Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics, Academy of Sciences of the USSR (26–27 May 1982)

Usp. Fiz. Nauk 139, 357–363 (February 1983)

PACS numbers: 01.10.Fv

A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on May 26 and 27, 1982 at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were presented:

May 26

1. *V. K. Abalakin, O. M. Gromova, V. N. Koǐko, Yu. L. Kokurin, V. V. Kurbasov, V. F. Lobanov, A. N. Sukhanovskiǐ, and M. A. Fursenko*, Lunar lidar as a method for solution of geodynamic and positional astronomy problems.

2. *S. K. Tatevyan*, Use of optical observations of artificial earth satellites for objectives in geodesy and geodynamics.

3. *V. A. Alekseev, V. N. Nikonov, and V. S. Troitskiǐ*, Radar positional astronomy: status and prospects.

May 27

4. *B. V. Chirikov*, Dynamic chaos in classical and quantum systems.

5. *M. I. Rabinovich*, Pathways to and properties of stochasticity in dissipative systems.

Below we present brief contents of four of the papers.

S. K. Tatevyan, *Use of optical observations of artificial earth satellites for objectives in geodesy and geodynamics*. Determination of the dimensions and geometric shape of the earth and study of the structure of the gravitational field that it creates constitute the basic scientific problem of geodesy. The fact that the geometric shape of the earth can be represented most accurately as an ellipsoid of revolution has been known for some time, but right up until the end of the 1960s the parameters of this ellipsoid as computed and used in various countries differed quite significantly from one another. For example, the disagreement as to the length of the semimajor axis of the ellipsoid ranged up to 240 m, while the flattening varied from 1 : 297.0 to 1 : 298.6. These disagreements, which are large from the standpoint of geodesy, resulted primarily from the nature of the very methods used in traditional geodetic measurements. The surface of the earth is covered by a network of points that form triangles no longer than 30 km on a side, all angles of which are then measured. The oceans, seas, and mountain ranges present insurmountable obstacles to the construction of ground geodetic networks, and for this reason a separate geodetic system is constructed on the territory of each continent and each individual country with adjustment of the parameters of the corresponding ellipsoid.

An artificial satellite circling the earth in practically the same orbit for a long period of time was found to be the most convenient target for observations from stations hundreds and thousands of kilometers apart. This was the principal factor in the rapid development, since 1957, of new "satellite" (or "space") geodesy. The first studies in this area[1,2] were oriented to practical geometric methods for satellite geodesy, which essentially constituted a three-dimensional variant of the ground triangulation network. A satellite illuminated by the setting or rising sun was photographed with special cameras[1,3] against the background of the stars. It was necessary to ensure that observations from two or three stations were synchronous to within 1-2 thousandths of a second. Positional-astronomy methods[4] with some resemblence to the procedure used to determine the positions of minor planets and asteroids were developed for determination of the satellite's spherical coordinates.

The Astronomical Council of the USSR Academy of Sciences organized an international network of satellite-observing stations and carried out several scientific experimental programs of synchronous observations, the most significant of which was the "Arctic-Antarctic" project proposed by I. D. Zhongolovich (see Ref. 5). Implementation of Soviet and international programs in satellite geodesy had, by the end of the 1970s, resulted in several model global coordinate systems[6] that define the positions of over 200 ground points in a unified space coordinate system referred to the earth's center of mass and axis of rotation. The rms errors of the station coordinates were 5–15 m, and the geoid as a whole was represented accurate to 5–10 m.

Improvement of satellite-observing techniques, and especially development in 1966–1970 of laser rangefinders that can measure distances to a satellite with errors smaller than 1 m[1,7] and improvement of the theory of satellite motion and the development of highly accurate methods for calculation of orbits[8,9] led to rapid development of dynamic methods in satellite geodesy in 1970–1980.[1,10]

Accurate calculation of the elements of satellite orbits and analysis of their variations in time forms a basis for determination of the structure of the earth's

 0038-5670/83/020182-06$01.80

external gravitational field and other physical parameters that influence the motion of satellites. The accuracy of the geopotential model has improved significantly during the last twenty five years. While harmonics only up to the 4th or 5th order in the expansion of the geopotential in spherical harmonics were known with certainty before 1957, it was possible even at the beginning of the 1970s to guarantee the first 10 harmonics. Now, in the last geopotential model derived by the Goddard Spaceflight Center in the United States,[11] the coefficients of the harmonics up to the 15th order and some of the coefficients up to the 30th order have been determined accurate to $\pm 5 \cdot 10^{-9}$. The error in determination of the global geoid is estimated as ± 1 m. The semimajor axis of the ellipsoid is $6\,378\,139 \pm 1$ m, and the flattening is 1 : 298.255.[11] Future development of research on observation of artificial earth satellites will be oriented to studying the dynamic parameters of the earth, such as the motion of the earth's poles and the variation of its velocity of rotation. The first observations of the "Lageos" satellite (altitude 6000 km) using laser range finders of decimeter accuracy, which were made during an international program to study the rotation of the earth (MERIT) in 1980, indicated that the components of the coordinates of the pole can be determined reliably with an accuracy of 30–40 cm over a 5-day interval.[12] With improvement of the accuracy of the orbit-computing models to 1 m in the radial direction and to 10 cm along the orbit, and with the use of a larger number of laser stations of centimeter accuracy, it will be possible to determine the coordinates of the pole with a 5-cm error on a one-day interval. New laser satellite rangefinders of centimeter accuracy are expected to go into operation during the next 2–3 years at stations in the United States, the Federal Republic of Germany, France, and Japan. A similar instrument is being developed in the Soviet Union (Lebedev FIAN). Using 5–7 laser stations of this accuracy uniformly distributed over the globe, assuming that the orbit-computing models become accurate to 1 meter in the radial direction and 10 cm along the orbit, it will be possible to determine the coordinates of the pole regularly with a 5-cm error on a 1-day interval and the velocity of the earth's rotation with an error of 0.2 m/sec.

It may be concluded from a comparative analysis of the errors in determination of earth-rotation parameters from laser observations of satellites and the moon that on short intervals of time (1-2 days) it will be more effective to use lidar on "Lageos"-type satellites with orbital heights of 6–7 thousand km. Lunar lidar gives reliable values of Universal Time (UT 1) and the speed of the earth's rotation. Accordingly, special interest attaches to laser systems that can be used to observe both satellites and the moon. In this case, the coordinates of the pole will be determined from satellite observations on 1-day intervals, while the lunar lidar data will be used to determine the time corrections over longer time intervals and to apply the corresponding corrections to the computed satellite orbits.

[1]N. I. Georgiev, A. G. Masevich, V. M. Klenitskiĭ, and S. K. Tatevyan, Ispol'zovanie opticheskikh nablyudeniĭ iskusstvennykh sputnikov Zemli dlya geodezii (Use of Optical Observations of Artificial Earth Satellites for Geodesy). Izd-vo Bolg. Akad. Nauk, Sofia, 1979.

[2]E. G. Boĭko *et al.*, Ispol'zovanie iskusstvennykh sputnikov Zemli Dlya postroeniya geodezicheskikh seteĭ (Use of Artificial Earth Satellites to Construct Geodetic Networks). Nedra, Moscow, 1977.

[3]A. G. Masevich and A. M. Lozinskiĭ, Vestn. Akad. Nauk SS SSSR, no. 2, 38 (1970).

[4]A. A. Kiselev *et al.*, Byull. SON ISZ, No. 3(13), 53 (1960).

[5]I. D. Zhongolovich and A. A. Malkov, Nablyudeniya ISZ (Berlin), No. 11, 189 (1971).

[6]K. Lunquist and G. Weiss, The Standard Earth, Mir, Moscow, 1969.

[7]A. G. Massevitch and K. Hamal, Intercosmos Laser Ranging Stations. In: COSPAR Space Research XVII, Praha, 1977.

[8]E. P. Aksenov, Teoriya dvizheniya iskusstvennykh sputnikov Zemli. (The Theory of Motion of Artifical Earth Satellites), Nauka, Moscow, 1977.

[9]A. A. Izotov *et al.*, Osnovy kosmicheskoĭ geodezii (Fundamentals of Space Geodesy). Nedra, Moscow, 1974.

[10]S. K. Tatevyan, Nablyudeniya ISZ (Moskva), No. 13, 184 (1974).

[11]F. J. Lerch *et al.*, Marine Geodesy 5, No. 2 (1981).

[12]H. Montag, Gendt, and W. Wehmann, Polar Motion and Variation of Earth's Rotation Derived from MERIT Laser Data to Lageos.