063 ± 0.041             | 0.137 ± 0.018             | 0.141 ± 0.040             | 0.122 ± 0.026             | 0.245 ± 0.018         | 0.675 ± 0.040             |
| WISE J2030+0749                         | IRTF/SpeX         | T1.5                   | 0.714 ± 0.002             | 0.828 ± 0.002             | 0.585 ± 0.001             | 0.889 ± 0.001             | 0.949 ± 0.002         | 0.854 ± 0.002             |
| WISE J2043+6220                         | IRTF/SpeX         | T1.5                   | 0.561 ± 0.009             | 0.520 ± 0.006             | 0.610 ± 0.011             | 1.009 ± 0.011             | 0.793 ± 0.008         | 0.995 ± 0.013             |
| WISE J2123–2614                         | IRTF/SpeX         | T5.5                   | 0.223 ± 0.018             | 0.383 ± 0.012             | 0.244 ± 0.035             | 0.297 ± 0.030             | 0.496 ± 0.013         | 0.745 ± 0.044             |

**Table 12**  
(Continued)

| Object Name<br>J2000 Coordinates<br>(1) | Instrument<br>(2) | NIR Sp.<br>Type<br>(3) | H <sub>2</sub> O–J<br>(4) | CH <sub>4</sub> –J<br>(5) | H <sub>2</sub> O–H<br>(6) | CH <sub>4</sub> –H<br>(7) | W <sub>J</sub><br>(8) | NH <sub>3</sub> –H<br>(9) |
|---|-------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------|---------------------------|
| WISE J2147–1029                         | Keck/NIRSPEC-J    | T7.5                   | ...                       | 0.214 ± 0.006             | ...                       | ...                       | 0.356 ± 0.004         | ...                       |
| WISE J2236+5105                         | Palomar/TSpec     | T5.5                   | 0.185 ± 0.001             | 0.374 ± 0.001             | 0.312 ± 0.001             | 0.423 ± 0.001             | 0.477 ± 0.001         | 0.708 ± 0.001             |
| WISE J2237+7228                         | Keck/NIRSPEC-J    | T6                     | 0.170 ± 0.004             | 0.345 ± 0.005             | ...                       | ...                       | 0.484 ± 0.004         | ...                       |
| WISE J2301+0216                         | IRTF/Spex         | T6.5                   | 0.133 ± 0.006             | 0.266 ± 0.005             | 0.343 ± 0.012             | 0.276 ± 0.010             | 0.421 ± 0.005         | 0.844 ± 0.016             |
| WISE J2303+1914                         | Palomar/TSpec     | T4:                    | 0.412 ± 0.002             | 0.467 ± 0.001             | 0.405 ± 0.003             | 0.525 ± 0.002             | 0.666 ± 0.001         | 0.841 ± 0.003             |
| WISE J2335+4222                         | Keck/NIRSPEC-JH   | T7                     | ...                       | 0.274 ± 0.008             | ...                       | 0.208 ± 0.009             | 0.390 ± 0.010         | 0.671 ± 0.013             |
| WISE J2357+1227                         | IRTF/Spex         | T6                     | 0.143 ± 0.005             | 0.384 ± 0.004             | 0.245 ± 0.009             | 0.295 ± 0.008             | 0.387 ± 0.004         | 0.593 ± 0.010             |
| T Dwarfs from Table 6                   |                   |                        |                           |                           |                           |                           |                       |                           |
| WISE J0920+4538                         | Palomar/TSpec     | L9 sb?                 | 0.588 ± 0.001             | 0.745 ± 0.001             | 0.618 ± 0.001             | 1.003 ± 0.001             | 0.774 ± 0.001         | 0.872 ± 0.001             |
| ULAS J0950+0117                         | Magellan/FIRE     | T8                     | 0.066 ± 0.002             | 0.187 ± 0.001             | 0.189 ± 0.001             | 0.142 ± 0.001             | 0.394 ± 0.001         | 0.705 ± 0.002             |
| WISE J1246–3139                         | Palomar/TSpec     | T1                     | 0.529 ± 0.001             | 0.682 ± 0.001             | 0.553 ± 0.001             | 0.909 ± 0.001             | 0.776 ± 0.001         | 0.868 ± 0.001             |
| LHS 2803B                               | IRTF/Spex         | T5.5                   | 0.168 ± 0.007             | 0.270 ± 0.005             | 0.297 ± 0.015             | 0.415 ± 0.014             | 0.534 ± 0.006         | 0.711 ± 0.019             |
| BD +01° 2920B                           | Magellan/FIRE     | T8                     | 0.070 ± 0.006             | 0.182 ± 0.002             | 0.236 ± 0.004             | 0.125 ± 0.002             | 0.393 ± 0.003         | 0.720 ± 0.004             |
| WISE J1449+1147                         | Gemini/GNIRS      | T5 pec                 | 0.268 ± 0.006             | 0.378 ± 0.004             | 0.301 ± 0.006             | 0.394 ± 0.009             | 0.559 ± 0.005         | 0.767 ± 0.011             |
|   | Palomar/TSpec     | T5 pec                 | 0.232 ± 0.016             | 0.350 ± 0.009             | 0.303 ± 0.026             | 0.387 ± 0.017             | 0.543 ± 0.011         | 0.796 ± 0.029             |
| PSOJ226.25–28.89                        | Palomar/TSpec     | T2:                    | 0.699 ± 0.018             | 0.649 ± 0.008             | 0.561 ± 0.011             | 0.831 ± 0.008             | 0.799 ± 0.008         | 0.827 ± 0.010             |
| VHS J1543–0439                          | IRTF/Spex         | T5:                    | 0.321 ± 0.019             | 0.381 ± 0.014             | 0.396 ± 0.034             | 0.523 ± 0.028             | 0.621 ± 0.020         | 0.750 ± 0.040             |
| PSOJ246.42+15.46                        | Palomar/TSpec     | T4.5:                  | 0.319 ± 0.014             | 0.441 ± 0.009             | 0.373 ± 0.019             | 0.438 ± 0.013             | 0.604 ± 0.010         | 0.787 ± 0.019             |
| PSOJ247.32+03.59                        | Palomar/TSpec     | T2                     | 0.442 ± 0.003             | 0.589 ± 0.002             | 0.456 ± 0.002             | 0.898 ± 0.002             | 0.677 ± 0.002         | 0.751 ± 0.003             |
| WISE J1717+6128                         | Gemini/GNIRS      | T8                     | 0.026 ± 0.017             | 0.201 ± 0.009             | 0.207 ± 0.019             | 0.115 ± 0.018             | 0.316 ± 0.008         | 0.651 ± 0.028             |
| WISE J1809+3838                         | IRTF/Spex         | T7.5                   | 0.063 ± 0.014             | 0.232 ± 0.011             | 0.198 ± 0.024             | 0.148 ± 0.019             | 0.345 ± 0.010         | 0.609 ± 0.031             |
| WISE J2342+0856                         | IRTF/Spex         | T6.5                   | 0.114 ± 0.004             | 0.328 ± 0.004             | 0.213 ± 0.007             | 0.274 ± 0.007             | 0.380 ± 0.003         | 0.596 ± 0.009             |
| WISE J2344+1034                         | Gemini/GNIRS      | T9                     | 0.037 ± 0.012             | 0.107 ± 0.005             | 0.149 ± 0.015             | 0.062 ± 0.017             | 0.233 ± 0.005         | 0.538 ± 0.025             |

**Notes.**<sup>a</sup> Cushing et al. (2011).<sup>b</sup> Burgasser et al. (2011).



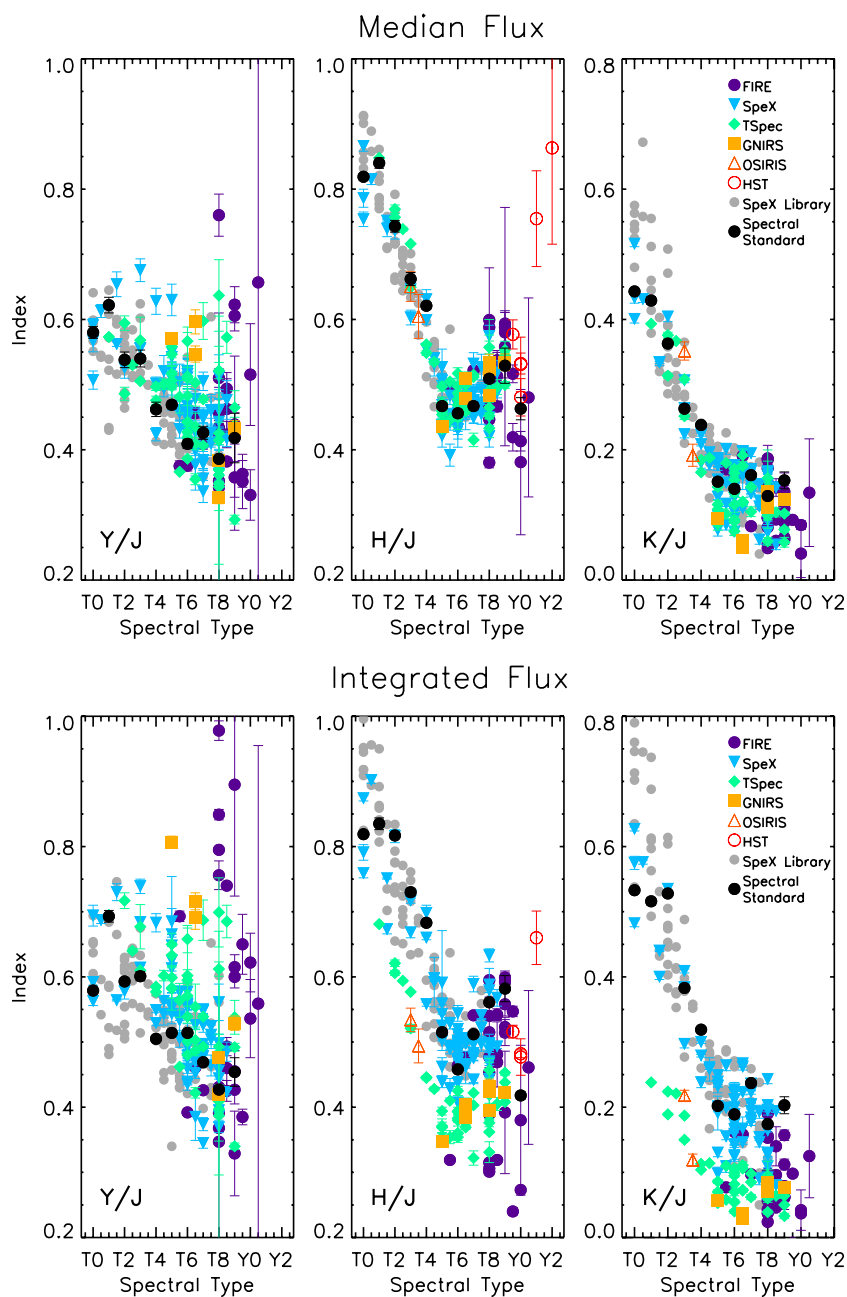
**Figure 29.** The six spectral indices from Burgasser et al. (2006b), Warren et al. (2007), and Delorme et al. (2008a), computed using the median flux and integrated flux for the T dwarfs in this paper and the T and Y dwarfs of Kirkpatrick et al. (2011, 2012) and Cushing et al. (2011). Objects are marked by instrument with the symbols and colors in the legend. Also included are the spectral standards as black filled circles and T dwarfs from the SpeX Prism Library as gray circles.

(A color version of this figure is available in the online journal.)

for the same instrument. To properly compare integrated flux spectral indices between instruments we would first need to interpolate the spectra onto similar wavelength scales. Even for the same instrument, changes in the resolution as a function of wavelength would need to be removed by interpolation. Using the median flux, rather than the integrated flux, sidesteps this issue and reduces the likelihood of errors when comparing spectra from numerous instruments, like we have done here. Another,

less significant, source of this offset is a negative noise bias of all non-IRTF/SpeX spectra reduced with Spextool. This is clearly seen in Figure 18, where the scatter in the per pixel flux is more often below the mean. This bias in the reduced spectrum results in smaller integrated fluxes and consequently, smaller index values. Employing the *median* flux instead of the integrated flux reduces data reduction and instrumental influences on the computed indices.





**Figure 30.** The peak flux ratios defined by Burgasser et al. (2004, 2006b), computed using the median flux and the integrated flux. Same symbols as in Figure 29. (A color version of this figure is available in the online journal.)

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