Radio Science Support

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Since 1967, radio scientists have used the Deep Space Network 26- and 64-m-diameter antenna stations to investigate pulsars, to study the effect of solar corona on radio signals, and to observe radio emissions from X-ray sources. More recently, very long baseline interferometry (VLBI) techniques have been used for high-resolution studies of quasars. During the reporting period, VLBI observations were made of quasars and pulsars. Support was also provided by the 64-m-diameter antenna for the measurement of cosmic background noise, mapping of nearby spiral galaxies, searching for ionized hydrogen in interstellar globular clusters, searching for interstellar molecules, and observing radiation from Jupiter.

I. Introduction

The 26- and 64-m-diameter antenna stations of the DSN have been used for several years to support radio science experiments. NASA, JPL, and university scientists have used key DSN facilities whose particular and unique capabilities were required for the performance of the experiments. In order to formalize the method of selecting experiments and experimenters, a Radio Astronomy Experiment Selection (RAES) Panel was formed in 1969. Notice of availability of these facilities was placed in professional journals to inform the scientific community that they were available for limited use by qualified radio scientists (Ref. 1). No charge is made for use of the standard DSN facilities and equipment; special equipment, however, must be provided by the experimenters. A summary of all experiments conducted through February 1972 is reported in Refs. 2 through 6.

II. Radio Science Operations

The amount of support in this reporting period increased considerably. Completion of the critical phases of the *Mariner 9* activities made available more time on the 64-m antenna at Goldstone (DSS 14). During the March–June period, the experiments conducted under the auspices of the RAES Panel utilized approximately 302 hours of DSS 14 time. This amounts to about 10.5% of the available time. The total for fiscal year 1972 is about 467 hours or 5.3%. Table 1 shows how the support was distributed through the year.

All of the RAES Panel experiments shown in Table 2, except the last four, are a continuation of previous measurements. These four experiments received support for the first time, having been recently approved by the Panel.

The observation of weak radio sources by D. Jauncey and others is a measurement at very low flux levels of the confusion factor due to weak background radio sources; the presence of this background radiation is a limiting factor in number-flux density surveys of radio sources made by radio astronomers. The transcontinental baseline VLBI by T. Clark and others is a feasibility demonstration. The use of three stations simultaneously in California, Massachusetts, and Alaska permits measurement of the closure capability of the technique. Pulsar observation by VLBI techniques is also a feasibility investigation to determine whether this difficult observation can be performed. Data from the observation are being evaluated. The observations by Hills and Klein, searching for ionized hydrogen, are an attempt to detect ionized gas in globular clusters for the purpose of determining the mean mass loss for those stars in a cluster currently evolving to the white dwarf stage. The experiment requires the high angular resolution and extreme sensitivity of the 64-m antenna at Goldstone.

The experiments sponsored by the Office of Space Science (OSS) and Office of Applications (OA) were also supported. The OSS experiments made first use of the new Ku-band (14 GHz) capability to detect interstellar molecules by microwave spectroscopy, and also to observe radio emissions from the outer planets. The OA experiment is a continuation of that described previously using VLBI techniques to make accurate baseline measurements.

III. RAES Panel Activities

The Radio Astronomy Experiment Selection Panel approved several experiments during the reporting period (Table 3).

IV. NASA Radio Science Plan Support

In June, the Laboratory forwarded to the NASA Radio Science Panel inputs to the long-range and annual Radio Science Plan being formulated by the Panel. These inputs are to be used to establish a support plan for fiscal year 1973. As was the case of the inputs supplied in January for the interim FY72 plan, the material included all experiments currently approved by the RAES Panel, description of requirements for all OSS and OA radio science experiments, and, for information, a description of DSN development activities that are related to radio science.

Included in the material on the RAES Panel experiments was the proposal for a *quasar patrol.* The purpose of the proposal is to provide a regularly scheduled set of VLBI observations. Measurements and observations of quasars and galaxies are required to detect the changes and variability in structure and flux output. The activity of such a patrol has been in effect during this reporting period and is characterized by 24-hour periods of observation from the 64-m antenna at Goldstone. The cooperating station is usually the 37-m antenna station at Haystack in Massachusetts and/or the 42-m antenna at the National Radio Astronomy Observatory (NRAO) in Greenbank, West Virginia. The X-band VLBI observations shown in Table 2 by the California Institute of Technology–National Radio Astronomy Observatory (Caltech–NRAO) and Goddard Spaceflight Center–Massachusetts Institute of Technology (GSFC–MIT) groups constituted the patrol for April, May, and June. These observations extend the investigations reported on in the publications cited in Refs. 5 and 6. Reference 7 is a recent publication resulting from this work. The VLBI proposals in Table 3 extend this work to higher frequencies.

References

1. *Bulletin of the American Astronomical Society*, Vol. 2, No. 1, p. 177, 1970.

2. Linnes, K. W., Sato, T., and Spitzmesser, D., "Radio Science Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. III, pp. 46–51. Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1971.

3. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. V, pp. 42–44. Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1971.

4. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VI, pp. 43–45. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1971.

5. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VII, pp. 29–31. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1972.

6. Linnes, K. W., "Radio Science Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. VIII, pp. 24–28. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1972.

7. Shaffer, D. B., et al., "Rapid Change in Visibility Function of the Radio Galaxy 3C120," *Astrophys. J.*, Vol. 173, pp. L147–L150, May 1, 1972.

Table 1. RAES Panel experiment support at the 64-m antenna station

Period	Station hours
July–December 1971	88
January 1972	32.5
February	44
March	36.5
April	54.5
May	119.5
June	92
Total	467.0

Table 2. Radio science experiments involving 64-m and 26-m antenna facilities

Experiment	Purpose	Experimenter	DSN facility	Date
RAES PANEL EXPERIMENTS:				
Very long baseline interferometry (medium data bandwidth, S-band)	To determine angular size of radio sources.	J. Gubbay (Univ. of Adelaide) A. Legg (Space Research Group, WRE) D. Robertson (Space Research Group (WRE) A. Moffett (Caltech) B. Seidel (JPL)	DSS 14 (64-m antenna) and DSS 41 (26-m antenna)	Jun. 12, 1971 Jan. 25, 1972 Feb. 21, 1972 Jun. 19, 1972
Spiral galaxy mapping		H. Arp (Hale Observatories)	DSS 14	Oct. 4, 7, 13, 20, 27, 1971 Dec. 8, 1971 Apr. 16, 1972
Quasar structure by X-band VLBI	To monitor time variations and fine structure and apparent position of quasars.	T. Clark (GSFC) R. Goldstein (JPL) H. Hinteregger (MIT) C. Knight (MIT) G. Marandino (Univ. of Maryland) A. Rogers (MIT Haystack Observatory) I. Shapiro (MIT) D. Spitzmesser (JPL) A. Whitney (MIT)	DSS 14 (also MIT Haystack antenna)	Jun. 9, 19 - 1971 Sep. 19, 1971 Oct. 2–4, 10, 17, 1971 Jan. 4, 1972 Feb. 18, 1972 Mar. 10, 1972 May 9, 1972
X-band VLBI	To study the structure of extra galactic sources with improved resolution.	J. Broderick (NRAO) B. Clark (NRAO) K. Kellermann (NRAO) D. Jauncey (Cornell Univ.) M. Cohen (Caltech) D. Shaffer (Caltech)	DSS 14 (also MIT Haystack antenna)	Feb. 1971 Nov. 2, 1971 Feb. 5, 1972 Mar. 4, 1972 Apr. 24, 1972 May 20, 1972 Jun. 6, 1972
Small-scale variations in cosmic background radiation	To search for small-scale spatial variations in the 2.7 K cosmic background radiation of 3.5 cm.	R. Carpenter (Calif. State College of Los Angeles) S. Gulkis (JPL) T. Sato (JPL)	DSS 14	Jan. 10, 11, 1972 Feb. 11, 12, 22, 1972 Mar. 14, 25, 1972 May 8, 28, 1972
Weak radio source observations	To measure the "confusion distribution" of weak radio sources at 2.3 GHz.	D. L. Jauncey (Cornell Univ.) M. J. Yerbury (Cornell Univ.) J. J. Condon (Cornell Univ.) D. J. Spitzmesser (JPL)	DSS 14	Jun. 5, 12, 1972

Table 2 (contd)

Experiment	Purpose	Experimenter	DSN facility	Date
RAES PANEL EXPERIMENTS (contd):				
Transcontinental baseline VLBI	To measure transcontinental vector baselines by VLBI observation of quasars.	T. A. Clark (GSFC) H. F. Hinteregger (MIT) C. A. Knight (MIT) S. Lippincott (MIT Haystack Observatory) A. E. Rogers (MIT Haystack Observatory) I. I. Shapiro (MIT) A. R. Whitney (MIT)	DSS 14 (also Haystack 37-m antenna and NOAA 26-m antenna in Alaska)	Mar. 18, 1972 Apr. 14, 1972 May 1, 28, 1972 Jun. 26, 1972
Pulsar observations	To measure position and apparent motion of pulsars at 2.3 GHz by VLBI.	T. A. Clark (GSFC) G. S. Downs (JPL) N. C. Erickson (Univ. of Maryland) P. E. Reichley (JPL) N. R. Vandenberg (Univ. of Maryland)	DSS 14 (also NRAO 42-m antenna at Greenbank, West Virginia)	May 4, 1972
Ionized hydrogen observations	To detect free-free emissions from ionized hydrogen in globular clusters.	J. Hills (Univ. of Michigan)	DSS 14	May 22, 29, 1972
OSS EXPERIMENTS:				
Interstellar microwave low-noise spectroscopy	To search for interstellar molecules at 14 GHz.	S. Gulkis (JPL) T. Sato (JPL) B. Zuckerman (Univ. of Maryland) D. Cesarsky (Caltech) J. Greenstein (Caltech)	DSS 14	Apr. 2, 10, 18, 1972 May 2, 6, 14, 17, 1972 June 3, 18, 1972
Planetary radio astronomy	To study radio emissions of Uranus and Jupiter at 14 GHz.	S. Gulkis (JPL) B. Gary (JPL) M. Klein (JPL) M. Jansen (JPL Resident Research Associate) E. Olsen (JPL Resident Research Associate) P. Rosenkranz (JPL Resident Research Associate)	DSS 14	Apr. 29, 30, 1972
OA EXPERIMENT:				
Earth physics VLBI	To demonstrate bandwidth synthesis techniques and to attempt to measure the baseline between DSSs 14 and 12 at Goldstone to 10 cm.	P. MacDoran (JPL) J. Fanselow (JPL) J. Thomas (JPL) J. Williams (JPL)	DSS 14 DSS 12	Apr. 4, 1972

Table 3. Recently approved radio astronomy experiments

Title	Purpose	Experimenters	Facilities required
2-cm VLBI observations	To make detailed measurements on a limited number of radio galaxies and quasars at 15 GHz; to search for weak compact sources in the nucleus of extended radio galaxies and quasars.	B. Clark (NRAO) K. Kellermann (NRAO) M. Cohen (Caltech) D. Shaffer (Caltech)	64-m antenna at Goldstone with Ku-band system (working with 47-m antenna at NRAO, Greenbank, West Virginia)
15.6-GHz VLBI observations	To monitor time variations in the fine structure and apparent positions of quasars at 15.6 GHz.	T. Clark (GSFC) R. Goldstein (JPL) H. Hinteregger (MIT) C. Knight (MIT) G. Marandino (Univ. of Maryland) A. Rogers (MIT Haystack Observatory) I. Shapiro (MIT) D. Spitzmesser (JPL) A. Whitney (MIT)	64-m antenna at Goldstone with Ku-band system (working with 37-m antenna at Haystack Observatory)
Ionized hydrogen detection	To search for microwave emission from ionized hydrogen in globular clusters.	J. Hills (Univ. of Michigan) M. Klein (JPL)	64-m antenna at Goldstone