V. A. Alekseev, V. N. Nikonov, and V. S. Troitskiĭ. *Radar positional astronomy: status and prospects.* During the 1970s, the development of broadband very long baseline radiointerferometers (VLBI) and methods for using them to determine the coordinates of cosmic radio sources and, in a system of these sources, the parameters of Earth chords anchored by radiointerferometer stations, gave rise to a new trend—radio positional astronomy—with a broad range of solvable fundamental and applied positional-astronomy problems in the radio-frequency band.[1] The accuracy of these solutions is more than an order of magnitude higher than the accuracy attainable with optical tools, and the all-weather utility of the radio systems and, most importantly, the use of "superdistant" compact cosmic radio sources—quasars and the nuclei of radio galaxies—as astrometric benchmarks produces solutions of a totally new quality for positional-astronomy problems and their applications.

A number of methods have now been proposed for solution of the main group of positional-astronomy problems (establishment of a nonrotating system of celestial coordinates, a system of earth coordinates, and the relationship between them): absolute[2] and differential[3] methods and a method of arcs[4] using VLBIs with independent reception systems, as well as dynamic and geometric methods using a VLBI whose stations are phased by two-way satellite communication.[5] The last method gives the ideal solution to a fundamental problem of positional astronomy—establishment of the celestial coordinate system—by virtue of the simplicity of its algorithms and the fact that the result of the geometric solution is independent of all geophysical and geodynamic theory. The celestial coordinate system anchored by the cosmic radio sources will be stable at a level of 10^{-3} arc sec for decades and on the 10^{-2} arcsec level over many centuries.

Measurement of the relative positions and displacements of points on the earth's surface based on measurements of the parameters of interferometer bases in a coordinate system anchored by cosmic radio sources is the object of geophysical and geodynamic applications of radioastrometric VLBIs. An attractive prospect is the use of radio-emitting satellites specified in cosmic radio source coordinates as a means of mapping the celestial coordinate system; this would make it possible to use simplified systems for radiointerferometry of these satellites in geodynamic research. Further, satellite radiointerferometry could be used to tie the radioastrometric earth coordinate system to the earth's center of mass and to tie the radio celestial coordinate system to the optical system.[6] On the whole the use of VLBI to determine the coordinates of natural and artificial cosmic radio sources and earth rotation parameters and for mutual space-time coordination of widely separated interferometer stations forms the basis for a high-precision coordinate-and-time service for various scientific and practical requirements.

The capabilities of radiopositional astronomy are limited by the error involved in taking into account the equivalent atmospheric refraction defined as the ratio of the unknown path advance of the interfering signals in the earth's atmosphere to the length of the interferometer base. An effective way of reducing this error is to use differential-interferometry methods with running determination of the atmosphere's electrical thickness from thermal radar data. Here the error of allowance for the mutual atmospheric path advance of the interfering signals at centimeter wavelength is estimated at ~1.5–3 cm, which, on a base of ~6 thousand km, would give an angle-determination error of $\sim(0.5-1)\cdot 10^{-3}$ arcsec in a single measurement session.

The achievements of modern radio positional astronomy are best illustrated by the results of the first observing campaign to study the earth's rotation, within the framework of the international MERIT project.[7] Use of radioastrometric VLBIs made it possible to obtain the coordinates of the pole accurate to ~0.0013 arcsec or 5 cm in linear measure, and Universal Time UT1 accurate to ~0.07 msec, all during a one-day measuring cycle. During the same interval of time, the distance between the interferometer stations was determined with an error of 2–3 cm for bases up to 6000 km long and 5–7 cm for bases up to 8000 km. The coordinates of the observed radio sources have been determined with an accuracy of thousandths of arcsec.

Radioastrometric experiments are now being conducted on existing radio telescopes that are burdened with other programs, and are therefore of episodic nature. Further, the informativeness of existing VLBI facilities with independent receiving systems is limited by the memory capacity of the systems used to record the interfering signals, and they are processed not only with a delay, but rather slowly, owing to the constant uncertainty as the position of the interference response in frequency and in the lag that results from desynchronization of the time scales and instability of the frequency standards at the interferometer stations. All this precludes organization of the continuous series of observations required for positional-astronomical studies. Obviously, realization of all the capabilities of radio positional astronomy will require the creation of specialized VLBI complexes that incorporate satellites for synchronization of the time scales at the stations receiving and transmitting the received information to the processing station and operating in real time. A plan for the corresponding hardware has been worked out in the USSR with participation of representatives from practically all the radio-astronomy and positional-astronomy organizations in the country, and its implementation will produce a unique broad-profile physical instrument.[8]

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