NATIONAL RADIO ASTRONOMY OBSERVATORY

Charlottesville, Virginia

MEASUREMENT OF PRECISE RADIO SOURCE POSITIONS WITH THE GREEN BANK INTERFEROMETER

C. M. Wade

During the latter part of 1968, a program to measure the positions of 45 selected radio sources to an accuracy of 1 second of arc or better was carried out at Green Bank. Accuracy of this order had been achieved previously only by observations of lunar occultations. Only a relatively small number of sources lie in the moon's path, however, so this method is of limited applicability. The procedure discussed here works equally well over nearly all of the sky visible from Green Bank.

Astronomical positions are customarily expressed in terms of two angles, declination and right ascension. These are respectively analogous to latitude and longitude on the earth. Declination is reckoned north and south from the celestial equator, the great circle on the celestial sphere which lies vertically above the terrestrial equator. Right ascension is measured counterclockwise along the celestial equator from the "first point in Aries", the point where the center of the sun crosses the celestial equator each spring as it moves into the northern sky. It is customary to express declination in arc measure (degrees, minutes, seconds) and right ascension in time measure (hours, minutes, seconds). One second of time is equivalent to 15 seconds of arc.

The three-element interferometer, operating at a wavelength of 11.1 cm, was used for the program. Element spacings ranging from 16200 to

24300 wavelengths were employed. This afforded angular separations of as little as 8.5 seconds of arc for the interference fringes.

The measurement technique, which is described fully in the accompanying manuscript, has some novel features. The vital point is that it is possible to derive all of the instrumental constants of the interferometer which are needed to measure source positions, by observing a group of sources well distributed over the sky, even though we do not know the positions of any of these sources accurately to start with. And once these instrumental constants have been fixed, one can use the same set of observational data to find accurate positions for all of the sources which were observed. The declinations thus determined are absolute, in that they are independent of any previous optical or radio measurement of the position of any radio source. Similarly, the differences of the right ascensions of the sources are fixed absolutely. The only use made of optical data is to fix the origin of the right ascension system.

The method depends on the fact that the interference fringe pattern one will observe, when looking at a radio source whose angular size is small compared to the separation of the fringes, can be computed exactly if the position of the object on the sky and the length and orientation of the interferometer baseline are known precisely. And one can readily calculate how the fringe pattern will be displaced in time if one varies the source position or the baseline parameters by a known amount. In my method, I turn the problem around. I assumed a set of baseline parameters and radio source positions, and observed the displacement of the actual fringes from those corresponding to the assumed values. By using the

procedure described in the manuscript, one can separate the effects of errors in the assumed baseline parameters from those caused by the errors of the assumed positions. Then the baseline errors are determined explicitly. Finally, one deduces the errors in the assumed positions.

The quality of the results given by this procedure can be judged from their agreement with accurate optical measurements of the positions of the same objects. At present, such data are available for 29 of the 45 objects in my list. The radio and optical positions agree to within 1 second of arc in 23 cases; in only one case does the disagreement exceed 1.5 seconds of arc. The algebraic mean difference in declination is 0.03 second of arc. The mean right ascension difference was forced to be zero, of course, since the optical positions were used to fix the origin of the right ascension scale. A further index of the quality of the agreement is given by the mean absolute difference of the radio and optical positions; this is 0.6 second of arc.