Implementation of the J2000 Coordinate System at the VLA

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The new IAU constant system is explained in USNO Circular No. 163. The changes are: use of the IAU 1979 precession constant rather than Newcomb's; use of the IAU 1980 Nutation Theory instead of Woolard's; rotation of the equatorial coordinate system to more nearly bring the origin of right ascension to the true equinox; and catalog positions are to be calculated as seen from the rest frame of the solar system barycenter (previous catalogs have generally been on an "astrometric" system, differing from the barycentric by "E terms" which could be represented by a constant motion of 500 m/s relative to the barycenter). The third of these will be referred to as "changing from the system of the FK4 to the system of the FK5". The first and, especially, the third of these require an adjustment of sidereal time between the two systems. Because we have at the VLA only one sidereal time, but may have two or even three observers on the array at the same time, it is not possible to switch from one system to the other as transparently as one might wish. However, we have attempted to implement things so that the transition will be as painless as possible. In our implementation, the use of the new system is keyed to the epoch of the given position. For 1950 positions, the behavior of the system will be, except in its internal operation, unchanged.

As of March, 1983, a step was inserted in the mean sidereal time, to bring our time system into alignment with the formula of USNO 163. In order that this not affect positions entered in 1950 coordinates, an additional step was introduced in the precession calculations, in which the right ascensions of the apparent positions are rotated to compensate for the changed sidereal time (a constant offset of 63.9 milliseconds is used, which is, technically, appropriate only for January 1, 1984, but which will introduce errors which accumulate only slowly). Similarly, the IAU 1980 Nutation is used to calculate the apparent sidereal time, and the apparent right ascensions of the sources precessed from 1950 are adjusted by the difference in the equation of the equinox as calculated by the two nutation theories.

In summary, then, positions given in epoch 2000 will be processed in accordance with the recommendations of USNO 163. Positions given in epoch 1950 will employ the adjustments of the paragraph above, so that they are effectively processed by the recommendations of the Explanatory Supplement of 1960. Positions of any other epoch will, currently, be processed by the recommendations of the Explanatory Supplement of 1960. The most serious consequence of this last is that planetary coordinates given in apparent coordinates of observing date are assumed to be in the system of the FK4. It seems likely that as soon as the system of the FK5 comes into more use for the production of planetary ephemerides, we shall reverse this decision, and use the FK5 and the formulae of USNO 163 for

epochs other than 1950.

A separate master calibrator list in J2000 coordinates has been provided, and should be used if the position of the object under investigation is in J2000 coordinates. The names in the J2000 calibrator list are in the IAU format, based on the J2000 position, with no distinguishing mark. Therefore, each calibrator will have two aliases, in identical format, one in each of the two calibrator lists (B1950 and J2000). Both names will appear in the VLA Calibration Manual. If B1950 calibrators are used with a J2000 source position, or vice versa, systematic errors in even the position offsets from the calibrators, of order 0.1 arcseconds, will occur.

In order to facilitate the recommended changeover to J2000 coordinates, a precession capability has been installed in the OBSERV program. If the default epoch code calls for J2000 coordinates, and a B1950 coordinate is explicitly entered, the program will automatically precess the coordinates to the J2000 system, assuming the epoch at which the B1950 position was derived was 1975.0. This assumption introduces an error of up to 0.04 seconds of arc per year in right ascension and 0.013 seconds of arc per year in declination. An additional 0.05 seconds of arc may be introduced by truncation errors in the single precision routine.

It now seems profitable for anyone interested in the highest positional accuracy to use J2000 coordinates for all future observations, unless compatibility with previous observations is critical and the whole series does not span enough time to be unduly confused by the known error in Newcomb's precession constant. (It is probably less work to put previous observations into J2000 coordinates than to calculate the corrections to the 1950 coordinates of various dates, if the observations span more than a couple of years.) For the general VLA user, the pressure to change systems is not so strong--he must consider whether it is more important that his observation remain compatible with previous observations of the object, or whether it should be compatible with future accurate astrometry, either radio or optical. I would certainly not recommend changing to J2000 coordinates for an object which you have observed here before, and might conceivably wish to combine the (u,v) data--there is no point in just asking for trouble. However, we encourage the use of J2000 coordinates unless there is a firm argument against doing so. It seems inevitable that J2000 coordinates are going to come into general use, and the sooner we can get through the painful transition period, the better off we all shall be.