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THE SPACE FLIGHT OF THE SOVIET-INDIAN CREW

S. A. Nikitin

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16. Abstract

After a brief discussion of the Indian space program, the paper examines the flight of the Soyuz T-11, which included an Indian crew member. Particular attention is given to experiments conducted aboard Soyuz T-11, including the Optokinez vestibular experiment, the Vektor cardiac bioelectricity experiment, the Yoga experiment for the counteraction of the negative effects of weightlessness, a supercooling experiment, and the Terra remote sensing experiment.

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THE SPACE FLIGHT OF THE SOVIET-INDIAN CREW

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Peaceful collaboration between the USSR and India on */66 the study and exploitation of space in the 1970's was based on the intergovernmental "Agreement for Further Development of Economic and Commercial Collaboration Between the Union of Soviet Socialist Republics and the Republic of India" of November 29, 1973. Several agreements on joint work in corresponding directions have been made between agencies of both countries both before and after the above-mentioned agreement.

The first joint work was begun more than 20 years ago in space meteorology, in relation to the Indian government's decision to build an international research proving ground for rocket probes of the Earth's upper atmosphere in Tkhumba (Kerala state) in southern India. Along with India, the Soviet Union, USA, France, Japan and other countries took part in construction of this proving ground, located near the geomagnetic equator. In January 1964, the Chief Administrative Office of the Soviet Union's Hydrometeorological Service and the Indian government's Department of Atomic Energy signed an agreement providing for Soviet assistance in equipping the proving ground in Tkhumba. In 1970, a new agreement was concluded on conducting systematic rocket probes from the proving ground in Tkhumba: Soviet meteorological rockets would investigate upper atmosphere parameters at tropical latitudes at altitudes up to 100 km. Since that time, Soviet meteorological rockets have been launched regularly from the international proving ground in Tkhumba; Soviet and Indian scientific equipment is installed on these

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* Numbers in the margin indicate pagination in the foreign text.

rockets; Indian and Soviet specialists take part in the launches and experiments; and the results are used, not only by meteorological organizations of both these countries, but by meteorological services of other governments as well.

In 1972, an agreement on launching the first Indian satellite with a Soviet carrier rocket was signed in Moscow by the Academy of Sciences of the Soviet Union and the Indian government's Indian Organization for Space Research (IOSR). Two more agreements between the USSR Academy of Sciences and the IOSR were signed in 1975 and 1979, providing for launching rockets designed and manufactured in India from Soviet territory with Soviet carrier rockets.

Soviet-Indian collaboration on space research is now being implemented in the following directions: rendering scientific-technological assistance to India in the development and launching of artificial earth satellites; research on upper layers of the atmosphere with rocket probes; research in γ-astronomy, and observations of artificial earth satellites.

On April 19, 1975, November 7, 1979 and November 20, 1981 the Indian satellites Ariabata, Bkhaskara and Bkhaskara-2 were launched from the Soviet Kapustin Yar cosmodrome by Soviet carrier rockets. In addition to supplying carrier rockets and launching the satellites, the Soviet side provided necessary consultations on all stages of development of the Indian satellites and their preparation for launch: stabilization systems, solar and chemical batteries for the electrical power supply system, an onboard data storage system, and thermal covering were manufactured for them. The Soviet side also took part in controlling the first Indian satellite, for which a ground station was built outside Moscow in the Medvezhiy Lakes.

The purpose of Ariabata, the first Indian satellite, was to conduct research in x-ray astronomy, detect solar neutron and γ - radiation and measure particle streams in the ionosphere. The principal purpose of the Bkhaskara-type satellites was to study India's natural resources, which has great significance for the country's national economy.

Ariabata, Bkhaskara and Bkhaskara-2 functioned for a long time and completed their assigned tasks.

During the work on these satellites, Indian specialists gained experience in solving complex scientific and technological problems related to the creation of space apparatus. This later helped them manufacture the Rokhnin and Eppl satellites, launched with Indian carrier rockets and the European Space Agency's Arian carrier rocket.

In 1977 a Soviet-Indian station for observing artificial earth satellites was built in India. Scientific equipment for this station was supplied by the USSR and other countries participating in the Interkosmos program. Results of observations made at these stations are available to the world's scientific community.

From 1977 to 1981, Soviet and Indian specialists made /67 joint experiments in the area of extra-atmospheric astronomy with Soviet γ-telescopes installed on Indian high-altitude balloons.

The joint space flight of Soviet and Indian cosmonauts on the Soviet Soyuz-T spacecraft and Salyut-7 orbiting station was the logical continuation of all this work.

In September 1982 two Indian candidates for cosmonaut, R. Sharma and R. Mal'khotra, arrived at the Yuriy Gagarin Cosmonaut

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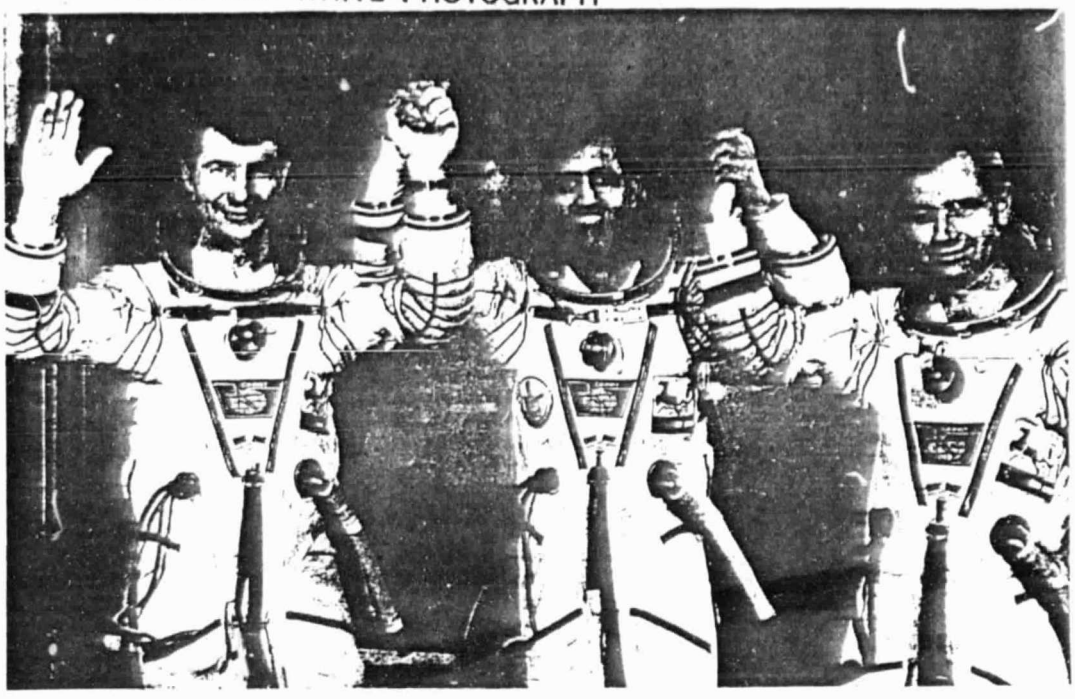

Soviet-Indian crew of the Soyuz T-11 spacecraft (from left to right): Flight Commander Yu. V. Malyshev, Cosmonaut-Researcher R. Sharma, Flight Engineer G. M. Strekalov.

Training Center and began studies and training. Having successfully completed all stages of preparation and passed the prescribed tests, the Indian candidates for cosmonaut were included in the roster of two crews. The main crew: Commander Yu. V. Malyshev, Flight Engineer N. N. Rukavishnikov, Cosmonaut-Researcher R. Sharma; back-up crew: Commander A. N. Berezovoy, Flight Engineer G. M. Grechko, Cosmonaut-Researcher R. Mal'khotra. Due to illness, G. M. Strekalov took the place of N. N. Rukavishnikov, the main crew's flight engineer.

Soviet and Indian specialists prepared an interesting scientific program for the international crew, which included research and experiments on space medicine, study of India's natural resources from space, and space materiology.

The Soviet-Indian international crew made up of Flight Commander Yu. V. Malys ev, a Soviet pilot-cosmonaut; Flight Engineer G. M. Strelakov, a Soviet pilot-cosmonaut; and Researcher-Cosmonaut Rakesh Sharma, a citizen of the Republic of India, lifted off from the Baykonur cosmodrome in the Soyuz-11 spac : transport ship on April 3, 1984 at 17 hr, 9 min (Moscow time). The carrier rocket took the ship into an initial orbit with an altitude of 202 km at perigee and 240 km at apogee, an inclination of 51.6° and a period of revolution of 88.6 min. The same day, a dual-impulse corrective maneuver was carried out during the fourth and fifth orbits, as a result of which the Soyuz-T-11 spacecraft went into an orbit with altitudes of 222 x 295 km. At that time, the Salyut-7 - Soyuz T-10 scientific-research complex was in a orbit with the following parameters: altitude at perigee, 294 km, altitude at apogee, 305 km, inclination, 51.6°, period of revolution, 90 min.

After several corrections in Soyuz T-11's orbit, the spacecraft docked with the Salyut-7 orbiting complex on April 4, 1984 at 18 hr, 35 min. That same day at 21 hr, 36 min, G. M. Strekalov and R. Sharma crossed over into the station's quarters. An international crew comprising six cosmonauts then began work on board the Salyut-7 - Soyuz T-10 - Soyuz T-11 scientific-research complex.

The international crew's flight plan included eight /68 experiments: six on space medicine, the "Pereokhlazhdeniye" (Supercooling) technological experiment and the "Terra" experiment, a remote probe of the Earth to study India's natural resources. Insofar as one of the experiments was done several times and the others were a series of investigations (for example, the "Pereokhlazhdeniye" experiment was done with alloys of three different compositions, and the Terra experiment was programmed to take photographic surveys during nine passes over

Indian territory), the total number of experiments done was 43.

The cosmonauts began their work on board with the "Optokinez" experiment - obtaining information on the condition of the oculomotor function and the features of vestibular-visual interaction under flight conditions. The "Anketa" and "Opros" medical experiments have become traditional for international crews on the Salyut stations. These experiments help continue the study of symptoms of vestibular disorders during flight and the readaption period, as well as identify a definite connection with data on resistance to motion-sickness on Earth. In addition, these experiments permit evaluation of the effect of different stages of flight on the psychological condition of crew members, especially on their mood dynamics.

In the "Vector" experiment, cardiac bioelectrical activity, the phase structure of the cardiac cycle, and hemocirculation volumes under space flight conditions were studied (the electrocardiograph and kinetocardiograph methods were used).

The "Ballisto" experiment is of great interest to space medicine. Evaluation and prognosis of the condition of a cosmonaut's cardiovascular system are related to research on the strength of cardiac contractions and coordination of work between the left and right sections of the heart. One of the methods used to complete this task is ballistocardiography - detection of microshifts of the body due to cardiac activity. Ballistocardiograms (BCG) obtained during space flight showed that both the strength of cardiac contractions and coordination of work between the left and right sections of the heart change depending on the length of stay under weightless conditions and the amount of physical training undertaken. At present there is still not sufficient experimental data for definitive conclusions on changes in the BCG's observed in space. Therefore, further research in this direction is very important.

The "Yoga" experiment could probably be considered the most curious of the medical experiments. It has been established that man's stay in weightlessness is accompanied by changes in the condition of various components of the motor apparatus (which affects movement biomechanics) and a disruption of coordination. During short flights, these changes are chiefly evidenced by deterioration in reflex muscle tone caused by loss of supportive weight and vestibular dysfunction. In the "Yoga" experiment, performed by cosmonaut-researcher Sharma, an attempt was made to study the possibility of using yoga exercises during space flight and their effectiveness in preventing harmful effects of weightlessness on the muscular-support apparatus.

The technological experiment "Pereokhlazhdeniye", done on the Soviet Isparitel' apparatus, clarified the role played by heterogeneous centers of a material's solid phase origin, present on the surface a melt; the degree of supercooling was defined, as well as the effect of convection caused by gravitation and temperature gradients on supercooling; the possibility of creating metastable phases and obtaining massive amorphous materials ("metallic glasses") was investigated.

The phenomenon of supercooling was studied on a model "silver-germanium" alloy, selected by Indian specialists due to the fact that intensive work is being done in India on refining such alloys with the slagging method. Three experiments were done with alloys of different compositions. The results of the "Pereokhlazhdeniye" experiment will have great significance for practical work aimed at obtaining the most diverse types of alloys used in modern technology.

The integrated Terra experiment has great significance for India's national economy. It included: photographic surveys of Indian territory with the multizonal MKF-6M apparatus and the

KATE-140 camera; visual observations and photographic surveys using hand-held cameras; quasisynchronic "subsatellite" aerial surveys and surface measurements of experimental sections of Indian territory by Indian specialists; processing the information on Earth and using it to study India's natural resources in the interest of developing the country's national economy.

According to the program, the "Terra" experiment was to have been done during nine passes over Indian territory. At the request of Indian specialists the experiment was expanded and conducted during two additional passes, when islands belonging to India in the Bay of Bengal were photographed.

After successful completion of the joint work program, the international crew returned to earth on the Soyuz T-10 spacecraft: on April 11, 1984 at 14 hr, 50 min, the descent vehicle with cosmonauts Yu. V. Malyshev, G. M. Strekalov and R. Sharma landed in the assigned region of Soviet territory 46 km to the east of the city of Arkalyk.

The successful space flight of the Soviet-Indian international crew is a new contribution to the further development of traditionally friendly relations between our countries and the long-standing collaboration between the Soviet Union and India on space research.