

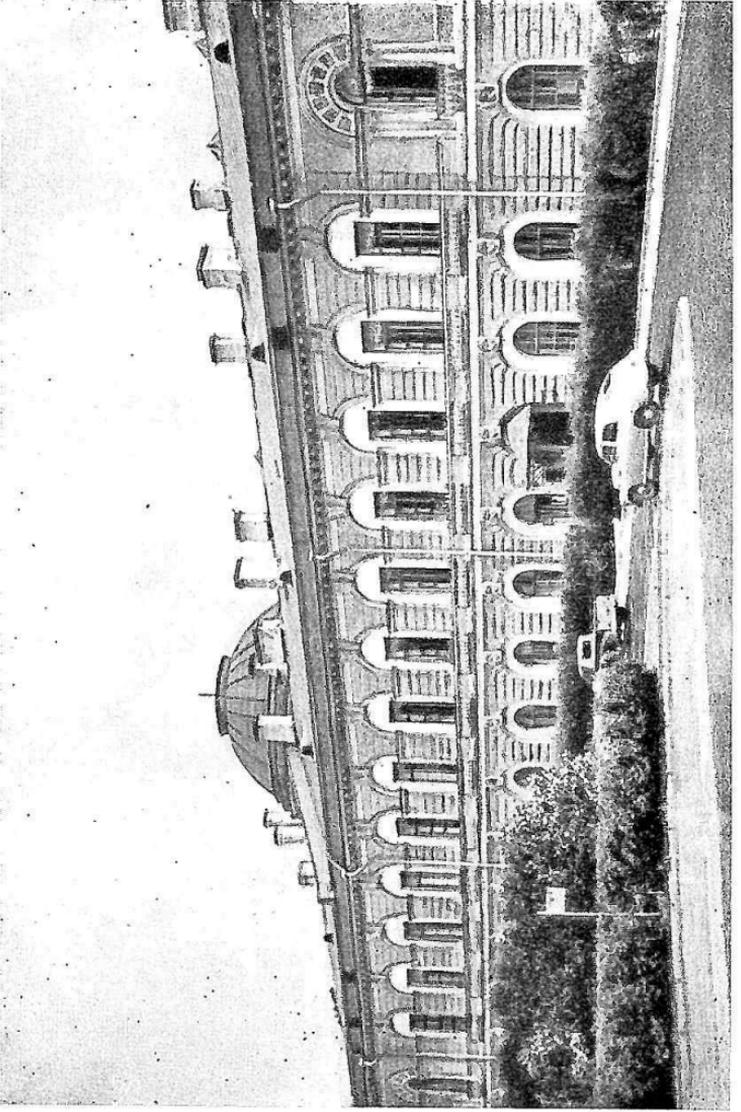
ACADEMY OF SCIENCES OF THE
USSR

M. F. SUBBOTIN

**INSTITUTE
FOR THEORETICAL
ASTRONOMY**



ACADEMY OF SCIENCES OF THE USSR PRESS



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Moscow — 1958 — Leningrad

Chief editor
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The Institute for Theoretical Astronomy occupies a special position among the astronomical institutions of the USSR because of the character of its work. It belongs to those very few astronomical institutions in the world in which theoretical and computational work on the motion of cosmic bodies is concentrated. This work forms the basis of astronomy and deals with the following.

1) The elaboration of general mathematical theories of motion, founded on the law of gravitation, these being the subject of celestial mechanics.

2) The development, on the basis of these general theories, of special theories of motion of celestial bodies: planets, satellites and comets.

3) The comparison of such specific theories with observations made at astronomical observatories and the evaluation by this means of the masses of celestial bodies, the elements of their orbits and other constants, characterizing the mechanical properties and motion of these bodies.

4) The computation of various ephemerides, which give the future position of celestial bodies necessary for astronomers, geodesists, hydrographers and sea and air navigators.

Thus one of the main tasks of the Institute for Theoretical Astronomy is the provision of our country with basic astronomical data indispensable to all branches of national economy connected with geodetical problems and also sea transport and aviation.

We shall first consider that part of the work of the Institute which is more widely known, that which is connected with meeting practical requirements.

Here, first of all, the compilation of such fundamental publications as the Astronomical Almanac of the USSR, the Nautical Almanac and the Aviation Astronomical Almanac should be mentioned.

The Astronomical Almanac of the USSR, published by the Institute, along with analogous publications in England, France and the USA, is at present one of the great astronomical almanacs on which the main astronomical works in the whole world are based. Other countries either use one of these almanacs or compile their own with less detail by means of one of them.

The Nautical Astronomical Almanac is of great practical importance and indispensable to every ship, while the Aviation Astronomical Almanac provides for the determination of the position of aircraft.

Besides these main publications, the Institute compiles and publishes various tables, nomograms and special ephemerides for the solution of different practical and scientific problems. So, for example, the Institute compiled special tables of the altitudes and azimuths of the Sun, Moon, planets and stars for all latitudes, from the North to the South Poles, for air navigation. In 1956 the Institute provided the Antarctic expedition of the Academy of Sciences of the USSR with special ephemerides

for determining geographic coordinates near the South Pole. Another example is a new method worked out at the Institute for the reduction of observations made for deriving the longitude of astronomical-geodetical points by Zinger's method. The special ephemerides needed for this were also calculated at the Institute. After the compilation of special auxiliary tables these calculations were transferred to the Central Scientific Research Institute of Geodesy, Air-Survey and Cartography for practical use.

The task entrusted to the Institute of providing the necessary data for the determination of astronomical coordinates on land and sea and in the air requires the elaboration of new scientific methods to meet new problems and higher demands. Therefore the almanacs compiled at the Institute are constantly being improved. Essential improvements were made in the 1945, 1955 and especially the 1960 editions of the Astronomical Almanac of the USSR. In 1944—1946 the Institute worked out a new form of the Nautical Astronomical Almanac. The ephemerides compiled according to this new form for the summer months of 1946 and 1947 were tested in practical navigation. As they were found to be very efficient, the new form of the Nautical Astronomical Almanac has been adopted since 1948.

When speaking about the practical significance of theoretical astronomy it is necessary to mention its fundamental importance for natural sciences. Only a detailed study of the motions of celestial bodies gives a possibility for establishing an inertial coordinate system. Geodetical and astrometrical investigations with the help of Astronomical Almanacs fix the space coordinate system first on the Earth and then in cosmic space. The Time Service also uses the ephemerides for determining Universal Time,

which serves as a basis for all practical purposes as well as scientific investigations not requiring exceptionally high precision. However Universal Time, which is measured by the rotation of the Earth, is not accurate enough for some very precise research problems, as the rotation of the Earth is irregular. The problem arising thereof, i. e. the transition from the time determined by the usual «Time Service» to uniform time, which figures in the equations of natural laws, is solved by theoretical astronomy. The development and continuous improvement of the theory of motion of celestial bodies — first of all the Moon — make such a transition possible.

The scientific problems studied at the Institute cover a wide variety of questions — from the most abstract theories of celestial mechanics to very concrete problems of ephemeris astronomy and computing technique.

Much work is being done at the Institute on the investigation of different questions connected with the so-called problem of three bodies. This problem, which studies the motion of three material points, mutually attracted according to Newton's law, has been the subject of investigations of great mathematicians and astronomers during the course of the last two centuries. However, in spite of all the attempts, a solution, which would satisfy all the requirements of astronomy, has not yet been found. So far only some particular solutions of this problem have been obtained. At the Institute some new types of periodic solutions of the problem of three bodies, which are of considerable interest for the study of the structure of the solar system, have been found and investigated. Numerous investigations which essentially developed the theory of final motions in the problem of three bodies must be

mentioned. These are directly related to some cosmogonical problems.

Several investigations made at the Institute have perfected the methods of studying the motions of planets, comets and satellites. In some cases the mathematical part of the methods was improved and much work was done on the application of modern computing technique. In connection with this such studies as the investigation of the motion of Ceres, Pluto and some of Jupiter's satellites should be indicated. The elaboration of precise analytical theories of motion of Ceres and Pluto, undertaken at the Institute, is exceptionally difficult and could be achieved only with the help of the high-speed electronic computing machines.

Studies of the motions of minor planets made at the Institute are of great importance. Here first of all the ephemeride service of minor planets should be mentioned. The Institute publishes the Ephemerides of Minor Planets annually. These publications are the basis of investigations of minor planets made all over the world.

The large number of discoveries of minor planets, a result of the application of photographic methods, had so complicated the study of their motions, that in 1911 at the Paris Conference on Ephemerides it was found necessary to establish an international center of minor planets. The Berlin Astronomisches Recheninstitut became such a center. It published annually the ephemerides of minor planets till 1945.

At the end of 1946 the Executive Committee of the International Astronomical Union proposed that the Institute for Theoretical Astronomy should calculate the ephemerides for observations of minor planets. Already in 1947 the Institute was able to publish the ephemerides of a considerable number of minor planets and in 1948 the

ephemerides of all the minor planets. This very important work is being continued at present at the Institute, the precision of the published ephemerides increasing noticeably from year to year. At first it was necessary, as at the Berlin Astronomisches Recheninstitut, to restrict the computations by calculating only the unperturbed elements. Later on with the help of punch-card machines and then electronic computing machines it became possible to increase the number of planets for which perturbations were accounted for. In the near future the perturbations will be taken into account, when deriving the ephemerides of all the minor planets.

In order to provide accurate ephemerides of minor planets it is not enough to calculate their perturbed coordinates, it is also necessary to have sufficiently reliable elements. Therefore at the Institute a large amount of work is done — the observations made at observatories all over the world are used for systematically correcting the elements of the orbits of minor planets. This work is also done partly in scientific institutions of other countries (mainly Germany, Japan, the USA and Spain), which communicate their results to the Institute, as an international center of this work.

Of other investigations dealing with the motions of minor planets the following should be mentioned: work on the application of periodic solutions for studying the motions of some groups of minor planets during a long period of time (of the order of hundreds and thousands of years) and work on the computation with the utmost precision of the motions of some specially selected minor planets for deriving the systematic corrections of fundamental star catalogues. As a result of these investigations the Institute worked out a plan of special observations of ten minor planets during 8—10 years, beginning with

1955, so as to ensure a more precise orientation of star catalogues. This plan was accepted by the Astrometric Conference in 1954. Besides Soviet observatories, the observatories at Leiden, Copenhagen, Bucharest, Sidney, La Plata, Santiago are also taking part in completing it.

The work done at the Institute for Theoretical Astronomy on the investigation of motions of comets is considerable. Besides the calculation of definitive orbits of non-periodic comets, the investigation of the motions of several short-period comets (Encke-Backlund, Du Toit-Neujmin 1941 VII, Faye, Neujmin 2), which ensures their future observations, should be mentioned. The most significant work from the point of view of its results is that dealing with the famous in the history of astronomy Encke-Backlund comet. The investigation of the motion of this comet during 1934—1957 not only revealed the cause of the acceleration of the comet's motion, which remained unexplained in the course of a whole century, but also gave a possibility of determining a reliable value of the mass of Mercury — one of the constants of the solar system, the derivation of which is most difficult.

With regards to motions of satellites of major planets the most significant are the investigations made during many years of the very difficult problem of working out a theory of the motion of Jupiter's satellite VIII and also of a high precision theory of the motion of Jupiter's satellite VII.

The enumerated works were accompanied in many cases by essential improvements in the methods of calculation, many of which are of interest not only to astronomy. So for instance, a general method of multiplying multiple trigonometric series on punch-card and electronic computing machines has been worked out.

A special part of the scientific investigations of the Institute is devoted to the study of the gravitational field of the Earth and the derivation of fundamental astronomical constants connected with it. The use of all available data of gravimetric surveys all over the world (26 000 gravimetric points) enabled a much more accurate analytical representation of the gravitational field of the Earth. The force of gravity was developed into a series of spherical functions to the eighth order inclusive and this gave a possibility of a more precise determination of the form of the geoid and the fundamental constants connected with the Earth's gravitational field.

The history of the foundation and later development of the Institute for Theoretical Astronomy is of interest in many respects.

One of the most important resolutions of the first Russian Astronomical Conference, which took place in Petrograd in the spring of 1917, was the organization of a special Computing Institute as a part of the then founded All-Russian Astronomical Society. Its task was to compile and publish an Astronomical Almanac, to study the motions of planets, comets and satellites and to compile fundamental astronomical tables. The Computing Institute began its work on October 7, 1919. On January 14, 1920 the Peoples Commissariat of Education, when adopting the status, renamed in the State Computing Institute. Soon a branch of this institute was organized in Moscow and then in Kazan and Samara.

On August 20, 1923, as the result of a decision of the Council of the Peoples Commissariat, the State Computing Institute was amalgamated with the Astronomical-Geodetical Institute (organized in Petrograd in April 1920) and

named the Astronomical Institute of the Peoples Commissariat of Education of the USSR.

The immediate task of the newly organized Institute was to provide the country with Astronomical Almanacs, as foreign almanacs had ceased to be received since 1918. Taking into account the needs of the Navy, the Institute published the ephemerides of the Moon and major planets, the apparent places of 18 stars and tables for the derivation of latitude from observations of Polaris in 1921. In December 1921 the State Computing Institute published the Russian Astronomical Almanac for 1922. Beginning with 1941 this almanac with essential additions was named the Astronomical Almanac of the USSR.

However one almanac could not satisfy all the various needs in astronomical data. At the beginning of 1927 the Institute organized a conference of representatives interested in the publication of a special Nautical Astronomical Almanac. Corresponding decisions were adopted and beginning with 1930 the Institute started the publication of the Nautical Astronomical Almanac and in 1935 the Aviation Astronomical Almanac, the latter instead of the Aviation Astronomical Calendar which was compiled during 1932—1934 in Moscow.

As it has already been stated, the Astronomical Institute was organized on the basis of two institutes. In accordance with this its work deals with investigations in theoretical astronomy and calculations of ephemerides, problems of the former Computing Institute, and work fulfilled formerly by the Astronomical-Geodetical Institute. The latter includes gravimetical problems, the elaboration of methods of astronomical and geodetical observations and other problems.

In 1929 astrophysical problems, connected first of all with astrophysical observations (electrophotometry, solar

eclipse observations), the construction of new instruments and the organization of a high-altitude astronomical observatory, were included in the problems of the Astronomical Institute.

A great contribution was made by the Institute in the general gravimetric survey of the Soviet Union which began in 1932. Besides the determination of the force of gravity in numerous points on land and sea, the elaboration of several important problems of theoretical gravimetry and the compilation of catalogues of gravimetric points, the Institute carried on with success work on designing new constructions of pendulum apparatus and their manufacture. So the Institute constructed a special pendulum apparatus for the expedition to the North Pole in 1937—1938.

A 13-inch reflector for the Abastumani Astrophysical Observatory was made at the shop of the Institute. This was the first large astronomical instrument manufactured in our country. The Institute also largely helped in the organization of the expeditions and the serial production of special apparatus for the solar eclipses of 1936 and 1941.

During the Great Patriotic War of 1941—1945 part of the staff of the Institute worked in Kazan, Alma-Ata and Abastumani, part stayed in Leningrad during the blockade.

The main work on the compilation of the Astronomical Almanac of the USSR was fulfilled by that part of the staff of the Institute which was in Kazan. The Nautical and Aviation Almanacs were computed in Leningrad.

On October 16, 1943 the Presidium of the Academy of Sciences of the USSR, under whose direction the Astronomical Institute had been since 1939, issued a decision that the Astronomical Institute should make research

work in theoretical astronomy and ephemerides and in connection with this renamed the Astronomical Institute, which is now called the Institute for Theoretical Astronomy of the Academy of Sciences of the USSR.

By this decision the work of the Institute was specified as a scientific center of investigations in the field of theoretical astronomy and its various applications.

The Institute for Theoretical Astronomy publishes regularly:

The Astronomical Almanac of the USSR,
The Nautical Astronomical Almanac,
The Aviation Astronomical Almanac,
The Ephemerides of Minor Planets.

The theoretical problems studied at the Institute are published mainly in the following:

The Bulletin of the Institute for Theoretical Astronomy of the Academy of Sciences of the USSR (published since 1923).

The Transactions of the Institute for Theoretical Astronomy of the Academy of Sciences of the USSR (published since 1952).

Зак. № 598.