Academic and Research Staff

Prof. A.H. Barrett
Prof. B.F. Burke
Prof. J.R. Melcher
Prof. P.C. Myers

Prof. D.H. Staelin
Prof. E.L. Wright
Dr. D.H. Roberts
Dr. P.W. Rosenkranz

Dr. M. Shao
J.W. Barrett
J.D. Kierstead
D.C. Papa

Graduate Students

A.D. Ali
B.R. Allen
H.T. Armstrong
Y. Bar-Yam
W.T. Baumann
C.L. Bennett
P.J. Benson
T.S. Bigelow
R.B. Buxton

R.L. Cheng
J.J. Daly
S.D. Dagaa
E.E. Falco
J.A. Garcia-Barreto
J.R. Gersh
P.E. Greenfield
J-s. Jin
J.H. Lang
C.R. Lawrence

S. Leibovic
T.H. Marshall
B.R. Rosen
M.H. Schneps
D.D. Stancil
J.C. Szczepanski
P. Toldalagi
J.V. Vallerga
Y. Yam

1. LONG-BASELINE ASTROMETRIC INTERFEROMETER

Michael Shao, David H. Staelin

A one-inch aperture prototype stellar interferometer was shipped to Mt. Wilson Observatory last year. The interferometer first tracked the white-light fringe in March 1979. The servo maintained equal path lengths in the two arms of the interferometer to 0.1 μm with a three-stage optical delay line. The fringe position was measured to 0.03 μm precision with 220 detected photons every 4 milliseconds. The optical bandwidth of the interferometer was 0.4 μm to 0.9 μm. Extrapolating from the fringe tracking data, the current tracking algorithm will track the fringes from 8.7 mag stars using 12-cm aperture optics.[1]

Two-color fringe measurements were made in June of 1979. For a 1-second integration time, two-color measurements were more accurate by approximately a factor of 3 over one-color measurements.

We have started work on phase two of the interferometer program, where we hope to demonstrate the elimination of atmospheric, thermal, and seismic errors at the milli-arc-second level.

References

1. M. Shao and D.H. Staelin, "First Fringe Measurement with a Phase Tracking Stellar Interferometer," to appear in Appl. Opt. (May 1980).

2. CONTROLLED THIN-FILM ANTENNA

David H. Staelin, Timothy L. Johnson, Jeffrey H. Lang, James R. Melcher

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$10-300 meter diameters in space; ground-based versions $\sim$2-10 meter diameter may also be of interest. This year the control experiments on the 1-meter square membrane were completed and rms surface tolerances of $\sim$10 μm rms were obtained in the presence of an electric pressure twice that necessary to destabilize the system; $\sim$30-100 μm rms were obtained at four times the basic destabilization pressure and three unstable modes were then controlled.

It was shown this year that the minimum diffraction-limited 3-dB beamwidth θ_B of such an antenna is approximately limited by

$$\theta_B(\text{radians}) \simeq \frac{1}{3AN(f/D)} ,$$

where N is the number of controlled modes, A is a factor near 10 which represents the intrinsic curvature of the reflector surface, and f/D is the reflector's ratio of focal length to diameter. Because the number of independent electrostatic control elements is limited by the antenna geometry and by Laplace's equation, it can be shown that one limit to resolution θ_B is

$$\theta_B(\text{arc sec}) \gtrsim \frac{900}{AM^2(f/D)^3} ,$$

where M is the number of controlled instabilities. For example, an antenna with f/D = 1 might achieve θ_B = 10 arc sec with 690 control elements and 3 controlled instabilities.

These experimental and theoretical results favor the development of this technology for space applications, and perhaps for terrestrial systems designed for submillimeter and millimeter wavelengths.

3.   SCANNING MICROWAVE SPECTROMETER EXPERIMENT

David H. Staelin, Philip W. Rosenkranz

The five-channel Scanning Microwave Spectrometer (SCAMS) yielded 10 months of data from the Nimbus-6 satellite, launched in 1975.[1]

Analysis of Typhoon June (1975) demonstrated that the radial derivative of microwave brightness temperature is related to the vertically weighted tangential wind through a wind weighting function; this relation follows from the thermal wind equation. Agreement with simultaneous 700-meter aircraft reconnaissance winds was good except near the eye of the typhoon, where the 150-cm resolution of SCAMS limited the performance.[2]

Snow and ice observations by SCAMS as a function of view angle and frequency have provided evidence that the microwave behavior of firn (long-term accumulated snow in Antarctica and Greenland) can be explained largely by the existence of random layering in the bulk of the firn with a vertical correlation length on the order of a millimeter; the variance in dielectric constant for these layers appears to grow as the ice grains grow with time and depth.[3] Similar studies of sea ice suggest that more isotropic bulk scattering dominates its radiometric signature.[3]

References

1.   D. H. Staelin, P.W. Rosenkranz, F.T. Barath, E.J. Johnston, and J.W. Waters, "Microwave Spectroscopic Imagery of the Earth," Science 197, 991-993 (1977).

2.   N.C. Grody, C.M. Hayden, W.C.C. Shen, P.W. Rosenkranz, and D.H. Staelin, "Typhoon June Winds Estimated from Scanning Microwave Spectrometer Measurements at 55.45 GHz," J. Geophys. Res. 84, 3689-3695 (1979).

3.   S.R. Rotman, A.D. Fisher, and D.H. Staelin, "Angular Microwave Radiometric Signatures of Firn and Sea Ice," in preparation.

4. TIROS-N SATELLITE MICROWAVE SOUNDER

David H. Staelin, Philip W. Rosenkranz, Paul Toldalagi

The first two satellites of the operational Tiros-N series have been launched; each incorporates a four-channel passive microwave spectrometer operating in the 50-58 GHz band.

Linear statistical estimators and Kalman filters were developed to retrieve temperature profiles from this data, the latter providing improvements in rms errors of ∿20 percent, comparable to earlier results with microwave data from the Nimbus-6 satellite. The most interesting result concerning Kalman filters was that incorporation of second-order statistics based on the actual local three-dimensional temperature field did not significantly improve the retrieval performance for summer data; it generally suffices to incorporate only the average latitudinal dependence and simple correlation constants between adjacent parcels of air. Significant improvement was prevented in part by the conflict between adequacy of representation and adequacy of statistics characterizing that representation.

A statistical view of linear retrieval techniques has led to a novel and useful procedure for updating statistical measures used in the retrieval of temperature profiles from Tiros-N data. The method has particular value over ocean, and should be incorporated in operational data interpretation procedures. In essence, the technique uses the variable scan angle of the microwave sounder to improve knowledge of the mean temperature profile, including certain components that may be invisible to the instrument at certain angles.

5. SCANNING MULTICHANNEL MICROWAVE RADIOMETER (SMMR)

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

The SMMR is an instrument on the Nimbus-7 satellite.[1] The objective of our research is to use the measurements to infer parameters which characterize the state of the atmosphere-ocean surface system. The parameters which we have found

possible to retrieve using this instrument are sea surface temperature, near-surface wind speed, integrated water-vapor content, integrated liquid-water content, and a characteristic radius of the drop-size distribution function. The inversion method which we have developed is one which operates on each spatial Fourier coefficient of the antenna temperature images (at five frequencies and two polarizations) to estimate the corresponding spatial Fourier coefficients of the geophysical parameters.[2,3] Efforts are also being made to improve models for the calculation of brightness temperatures given a specified state of the atmosphere-ocean system, particularly when the surface emissivity is increased by wind-generated white water and roughness.

References

1. P. Gloersen and F.T. Barath, "A Scanning Multichannel Microwave Radiometer for Nimbus-G and SeaSat-A," IEEE J. Oceanic Eng. OE-2, 172-178 (1977).

2. P.W. Rosenkranz, "Inversion of Data from Diffraction-Limited Multiwavelength Remote Sensors. 1. Linear Case," Radio Sci. 13, 1003-1010 (1978).

3. P.W. Rosenkranz and W.T. Baumann, "Inversion of Multiwavelength Radiometer Measurements by Three-Dimensional Filtering," in A. Deepak (Ed.), Remote Sensing of Oceans and Atmospheres (in press).

6. COMMUNICATION SATELLITES

National Aeronautics and Space Administration (Contract NAS5-25091)

David H. Staelin

In the late 1980's it will become practical to transfer a large fraction (perhaps 30 percent) of all long-distance telecommunications traffic to satellites, a step which will require significant switching capacity in space.[1-3] Analysis of market and technology issues has resulted in definition of a minimum-cost TDMA satellite-communications system architecture that could serve the entire United States by handling 30 GHz traffic. More than 1000 ground stations operating at 20,30 GHz would couple existing local toll centers or other nodes to a complex of very similar satellites sharing a single synchronous orbital slot. One novel feature of this architecture is the simultaneous use of more than one cooperating switched satellite with little intersatellite communication.

The projected costs for such a system appear to be very attractive and could facilitate establishment of new services such as video conferencing.

References

1. D.H. Staelin, "Expanding Broadband Switched Communications Networks," Satellite Communications, January 1979, pp. 26-30.

2. D.H. Staelin and R.L. Harvey, "Architectures and Economics for Pervasive Broadband Satellite Networks," Proc. IEEE 1979 International Conference on Communications, pp. 35.4.1-35.4.7 (June 1979).

3. D.H. Staelin and R.L. Harvey, "Future Large Broadband Switched Satellite Communications Networks," NASA Contract Report, December 1979. 270 p.

7. MICROWAVE SPECTROSCOPY OF THE INTERSTELLAR MEDIUM

Alan H. Barrett, Philip C. Myers

In 1979 Professors Barrett and Myers and their students carried out the following radio astronomical investigations of dense molecular clouds: (1) a study of the dense neutral globules in the Rosette Nebula; (2) a study of NH_3 emission from the galactic center; (3) a survey of nearby reflection nebulae in spectral lines of CO and NH_3; (4) first detection of the J = 3 doublet line of H_2CO in Orion; (5) searches for new regions of emission from the rare molecule HC_5N (six such regions were found); (6) large-scale mapping (full coverage of several square degrees) of CO emission from the nearest star-forming complexes in Taurus and Ophiuchus; and (7) construction of radiative transfer models permitting analysis of asymmetrical spectral lines in terms of cloud motions. These observational programs are part of our attempt to understand the formation and evolution of dark clouds in the interstellar medium and how they may relate to star formation. These programs, and others like them, will be continued in the coming year.

8. RESEARCH OBJECTIVES

Bernard F. Burke

The radio astronomy program covers a broad range of galactic and extragalactic problems. Some of these require equipment built in our laboratory, and some are carried out at large national facilities. The major research thrusts are as follows:

1. Performance of VLBI studies of celestial radio sources at a variety of wavelengths, to understand the physical processes in quasars and active galaxies. Long-wavelength (0.5-1 m) systems are being built and tested; the mm-band mixers under development will be used at the Haystack Observatory and elsewhere. Observations at standard VLBI frequencies will use existing equipment.

2. Study of time variations of interstellar masers, using VLBI methods to obtain maps with milli-arc-second accuracy. Time variations of adjacent maser spots would provide evidence for shock motions in maser complexes.

3. Completion of a large-scale survey of equatorial radio sources, using the 300-ft transit telescope of NRAO at Green Bank. Initial wavelength is 6 cm; observed sources will be reobserved at other wavelengths to determine spectra.