THE NAVOBSY/NRL PROGRAM FOR THE DETERMINATION OF EARTH ROTATION AND POLAR MOTION

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The joint program of NAVOBSY/NRL is discussed.

INTRODUCTION

The United States Naval Observatory (NAVOBSY) and the Naval Research Laboratory (NRL) are collaborating in a program to apply radio interferometric techniques to the determination of variations in Earth rotation, polar motion, and improved astronomical position reference systems. Investigations of VLBI and connected interferometer techniques and radio sources for astrometic application have been in progress for several years as part of the NRL radio astronomy program, and currently NRL and NAVOBSY are carrying out experimental programs to investigate VLBI time transfer techniques and UT determination using the connected element interferometer of the NRAO in Green Bank. Some previous results of observations using the Green Bank interferometer and proposed plans for operation as a dedicated system over a period of time to evaluate effectiveness for precise determination of Earth rotation parameters are discussed.

The Green Bank interferometer of the National Radio Astronomy Observatory (NRAO) includes three 26-meter antennas which are located along an azimuth of 242 degrees. Two of the antennas are moveable giving 16 possible antenna separations with the maximum separation being 2.7 km (Hogg, MacDonald, Conway, and Wade, 1969). The operating frequencies are 2695 and 8085 MHz. In addition to these three on-site antennas, a 14-meter antenna is located 35 km away. The signal from this antenna is transmitted to the site via a phase-stable radio link where it is combined with the signals from the three 26-meter antennas giving three long baselines which range in length from 33091 to 35266 m and in azimuth from 204° to 207°. The baseline geometry is shown in Figure 1.

D. D. McCarthy and J. D. Pilkington (eds.), Time and the Earth's Rotation, 211–215.

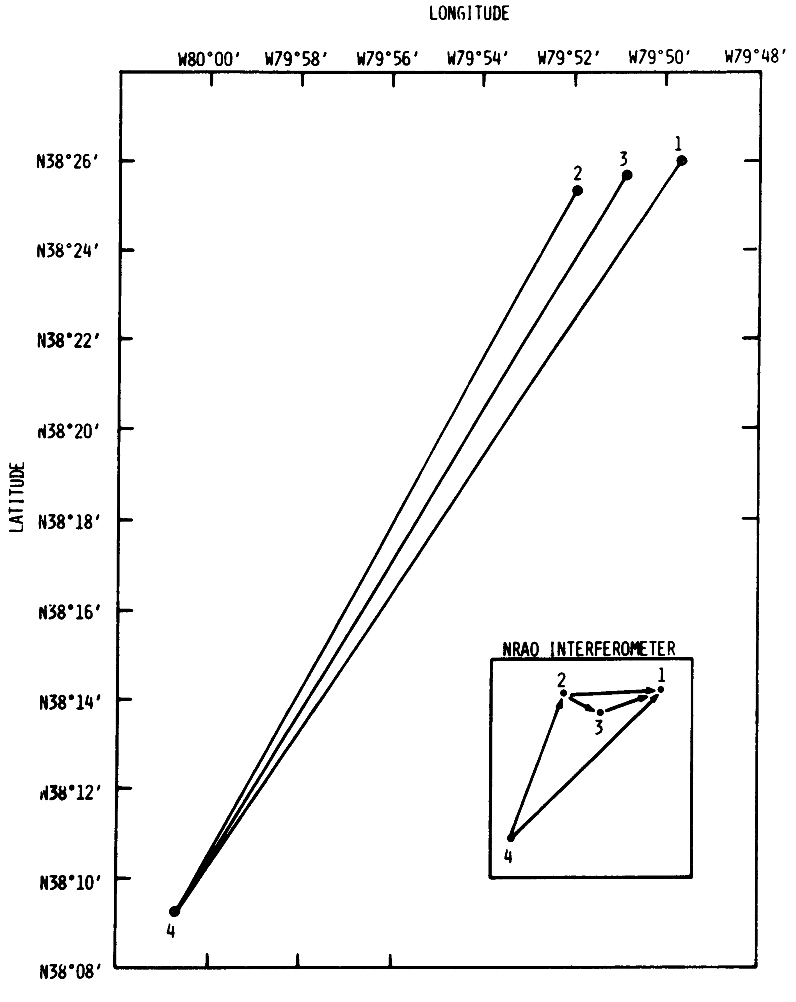

Figure 1. Geometry of the Green Bank interferometer. The three on-site 26 m antennas are designated as 1, 2, and 3 while the 14 m remote antenna is designated as 4.

Observations made with this instrument between December 1974 and January 1976 have resulted in the determination of the positions of 36 radio sources to an accuracy of a few hundredths of an arc second (Wade and Johnston, 1977). As a by-product of these observations, observations were made during January 1976 of the radio sources NRAO 140, 3C345, and NRAO 512 for the purpose of evaluating the accuracy of this instrument for the determination of Earth rotation parameters. Earlier Elsmore (1973) had demonstrated that a 3.6 km east-west baseline could determine UT1 to an accuracy of 4.6 ms. Since the three Green Bank baselines are close to parallel, both UT1 and the two components of polar motion could not be solved for independently (see Johnston, 1979). Polar motion from the Dahlgren Polar Motion Service was used to solve for UT1. Figure 2 displays the difference between the BIH value of UT1 and the value found from the radio observations. The average difference is 2.1 ± 1.2 ms.

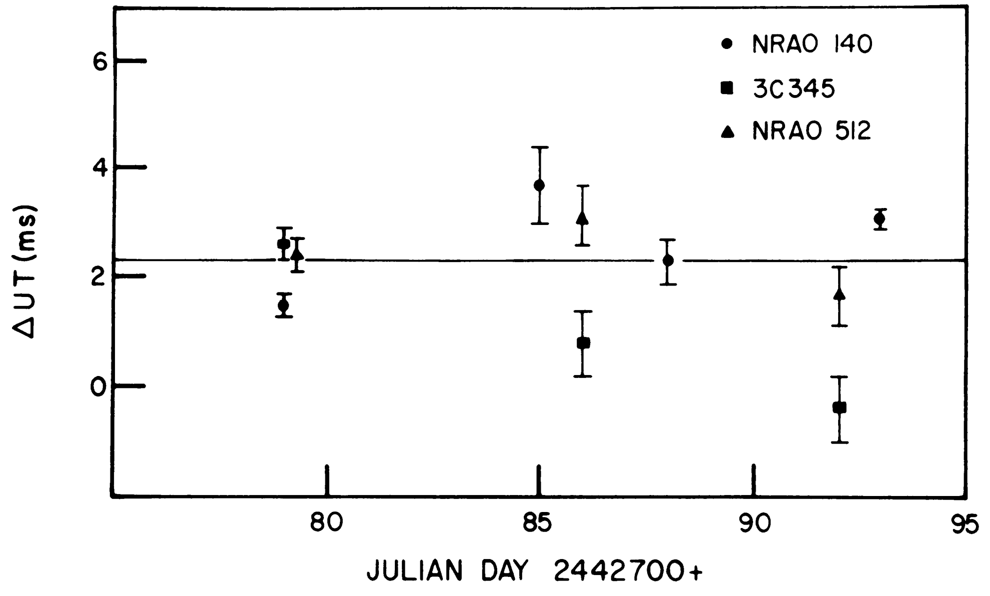

Figure 2. Measurements of UT1 made in January 76 using the Green Bank interferometer. The error bars display the rms accuracy of the solution for each determination.

There are the following advantages in using a connected element interferometer to determine Earth rotation parameters (Johnston, 1974):

1. Single station operation leading to lower cost.
2. Simple electronics - no video tape recorders and no need for hydrogen maser frequency standards.
3. Real time capability - the data can be reduced immediately allowing the immediate determination of UT1 and polar motion.
4. The system can be easily automated.
5. The relatively short interferometer baselines which are adequate with this technique minimize the effects of the atmosphere, ionosphere, and Earth tides.

However there are some disadvantages:

1. The baselines must be determined to millimeter accuracy. Deformations of the antennas may lead to significant systematic effects.
2. For the existing interferometer in Green Bank the remote 14 meter antenna is more than 200 m higher than the on-site 26 meter antennas. Variations in atmospheric conditions between the remote and main sites may lead to errors in baseline determination.

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With the construction of the VLA, the National Radio Astronomy Observatory is phasing out operation of the Green Bank interferometer by October 1978. It is proposed that this facility be operated initially to evaluate the accuracy with which this instrument can determine Earth rotation parameters such as UT1 and polar motion in all weather conditions over periods of observation of eight hours duration. If the results are favorable, another long baseline can be added by locating an antenna at a second remote site to form orthogonal baselines. With two perpendicular baselines, UT1 and both components of polar motion can be found independently from the observations making this the only observatory that can precisely determine all three components of the motion of the Earth's crust.

This facility will be the first dedicated to radio astrometry. As such it will provide daily observations for the determination of Earth rotation parameters. In addition to the determination of Earth rotation parameters, this program will improve the positions of the approximately twenty radio sources observed to $\leq 0\farcs01$. These positions will define an almost inertial reference frame. The accuracy of the short period nutation terms will also be improved through the continuous radio observations.

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DISCUSSION

E. Silverberg: Would any VLBI investigator comment on the "all weather capability" of VLBI, with particular reference to the determination of baselines to 5cm accuracy?

J. L. Fanselow: Over the past five years we have had several hundred VLBI experiments, all of them scheduled well ahead, so that we had to accept the weather that came. I am not aware of more than one or two experiments during that interval that were lost because of weather. In several experiments we had heavy rain at all sites; this increased system noise temperatures, and so reduced signal-to-noise ratios. High winds, of more than 45 miles per hour, have forced curtailment of several experiments in order to prevent mechanical damage to the antenna structure.
Observations of time delay and its rate of change, made with long baselines, are relatively insensitive to small changes in the atmosphere: for example, a 13 cm change due to the atmosphere causes only a $0\farcs003$ error in the typically measured VLBI angle when time delay is observed on a 10 000 km baseline.

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Ya. S. Yatskiv: Your slide mentioned the determination of satellite positions; please comment.

K. Johnston: We are studying the accuracy of both conventional interferometry and VLBI for the determination of satellite positions relative to an almost inertial frame defined by celestial radio sources. At present I estimate the accuracy of the relative positions of a satellite-quasar pair as $0\overset{''}{.}001$.

L. V. Morrison: You said that you have to determine the baseline with millimeter accuracy. Is there correlation here with UT1 and polar motion, the quantities you are trying to measure?

K. Johnston: Not really; we have used data from three one-week observing runs, corrected for nutation and similar effects, and we solved to get source positions and baselines as nearly independent as we could. There is a small problem associated with the use of equatorial mounts, because there is correlation between the determination of axis separation and source declinations, but we believe we have now overcome this.