Radio Astronomy

R. D. Shaffer
Mission Control Center Section

S. Gulkis
Planetary Atmospheres Section

This article reports on one Radio Astronomy activity supported by the Deep Space Network: namely, use of the Tidbinbilla Interferometer to refine the source positions in the Parkes 2.7-GHz survey of the southern sky. A result of the first phase of this work was the identification of a quasi-stellar object which appears to be the most remote object yet observed.

The 34- and 64-m antennas at the Tidbinbilla Deep Space Communications Complex (DSCC) can be configured as a real-time interferometer operating in the 13-cm band. The system parameters are as follows:

Operating frequency:	2.3 GHz
Predetection bandwidth:	12.0 MHz
Baseline:	200.0 m (north-south)
Lobe separation:	2.3 arc min
IF frequency:	70.0 MHz
Sensitivity:	1.6 mJy/hr (5 × rms)

Funding for the equipment necessary to create the Tidbinbilla Interferometer was granted by the Laboratory Director's Discretionary Fund (DDF) in 1972. Once the system was built and its capability demonstrated, funding for its operation and for the reduction of data was provided by the Office of Space Science and Application (OSSA 188-41-55-16). The Tidbinbilla Interferometer is used primarily to accurately measure the positions of southern hemisphere radio sources. The accurate positions thus obtained then allow astronomers to identify the optical counterparts of the radio sources.

The primary catalog of radio sources used at Tidbinbilla is the Parkes Radio Observatory's survey of the southern sky at 2.7 GHz. The source positions in the Parkes Survey are accurate to within 15 arc seconds. The use of interferometric techniques allows more accurate position determinations than can be made with a single antenna. With the Tidbinbilla Interferometer, the source positions from the Parkes Survey can be determined within 1-2 arcseconds. Thus, when an astronomer inspects a patrol plate taken by a widefield camera, he or she must inspect only 1% as much of the plate with the Tidbinbilla results as would be necessary with the unrefined Parkes Survey data. This allows for unambiguous source identification in approximately 85% of all cases.

The April 1982 issue of *Astrophysical Journal* contains an article entitled "2.3 GHz Accurate Positions and Optical Identifications for Selected Parkes Radio Sources," by S. Gulkis (JPL), D. L. Jauncey and M. J. Batty (CSIRO), and A. Savage (Royal Observatory). This article contains the refined positions of 74 sources from the Parkes Survey. Even before publication, A. Savage, A. Wright (CSIRO), and B. Peterson (Australian National Observatory) were making optical observations of many of the objects identified in the article.

One object, PKS 2000-330, was of particular interest because it is approximately 15 times as bright in the red as it is in blue light. On 25 March 1982, a spectrogram of this quasi-stellar object (QSO) revealed that the normal positions of spectral lines are red-shifted by the largest amount ever recorded.

The red shift is given by:

$$Z = \frac{\lambda - \lambda_0}{\lambda_0}$$

where λ is the observed wavelength of the spectral lines, and λ_0 is the wavelength of the same spectral lines in a laboratory frame of reference. The value of Z for PKS 2000-330 is 3.78, surpassing the previously recorded 3.53 by a wide margin.

Most astonomers believe that the large red shifts exhibited by QSOs are caused by enormous velocities of recession, i.e., that the radiation from QSOs is being Doppler-shifted toward the red by the fact that the QSOs are receding from us at velocities which are a large fraction of the speed of light. In the case of PKS 2000-330, its velocity of recession is equal to 91% of that of light. On a cosmological scale, an object's distance from the observer is thought to be proportional to its velocity of recession. This is known as Hubble's law. Using a proportionality constant of the 70 km/sec/10^6 parsec, a widely used value of the Hubble constant, PKS 2000-330 appears to be 12 billion light-years away. In any case, PKS 2000-330 appears to be the most remote object yet observed.