VII. RADIO ASTRONOMY*

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RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

1. Development of long-baseline interferometry techniques and studies of small angular diameter sources. The use of highly stable atomic frequency standards for frequency and time control has made possible the construction of radio interferometers of arbitrarily long baseline. Separate stations have been operated simultaneously at the Haystack facility of Lincoln Laboratory, M.I.T., the National Radio Astronomy Observatory at Green Bank, West Virginia, and the Hat Creek Observatory of the University of California at Berkeley, giving spacings of up to 19,500,000 wavelengths at OH frequencies and resolution of .005 second of arc. Studies of the OH regions have demonstrated structure of the order of .01 second of arc, and an unresolved component of the quasar 3C273B has been shown to be smaller than .005 second of arc. The observations continue and the technique shows promise of yielding interesting information concerning the validity of general relativity and can also be used as a potentially powerful geophysical technique.

2. Measurements of the cosmological microwave black-body radiation. A measurement of the isotropic radio background was made at 9.24-mm wavelength, which yielded a background temperature of 3.16 ±.26°K. Plans are being made to extend the technique to much shorter wavelengths in the vicinity of 1 mm, beyond the Planck minimum, thereby giving a sensitive test to the cosmological interpretation.

3. Galactic studies. Making use of measurements of the hydrogen recombination line 109α, we have completed a survey of H II regions in the galaxy. The observations were made at 6 cm, using the 140 ft telescope of the National Radio Astronomy Observatory, and interpretation of the results is proceeding. One of the members of our group will travel to Australia, to extend the survey to the Southern sky, using the 210 ft telescope of the CSIRO Radio Physics Laboratory.

4. Aperture synthesis. A 2-cm interferometer is nearing completion, and will be used to make high-resolution studies of the bright radio sources. The interferometer will make use of an on-line computer for real-time data reduction, and is intended to serve as a prototype for further high-resolution instruments for continuum studies.

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5. Study of the microwave continuum from galactic and extragalactic radio sources at short centimeter wavelengths. The variable quasi-stellar radio sources are observed at 3.75 cm and 2.0 cm wavelengths to determine their time-variant spectra and polarization properties.

6. Study of microwave emission and absorption by the terrestrial atmosphere, with particular emphasis on meteorological satellite application. This work has included ground-based observations of atmospheric water vapor and ozone, and balloon observations of microwave emission by molecular oxygen. Up-looking balloon observations have been conducted to determine the line absorption coefficient, and down-looking flights have been carried out to test inversion techniques to recover the temperature profile.

A. H. Barrett, B. F. Burke

A. GALACTIC STUDIES OF THE HYDROGEN RECOMBINATION LINE

The second phase of our 6-cm 109α recombination line survey has been completed, and data analysis is proceeding. In the first phase, with observations made last spring, we have completed analysis of line intensities and radial velocities of 80 galactic sources. A line was detected in 52 of these sources, and a comparison of the observations with neutral hydrogen line (21 cm) surveys has been made. It is clear that most of the intense H II regions are concentrated in the inner regions of the galaxy, from roughly 4 kpc to 6 kpc, although a few occur farther out. Our latest observations, also using the 140 ft telescope of the National Radio Astronomy Observatory, will extend the list to twice the number of sources, and include nearly every thermal source visible at Green Bank of flux greater than 6×10^{-26} mks at 5009 MHz. A detailed analysis is in progress, and should soon be ready.

Observations were also made of the galactic center region, which have shown that several components may be nonthermal, even though their continuum spectrum appears to be thermal. Three components, with G-numbers (0.5, -0.0) (0.7, -0.0), and (1.1, 0.4) are clearly thermal, and their observed radial velocities indicate that they are not chance foreground objects, but must participate in the peculiar motions of the central region.

B. F. Burke, E. C. Reifenstein, T. C. Wilson

B. Ku-BAND INTERFEROMETER

The 17 GHz interferometric system is, at present, in its final stage of construction. Two of the three 8-ft dishes have been mounted on the polar mounts built by the Research Laboratory of Electronics shop. A preliminary feed will be completed within a few days, and will be used to measure the efficiency of the antennas.

A small computer (PDP-8) was purchased last June for real-time data processing and sytem control. The program has been written and the interface is now under test.

The front end and the phase-lock parts of the system are now under test.

George Papadopoulos, B. F. Burke

C. STRUCTURE OF W3

We have been investigating the structure of the 18-cm OH emission in the H II region W3. Owing to the small angular size of the emitting region, it has been necessary to use very long-baseline radio interferometers to resolve the source. The Agassiz-Millstone interferometer,[1] with baseline of 74,000 λ, revealed that the spectral features in the 1665-MHz spectra were spatially separated by roughly 1 arc second. In June 1967, the Haystack antenna and the 140 ft antenna at the National Radio Astronomy Observatory were linked to give a baseline length of 4.6×10^6 λ. This instrument showed that some of the individual spectral features were .02 second of arc in size or smaller.[2]

In July 1967, an interferometer experiment was carried out between Hat Creek, California, and NRAO to give a baseline of 19.5×10^6 λ and a fringe spacing of .01 second of arc. The signals received at each site were clipped and sampled and recorded on magnetic tape. Later the tapes were brought together and the data were crosscorrelated. Atomic frequency standards were used to control the local oscillators and samplers.

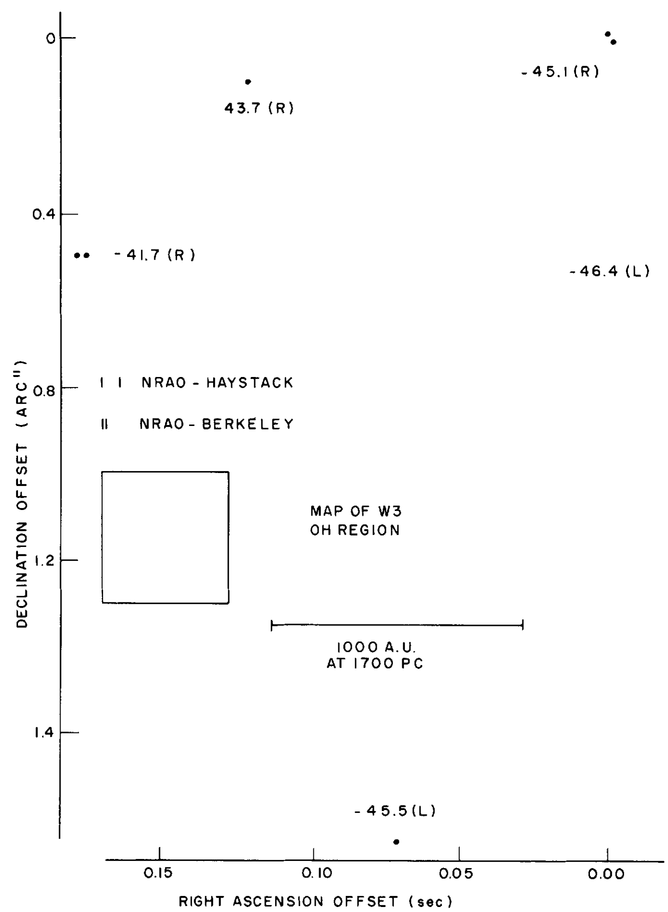

Fig. VII-1. Map of OH sources near W3.

Because the spectral features originate from slightly different locations the interference fringes that they produce move at slightly different frequencies. By measuring the relative fringe frequency caused by two spectral features at many orientations of the baseline, the separation of these features can be computed. Because this is a relative measurement the instrumental effects of uncertainty in the baseline orientation and the frequency of the atomic standards are removed. For an integration time of 2 minutes the relative fringe frequency can be measured to .0001 Hz out of a total fringe frequency of approximately 1000 Hz. Hence several measurements are enough to compute the relative positions to .1 second of arc. Figure VII-1 shows a detailed map of the OH source near W3 comprising 2 square arc seconds, or approximately one hundred billionth of the entire sky.

We were not able to resolve the −43.7 km/sec component, which gives an upper limit on its size of .005 second of arc. Its linear dimension is less than 8 A.U., and its brightness temperature is greater than 4×10^{12} °K. The features at −45.1 GHz and −41.7 GHz are double, with separations ~.02 second of arc, while the feature at −46.4 GHz is elongated or possibly double with dimensions .01 × .005 second of arc.

J. M. Moran, B. F. Burke, A. H. Barrett

References

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2. J. M. Moran, B. F. Burke, and A. H. Barrett, Quarterly Progress Report No. 87, Research Laboratory of Electronics, M.I.T., October 15, 1967, pp. 11-15.