

XV. RADIO ASTRONOMY

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1. MICROWAVE SPECTROSCOPY OF THE INTERSTELLAR MEDIUM

National Science Foundation (Grant AST79-25075)

Alan H. Barrett, Philip C. Myers

In 1980 three main efforts were pursued: (1) a study of motions and physical conditions in the galactic center, as indicated by emission in NH_3 inversion lines; (2) observations in lines of CO and NH_3 to analyze nearby reflection nebulae; and (3) studies of CO and NH_3 emission from nearby regions of high extinction. In this last study, about 15 regions have been identified as cold cloud cores, with density $\sim 3 \times 10^4 \text{ cm}^{-3}$, temperature $\sim 10 \text{ K}$, mass $\sim 1 M_\odot$, and velocity dispersion between 1 and 2 times the thermal dispersion. These are good candidates to be future low-mass stars.

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2. RESEARCH OBJECTIVES

National Science Foundation (Grant AST79-20984)

B.F. Burke

The research program in radio astronomy is primarily centered on the use of interferometric techniques, including hard-wired arrays and Very-Long-Baseline Interferometry (VLBI), to study phenomena on the galactic and extragalactic scale. The principal activities are as follows:

1. Interstellar masers are being studied, using VLBI, to determine their structural, polarization, and time-variation properties.
2. The VLBI technique is being pressed to lower frequencies (300 MHz, 600 MHz, and 1400 MHz) to study the characteristics of quasars and galactic nuclei.
3. The double quasar 0957+561, the first observational example of the gravitational lens phenomenon, will continue to be studied. We are particularly concerned with its time variations, which may provide an entirely new class of cosmological information. Both VLA (Very Large Antenna of the NRAO) and VLBI observations will be employed.
4. A computing system for reducing VLA snapshot data is being developed. The basic instrument will be our NOVA 800 computer, with added disc and core memory. The software development will be partly in collaboration with Dr. Hjellming of the NRAO.
5. Our survey of radio sources under way at the NRAO, using the 300-ft transit telescope at 5 GHz, has been broadened to include a general survey of the entire strip -3° to $+20^\circ$, comprising 2 steradians of sky. The survey should be completed by late 1981.
6. A new project has been started to look for spatial fluctuations in brightness of the cosmic microwave background. A multichannel receiver is being built, for use with the 140-ft NRAO telescope, to improve statistics and to give better discrimination against spurious effects such as atmospheric fluctuations.

3. LONG-BASELINE ASTROMETRIC INTERFEROMETER

National Science Foundation (Grant AST79-19553)
U.S. Navy — Office of Naval Research (Contract N00014-80-C-0348)
National Aeronautics and Space Administration (Grant NAG2-50)
M.I.T. Sloan Fund for Basic Research

Michael Shao, David H. Staelin

Initial results from the Mark I one-inch aperture, 1.5-meter baseline interferometer experiment at Mt. Wilson Observatory were published,¹ and further reduction of the data continued during the year.

Work began on the Mark II dual 5-cm aperture, 3-meter baseline interferometer intended to demonstrate a few milliarc sec day-to-day repeatability for measurement of angles between stars $\approx 1.5^\circ$ apart, and $\lesssim 0.05$ arc sec repeatability for stars $15\text{-}20^\circ$ apart. The design sensitivity is $\sim 6\text{-}7$ mag for 2 arc-sec seeing and 10-msec averaging times. The system contains two parallel interferometers that share the same optics but view different stars (one is one magnitude more sensitive than the other).

References

1. M. Shao and D.H. Staelin, "First Fringe Measurements with a Phase-Tracking Stellar Interferometer," *Appl. Opt.* 19, 1519-1522 (1980).

4. CONTROLLED THIN-FILM ANTENNA

Joint Services Electronics Program (Contracts DAAG29-78-C-0020 and
DAAG29-80-C-0104)

Jeffrey H. Lang, Timothy L. Johnson, David H. Staelin

The use of electrostatic charges for rapidly manipulating a thin membrane is being studied as a method for precisely controlling the shape of reflector antennas of $\sim 10\text{-}300$ -meter diameter in space; beamwidths $\sim 1\text{-}10$ arc sec are sought.

This year we began the design of a 5-ft diameter rubber-membrane mirror with 100 control elements. Theoretical studies have focused on finite-element representations for control and on formulations that can handle more effectively the spillover between sensors, actuators, and modes.

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5. IMPROVED MICROWAVE RETRIEVAL TECHNIQUES

National Aeronautics and Space Administration (Grant NAG5-10)

Philip W. Rosenkranz, Michael J. Komichak, David H. Staelin

This program, which began in 1980, is directed toward the development of improved techniques for retrievals of atmospheric temperature, wind, and humidity fields from passive microwave spectral images of the earth, as observed from satellites. Linear statistical retrieval techniques were applied to data for which the temperature weighting functions varied in a systematic way with view angle. Improvements were obtained in the mean profile because of the increased number of effective temperature weighting functions, but the decorrelation between atmospheric temperatures in the horizontal direction was found to be too great to permit further benefits.

Evaluations were also made of second-order nonlinear effects in optimum three-dimensional linear statistical retrievals employing Fourier transforms of the data field. These procedures were successfully applied to atmospheric humidity, water content, and other parameters using microwave data from the Nimbus-7 satellite; these case studies were performed under another contract described separately here.

Other studies were also performed. For example, regionalization of a priori statistics was found to help primarily when retrieving tropical parameters, and progress was made in developing retrieval techniques appropriate for species with opaque spectral lines, such as the 183-GHz resonance of atmospheric water vapor.

6. COMMUNICATIONS SATELLITES

National Aeronautics and Space Administration (Contract NAS5-25091)

David H. Staelin, Ali D.S. Ali

This year a major study of future large broadband switched satellite communication networks was completed and distributed; it was co-authored by David H. Staelin of the Research Laboratory of Electronics and Robert L. Harvey of Lincoln Laboratory. It explored the future markets for communications services, technical

means for providing the necessary communications systems, economic analyses and tradeoff studies, and a survey of many of the primary policy issues such expansion would have. Novel technical concepts include an efficient multibeam antenna and signal-switching configuration for satellites, and a concept for clusters of cooperating but individually switched satellites that share a single orbital slot.

Related analyses have been performed on the relative merits of FDMA and TDMA systems and on the optimum relationship between terrestrial links employing optical fibers or other low-cost technologies versus the use of satellites.

7. VIDEO-BANDWIDTH COMPRESSION TECHNIQUES

M.I.T. Sloan Fund for Basic Research

David H. Staelin, Bernard I. Szabo

Experiments were performed on adaptive-quantization picture-coding schemes that were applied to two- and three-band images; the bands included (1) low-frequency images formed by 8 x 8-pel averages which were bilinearly interpolated, (2) medium-frequency images formed by the difference between bilinearly interpolated 2 x 2-pel averages and the low-frequency images, and (3) high-frequency images which were the difference between the total true images and either the low-frequency images or the sum of the low- and medium-frequency images. An image of a cameraman was coded with 1.5-0.9 bits per pel to produce images that ranged from excellent to slightly annoying, respectively. Conditional replenishment video-coding schemes using these representations are estimated to require ~0.4-4 Mbps for acceptable monochrome video images of 512 x 512 pels.

8. SCANNING MULTICHANNEL MICROWAVE RADIOMETER (SMMR)

National Aeronautics and Space Administration (Contract NAS5-22929)

Philip W. Rosenkranz, Timothy S. Bigelow, William T. Baumann, David H. Staelin

Research under this contract has been in two areas:

(1) Application of a linear spatial filtering to the problem of estimating ocean-surface temperature, near-surface wind speed, and atmospheric water vapor and liquid water from measurements made by the Scanning Multichannel Microwave

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Radiometer, an instrument which was launched on the experimental satellites NIMBUS-7 and SEASAT.^{1,2}

(2) Nonlinear techniques for remote sensing of atmospheric water vapor and mesospheric winds.³

References

1. P.W. Rosenkranz and W.T. Baumann, "Inversion of Multiwavelength Radiometer Measurements by Three-Dimensional Filtering," in A. Deepak (Ed.), Remote Sensing of Atmospheres and Oceans (Academic Press, New York, 1980), pp. 277-312.
2. P.W. Rosenkranz, "Inference of Sea Surface Temperature, Near-Surface Wind, and Atmospheric Water by Fourier Analysis of Scanning Multichannel Microwave Radiometer Data," COSPAR/SCOR/IUCRM Symposium on Oceanography from Space, Venice, Italy, May 26-30, 1980.
3. D.H. Staelin, "Progress in Passive Remote Sensing: Nonlinear Retrieval Techniques," in A. Deepak (Ed.), Remote Sensing of Atmospheres and Oceans (Academic Press, New York, 1980), pp. 259-276.

9. TIROS-N SATELLITE MICROWAVE SOUNDER

U.S. Department of Commerce — National Oceanic and Atmospheric Administration
(Grant 04-8-M01-1)

David H. Staelin, Philip W. Rosenkranz, Paul Toldalagi, Jian-sheng Jin

The purpose of work under this contract is to develop improved methods of estimating atmospheric parameters, especially temperature, using the Microwave Sounding Unit, a four-channel scanning microwave radiometer which has been launched on the operational weather satellites TIROS-N and NOAA-6. Adaptive Kalman filtering¹ for temperature estimation and pattern recognition for cloud correction have been studied.

References

1. P.M. Toldalagi, "Some Adaptive Filtering Techniques Applied to the Passive Remote Sensing Problem," in A. Deepak (Ed.), Remote Sensing of Atmospheres and Oceans (Academic Press, New York, 1980), pp. 19-44.