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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 1995

CHAPTER 6. EARTH SCIENCES AND GEOPHYSICS

THE KOLA ARRAY

Mining Institute of the Kola Science Centre

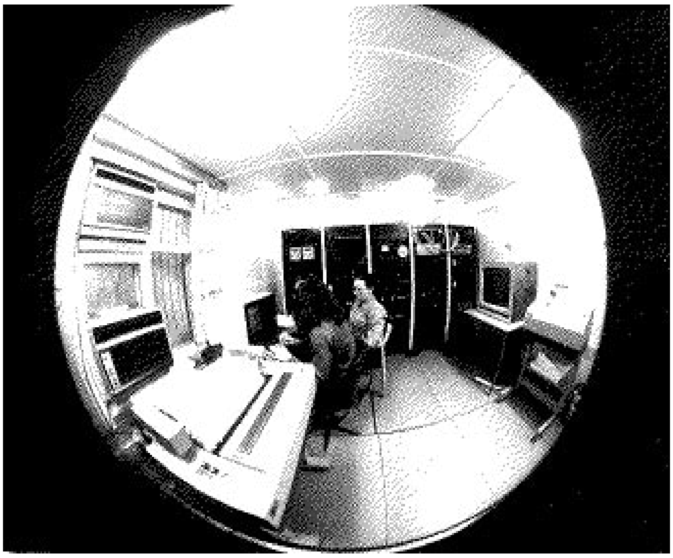
The Kola array of geodynamic stations was founded in 1990.

Field of science

The Earth's physics and nuclear power engineering.

Field of research

Nuclear waste disposal in deep geological formations of crystalline rocks in the Kola Peninsula and Arctic regions and construction of underground nuclear power plants, including in particular those that supply towns and settlements with heat.



Automated system for rock massifs seismisity monitoring

Main parameters

The Kola geodynamic array comprises the underground and surface parts.

The underground part is a station intended for long-term monitoring and equipped by high-precision tensometers, tiltmeters and a measuring apparatus to control the inner atmosphere as well as by the levelling grounds, seismic pavillions, monitoring stations to measure stresses and acoustic/electromagnetic emission parameters.

The surface part involves the Kukiswumchorr Observatory, Express Array of seismic monitoring and recording of parameters of acoustic and electromagnetic emission, seismic stations located in the industrial site of the Apatit Joint-Stock Company, and the seismic stations Apatity of the Kola Regional Seismic Centre, Russian Academy of Sciences. Also related are the surface levelling lines and special stations for surface deformation monitoring by a laser range finder Kern ME 5000.

Major advantages

Studies carried out at the Kola geodynamic array permit testing and improving of the geological medium monitoring technique in terms of geomechanics: they also provide geological information for construction and exploitation of such complex and significant engineering structures as nuclear power objects. The long-term observation results obtained by the stations also promote prediction and prevention techniques for such catastrophic dynamic phenomena as mining-induced rock bursts and earthquakes occurring in rock masses, which are of great importance for radioactive waste disposal and for underground nuclear power plants.

The Array is unique in that it makes possible the most complex study of geodynamic problems ever carried out for nuclear power engineering needs in the Arctic.

At present, research on the impact of modern geodynamic processes occurring in the upper Earth's crust and of large-scale mining on the state of geological and geophysical media is carried out to determine the precursors of mining-induced earthquakes and rock bursts.

Current research

- Development of physical models of the geophysical medium as a hierarchic block system.
- Study of temporal variability of the characteristics of the geophysical medium as a result of geodynamic processes and technogenic impacts.
- Study of rocks as multi-component systems varying with time.
- Theory and techniques of improving the properties of rocks and rock massifs.
- Scientific substantiation of the mining part of the project on disposal of nuclear waste in the Murmansk and Arkhangelsk regions in deep geological formations of the Kola Peninsula.
- Development of the project for an underground nuclear heating plant UNHP-RUTA for the city of Apatity.

Possible research

There are opportunities for carrying out joint tests of methods and hardware which can be used to determine properties and state of rocks in a rock mass, as well as joint development of information technology when large amounts of geophysical information are processed and analysed. A joint search and verification of short-term precursors of powerful dynamic phenomena in rock mass is also proposed.

Main scientific results

A database technique has been developed to design underground structures for nuclear power objects. It gives a preliminary assessment of possible underground siting of nuclear power objects in the central part of the Kola Peninsula. Some regularities in the behaviour of powerful seismic events ($E > 10^5$ J) are revealed to be peculiar for the Khibiny rock massif.

Basic papers

N. Melnikov, A. Kozyrev, and V. Panin (1993), Geomechanical control over mining in high stressed rock mass. In: *Assessment and Prevention of Failure Phenomena in Rock Engineering*, pp. 699–701, Balkema, Rotterdam.

A. Kozyrev and V. Panin (1993), Effect of large-scale mining on geodynamic behaviour of the area, and mining-induced seismicity manifestation. In: *Safety and Environmental Issues in Rock Engineering*, pp. 841–845, Balkema, Rotterdam.

A. Kozyrev and V. Panin (1994), Geomechanical aspects of the environment protection carried out in mining and underground construction. *Proc. 20th Int. Conf. on rock mechanics*. Moscow, pp. 79–87.

N. Melnikov, V. Konukhin, A. Kozyrev *et al*. (1996), The choice of sites suitable for the radioactive waste repositories in North–West Russia. *Power-Generating Construction*, Nos. 5–6, pp. 27–31.

N. Melnikov, V. Konukhin, and V. Komlev (1994) *Underground Radioactive Waste Disposal.*. Apatity, Publ. House of the Kola Science Centre, Rus. Acad. Sci.

N. Melnikov, V. Konukhin, A. Kozyrev *et al*. (1994), Underground nuclear waste repositories in deep geologic formations of hard crystalline rock. *Proc. 7th Int. IAEG Congress*, pp. 2557-2564, Balkema, Rotterdam.

Current financial support

Russian Foundation for Basic Research Grant 93-05-08090

Contract of the Ministry of Environment and Natural Resources of the Russian Federation EBR-467-43-KO.

Scientific and technical personnel

Twenty-one persons are needed to operate the station.

Possibilities for international exchange

The Institute is ready to invite five researchers from any country annually on the basis of equivalent exchange to undertake research using the Kola array of geodynamic stations.

General information

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LARGE THERMO-STRATIFIED TEST TANK

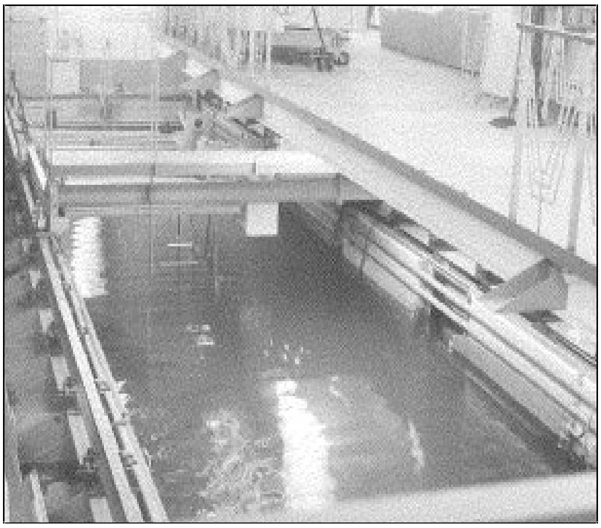
Institute of Applied Physics

Date of commissioning: 1992.

Field of science

Hydro-physics (scale modelling and experimental investigation of hydro-physical processes of the upper ocean).

Fields of research



- Convection of stratified fluid, its role in the formation and maintenance of a scaled thermocline similar to the ocean thermocline.
- Internal and surface waves, their interaction with each other, as well as with currents and turbulence.
- Dynamics of submerged bodies in a stratified flow and generation of internal ship waves.
- Mechanisms of optical and radar imaging of the sea surface.
- Other problems of oceanography, ship-building, and ecology.

Main characteristic

The hydro-channel 20 m long, 4 m wide and 2 m deep is filled with fresh water and equipped with a device providing temperature stratification.

The tank is supplied with a self-propelled towed trolley (V_t = 0.005–1.0 m·s^{-1}) with a co-ordinating device for arranging temperature sensors (the range 0–30°C with an error of no more than 2%); surface wave makers (0.1–1.0 m long and 5–60 mm high) and internal (period of 20-120 s) waves; an inductor of shear flows (V_s = 0.01–0.1 m·s^{-1}); a rope towing system (V_t = 0.005-1.0 m·s^{-1}), and a data acquisition and processing complex.

Major advantages

- Ecologically clean method of producing stratification.
- Stable (for infinitely long time) and reproducible stratification.
- Economical use of a refrigerator (heat pump) with side heaters.
- The same water temperatures as in the real ocean.
- Scale modelling of the ocean thermocline.

The installation is unique since a device, first realised in it, enables one to produce a scaled stratification, maintain and reproduce it in tanks comparable with large ship-building test tanks, which provides quantitative scale modelling.

A conventional scheme of studying wave motions of any physical nature implies determining the dispersion relation and mode structure of small-amplitude free waves, conditions of generation (radiation) of waves by various sources, methods of recording (reception) of waves, and, finally, characteristics of diffraction and wave scattering by inhomogeneities of the medium. For large-amplitude waves, problems of non-linear transformation and interaction also arise.

For internal waves (IW) in the ocean, the problems are not as well and often insufficiently understood. Difficulties in field experiments in the ocean are encountered even when recording internal waves by an echo sounder (using oscillations of sound-scattering layers) or by a bathythermograph using oscillations of isotherms. The problem is exacerbated because of the rather large spatial (tens of meters to kilometers) and temporal (hundreds of seconds to tens of minutes) scales of measured waves. If necessary, the dispersion characteristics of IW can be calculated by the data of hydrological measurements.

The problem of IW generation appears even more complicated.

First, IW sources are rather different. They may be submerged or oscillating bodies of a constant volume, bodies of variable volume, and moving bodies. A direct source of IW may be hydrodynamic perturbations of a medium, mixed turbulent regions (for example, vortex rings and pairs, a pulsating submerged wake, etc.). IW can be generated by thermal sources or sources (sinks) of mass. The efficiency of IW excitation depends not only on source intensity but also on its relation to the ambient IW field, i.e. on its position in the thermocline.

Second, if IW are produced by regular sources, it may be difficult to separate one mechanism from another. For example, when a body of irregular shape moves in a stratified fluid, IW can be generated by the body itself, by its collapsing wake, and by vortices separating from the body edges.

Third, the action of many sources is due to the currents in the vicinity of a source and to the violation of thermocline structure.

And finally, IW generation in the ocean is often camouflaged by high natural IW background related to tidal phenomena, shear flows, or flows above an uneven bottom, etc.

Though some problems of IW generation can be solved using a computer, it is difficult to avoid simplifying assumptions, the validity of which should be checked experimentally. Therefore, when solving such problems, direct laboratory modelling seems to be important, while the use of large stratified tanks approximates experimental conditions to the conditions of the real ocean.

Current research

Work on investigating internal waves in a large thermostratified tank is being carried out now. The study has seven stages, each of which has a specific scientific and experimental direction and results in a detailed report.

Possible research

In addition, the problem of modelling perturbations produced by a moving submerged body can be studied in the tank. This seems to be interesting due to increasing importance of development of submerged modules used in studies on shelf exploration and rescue operations.

Main scientific results

- The main regimes of producing steady-state stratification and its characteristics have been studied. Temperature profiles obtained in the tank model the stratification of various areas of the world ocean effectively.
- Characteristics of internal waves generated by a wave maker at various depths in the thermocline have been thoroughly investigated.
- Characteristics of IW produced by a sphere towed with various velocities and for various positions in the thermocline have been found. The regimes, at which ship internal waves are analogous to the Kelvin or Cherenkov waves and when waves are generated by a collapsing wake have been determined; the IW amplitude variation versus the Froude number has been investigated.
- Parametric investigation of IW generation by spheres (of three different diameters) at high velocities of motion (Froude number up to 100) has been performed. IW parameters versus the Froude and Reynolds numbers have been plotted.

Basic papers

S.D. Bogatyrev and V.I. Talanov. Laboratory model for the upper ocean. *Black Sea 92*, pp. 41–43.

O.A. Druzhinin, V.I. Kazakov, P.A. Matusov *et. al.* (1993), Thermocline evolution affected by turbulent stream in the upper layer: laboratory experiment., In: *EOS Transactions*, Vol. 74, No. 16 (Supplement), p. 181.

V.I. Kazakov, P.A. Matusov, and D.V. Zaborskikh (1994), Dynamics of microstructure in developing thermocline. Rept. at Ocean Sciences Meeting, San Diego, California.

Current financial support and co-operative projects

Grant of the Russian Foundation for Basic Research: Investigation of internal waves in the large thermo-stratified tank of IAP RAS.

Master Task Agreement No. D239606 between the University of California and the Institute of Applied Physics.

Scientific and technical personnel

5 researchers and 4 technicians (for two-shift operation—6 technicians).

Possibilities for international exchange

Vacancies for accommodation of foreign scientists: 2–3 man-year.

General information

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Responsible person: Vladimir I. Talanov

INCOHERENT-SCATTERING RADAR

Institute of Solar-Terrestrial Physics

Date of commissioning: 1993.

Fields of science

Physics, Earth sciences (radio physics, radio physical ionosphere research; physics of the ionosphere and upper atmosphere).

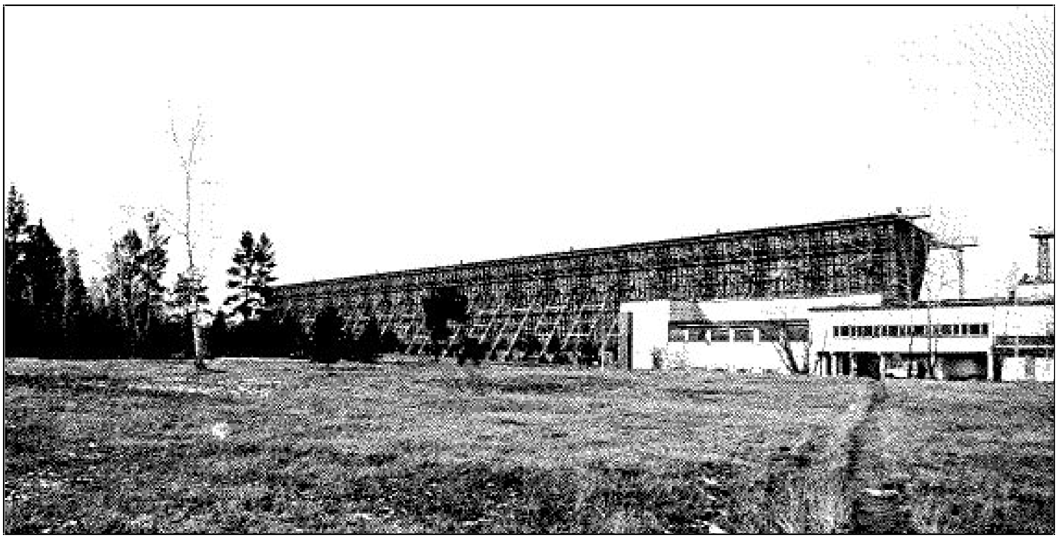
Fields of research

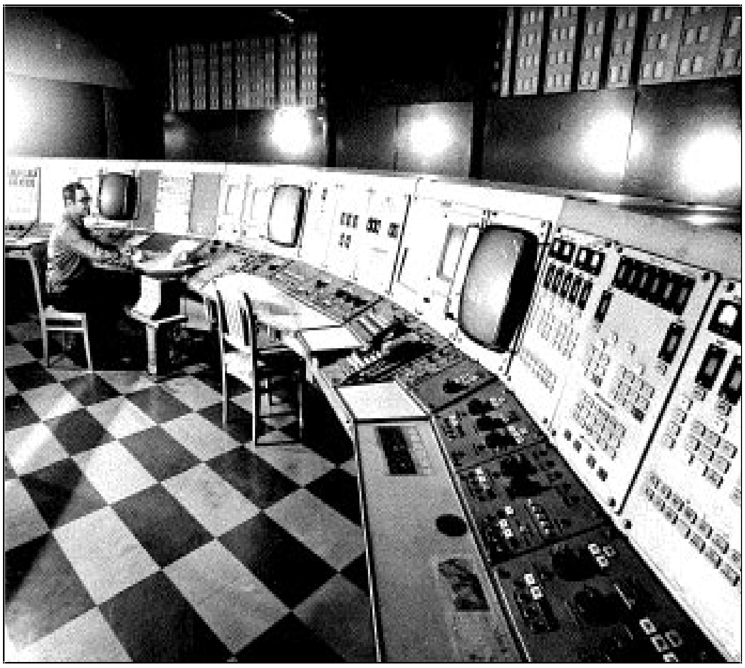
Research on the structure, dynamics and coupling of ionised and neutral regions of the upper atmosphere under various helio- and geophysical conditions; development of radar-based diagnostic tools for FM radio wave propagation in the ionosphere and atmosphere; modification of the ionosphere by two powerful HF radio waves with different frequencies.

Main characteristics

The incoherent-scattering (IS) radar has been implemented on the basis of a converted radar installation, Dnieper. It is a mono-static pulsed frequency scanning radar.

Operating frequencies, MHz	154–162
Pulse power, MW	2.5–3.2
Pulse duration, ms	140–820
Pulse-repetition rate, Hz	24.4
Antenna system	sectorial horn
Mouth of horn, m	246×12.2
Antenna gain, dB	35–38
Beam's angular size, deg	0.50 (N–S); 100 (E–W)
Scanning sector, deg	±30 from zenith (N–S)
Polarisation	linear
System's noise temperature, K	600–700





Major advantages

The radar features a high potential because of the large radiation power and antenna aperture. This permits ionospheric probing using of the most informative IS method. However, IS radars are highly sophisticated and expensive facilities. Only ten such efficient instruments are in operation world-wide. The IS radar of ISTP is the only active Russian instrument of this type; it complements the longitudinal radar chain of the United States, Europe, and Japan.

Current research

- Based on regular observations by the IS method, research is being pursued into electron and ion temperatures, velocity, and ionospheric plasma density under various helio- and geophysical conditions.
- Ionospheric probing techniques are under development.

Possible research

- Further development of sounding methods and facilities for the neutral atmosphere (mesosphere and stratosphere).
- Study on FM radio wave propagation.
- Two-frequency modification of the ionosphere using powerful radio waves.

Main scientific results

Ionosphere research at this radar was initiated in the 1980s, and since 1993 it has been done on a regular basis. As a result, for the first time in East Siberia a representative series of IS data has been obtained on ionospheric F-region parameters under various helio- and geophysical conditions (time of the day, season, solar and geomagnetic activity). Experimental time and amplitude characteristics of ionospheric parameter variations have been taken during disturbances, such as solar eclipse, ionospheric storms, and powerful surface explosions. Trial experiments in the ionosphere have demonstrated the effect of its two-frequency perturbation.

Basic papers

G.A. Zherebtsov (1993), Radar for atmospheric and ionospheric research in East Siberia. Abst. 24th General Assembly URSI. Kyoto, p. 280.

G.A. Zherebtsov, I.I. Orlov, and A.P. Potekhin (1994), Prospects of development of East-Siberian radar for probing the ionosphere and neutral atmosphere. Abst. 19th General Assembly EGS. Grenoble.

V.G. Abramov, E.V. Voronov, V.V. Evstafyev *et al.* (1994), Ionosphere research using a high-potential radar installation. *Investigation on Geomagnetism, Aeronomy, and Solar Physics*. Novosibirsk: Nauka, Vol. 100, pp. 124–139.

V.G. Abramov and V.V. Evstafyev (1992), Ionosphere heating by nonlinearly interacting waves. *Investigation on Geomagnetism, Aeronomy, and Solar Physics*Vol. 96, pp. 86–91.

V.G. Abramov, B.N. Velichansky *et al*. (1983), Some results of ionosphere research by the radio wave incoherent-scatter method during a powerful industrial explosion. *Geomagnetism and Aeronomy*, Vol. 6, pp. 134–135.

Current financial support and co-operative projects

Grant of the Russian Foundation for Basic Research: 93-02-15286.

Participation in the International Coordinated Days IS Observation Programme.

Scientific and technical personnel

14 researchers and 40 technicians.

Possibilities for international exchange

The Institute can receive and has vacancies for accommodation of foreign specialists: 3 man-year.

General information

The radar is located 120 km north-east of Irkutsk.

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POLARISATION LIDAR FOR HIGH-ALTITUDE REMOTE SENSING OF THE ATMOSPHERE

Tomsk State University

Date of commissioning: 1976.

Fields of science

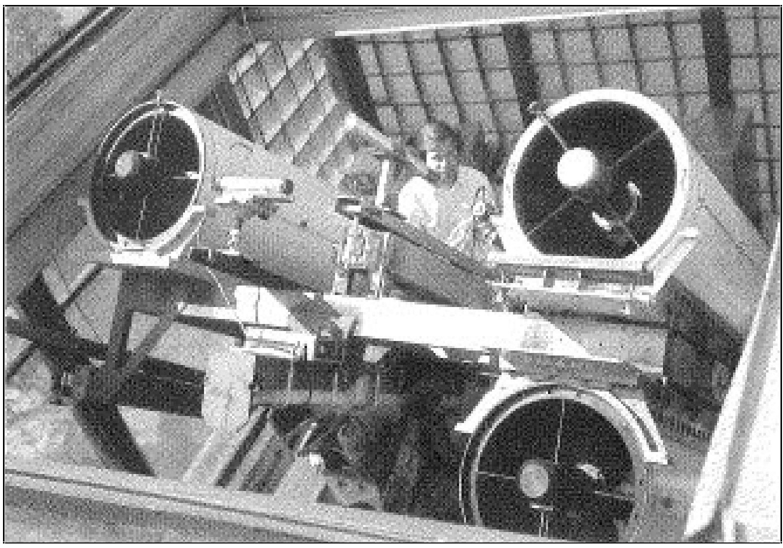
Physics, geophysics (optics, physics of the atmosphere).

Fields of research

Optical properties of tropospheric and stratospheric aerosol; microstructure of the middle-atmosphere background aerosol; backscattering matrix of the upper crystal clouds; influence of external physical fields on orientation of crystals in cirrus and mother-of-pearl clouds; polarisation properties of non-spherical particles of the middle-atmosphere aerosol; wave processes in the atmosphere; stratospheric aerosol and ozone; influence of the solar wind on optical properties of light-scattering layers in the atmosphere of the northern hemisphere; global transfer of aerosols emitted into the middle atmosphere by volcanic eruptions and technogenic disasters.

Main characteristics

As a source of radiation, an ILTI 405 laser is used in the lidar. This laser delivers about 0.8 W mean power of pulsed radiation at 532 nm wavelength, 14 ns pulse duration and 25 Hz repetition frequency. The output beam can have linear polarisation with the polarisation vector oriented at 0°, 45°, and 90° relative to the basis chosen, as well as circular polarisation. Optical receiver of the lidar has three optical antennas of 0.5 m diameter (see photograph); interference filters used in the lidar have 2.7 nm wide transmission band with the transmission maximum of 69%; a PMT of FEU-130 type is used as a detector; each optical channel of the lidar is equipped with a polarisation analyser involving a phase plate and a Wallaston polarisation prism. The recording system is a 6-channel photon counter providing acquisition of lidar return signals to be done in 4 096 time gates, the duration of which can be varied from 40 to 320 ns. The whole data digital acquisition system of the lidar is controlled by a CAMAK MERA-60 computer complex.



The transmitter–receiver of the lidar is mounted on a rotating platform to provide scanning within the elevation-angle range from 0 to 90° and $\pm 10^{\circ}$ about a pre-set azimuth.

Lidar return signals are recorded by using a photon counting technique. The time required to measure a vertical profile of a single Stokes parameter of a backscattered signal is 40 to 80 s at a pulse repetition frequency of 25 Hz. Spatial resolution of lidar measurements in cirrus clouds is 96 m at altitudes of 8 to 10 km and 960 m at altitudes of 20 to 30 km in the stratosphere. Relative error of the lidar-return amplitude measurement is about 3%.

The time required to measure the polarisation matrix of light backscattering (16 elements) is about 30 min at altitude of 30 km.

Measured data are stored on a magnetic disk. For a qualitative analysis the profiles of Stokes parameters are displayed on a three-colour X-Y plotter.

Major advantages

Measuring the full polarisation matrix of light backscattering makes this lidar a unique instrument in the world. Since the scattering matrix carries complete information on the aerosol ensemble, the observations of temporal and spatial behaviour of its elements could provide data not only on the aerosol microstructure at a chosen height and could also allow estimating some parameters of external physical fields. For example, the preferred orientation of non-spherical particles, which often occurs in cirrus clouds, can be explained by electric and magnetic fields or by a strong air flow at these altitudes. Such investigations could be more efficient if done simultaneously with observations of the ionosphere, magnetometric measurements, measurements of stratospheric ozone and UV radiation. Systematic observations of the aerosol structure in the upper atmosphere makes it possible to detect an in-flow of foreign aerosols connected with atmospheric circulation and trans-border air-mass transfer.

Since direct measurements of aerosol parameters in the stratosphere are very difficult because of the need to use special balloons or high-altitude aircrafts to carry instrumentation, the use of such a polarisation lidar for routine observations of the atmosphere at about 30 km is more efficient and less expensive.

The method of measuring of polarisation characteristics of lidar return signals and some units of the instrument are protected by a patent in Russia.

Current research

Measurement of the backscattering matrix of cirrus clouds, light-scattering anisotropy in crystal clouds, and polarisation properties of stratospheric aerosol.

Possible research

Study of wave processes and structures in the atmosphere. Investigation of the influence of aerosol stratification on UV radiation fluxes reaching the lower atmospheric layer. Observing dynamics of the middle-atmosphere aerosol as influenced by natural and technogenic disasters. Study of influence of the solar wind on the light-scattering properties of middle atmosphere.

Main scientific results

This lidar facility enabled us to obtain, for the first time, information on the background aerosol microstructure at different altitudes in the stratosphere. The Stokes vector parameter of lidar return from aerosol was also measured by this lidar for the first time in the altitude range from 5 to 25 km.

This lidar first allowed the backscattering matrix of crystal clouds and stratospheric aerosol to be measured. These investigations have demonstrated a possibility of determining preferred orientation of particles in crystal clouds as well as of detecting aerosol with a microstructure different from that of a background aerosol.

Basic papers

V.E. Zuev, N.V. Kozlov, E.V. Makienko *et al*. (1977), Some results on remote sensing of aerosol microstructure with a multi-frequency lidar. *Izv. AN SSSR, Fiz. Atm. i Okeana,* Vol. 13, No. 6, pp 648–654.

M.P. McCormick (ed.) (1993), *Third Intern. Lidar Researches Directory.* Compiled by. Atmos. Sci. Div., NASA Langley Research Center p. 71.

B.V. Kaul, O.A. Krasnov, A.L. Kuznetsov, and I.V. Samokhvalov (1991), Polarisation sounding of the upper-level aerosol formations in the atmosphere. *Atm. Opt.* Vol. 4, No. 4, pp 394–403.

B.V. Kaul, A.L. Kuznetsov, and E.R. Polovtseva (1992), Measurements of backscattering phase matrix of crystal clouds with a polarisation lidar. *Atm. Ocean. Opt.* Vol. 5, No. 6, pp. 605–607.

B.V. Kaul, A.L. Kuznetsov, E.R. Polovtseva, and I.V. Samokhvalov (1993), Studies of the crystal clouds based on remote measurements of backscattering phase matrices. *Atm. Ocean. Opt.*, Vol. 6, No. 4, pp. 423–430.

B.V. Kaul, A.L. Kuznetsov, and I.V. Samokhvalov (1994), Effects of light-scattering anisotropy in the stratospheric aerosol layers. *Atm. Ocean. Opt.*, Vol. 7, No. 11–12, pp. 11–17.

B.V. Kaul, A.L. Kuznetsov, and I.V. Samokhvalov (1994), Lidar studies of light scattering anisotropy in the atmosphere. 17th ILRC. Sendai, Japan Conf. Abst. pp. 125–126.

B.V. Kaul and C. Werner (1994), Some peculiarities in sounding cirrus clouds from space. *Proc. SPIE,* Vol. 2310. Lidar Techniques for Remote Sensing, pp. 164–167.

Current financial support and co-operative projects

International Project X225.6 “Crystal Clouds” approved by the Russian–German Commission on Co-operation in Science and Technology.

Russian Foundation for Basic Research: Study of the Light-Scattering Anisotropy in Crystal Clouds (93-05-9376).

The “Universities of Russia” programme, Section II. Project, Polarisation Characteristics of Crystal Clouds.

Development of optical methods for detecting aerosol emissions into the lower and middle atmosphere from natural and technogenic disasters, No. 93-1-5, in the programme “Fundamental Problems of Environmental Protection and Ecology”.

The Geokosmos Programme. Project: “Study of the influence of solar wind on the scattering properties of aerosol layers in the middle atmosphere of northern hemisphere”

Scientific and technical personnel

5 researchers and 8 technicians.

Possibilities for international exchange

Possibilities of receiving foreign scientists during a year: 2–3 man-year.

Vacancies for accommodation of foreign specialists: 3 man-year.

General information

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Responsible person: Ignatii V. Samokhvalov

MULTI-PURPOSE FACILITY SURA FOR INVESTIGATION OF CIRCUMTERRESTRIAL AND OUTER SPACE

Nizhny Novgorod Radiophysical Research Institute

Date of commissioning: 1981.

Fields of science

Physics, astronomy, and Earth sciences (radio physics, statistical radio physics; physics of low-temperature plasma; solar system, physics and evolution of stars and the interstellar medium, the Galaxy and Metagalaxy; geophysics of the ionosphere and the magnetosphere, wave processes in the atmosphere, physics of the upper and middle atmosphere).

Fields of research

- Modelling of turbulence formation and electromagnetic emission in space plasma under conditions of the ionosphere modified by powerful radio waves; development of new methods of space plasma diagnostics.
- Investigations of physical phenomena in the atmosphere using the facility as an atmospheric radar and an element of the radio acoustic probing set-up, as well as a controlled mesosphere source of induced ultralow-frequency radiation (the Getmantsev effect).
- Radar investigation of auroral magnetosphere turbulence, outer solar corona, and solar wind.
- Investigation of resonant and waveguide systems in circumterrestrial space.
- Investigation of long-wave cosmic radiation.
- Heating of the ionosphere by opposite high-power radio waves.

Main characteristics

The facility basis consists of three 250 kW short-wave broadcasting transmitters PKW-250 (frequency band of transmitters is 4–25 MHz) and three-section 4.3–9.5 MHz transmitting-and-receiving antenna of 300×300 m^2 with a gain of 26 dB at a frequency 6.6 MHz. There is a corresponding diagnostic equipment as well. The power consumed under the facility operation is about 1.5 MW.

Major advantages

World-wide, there are three effectively operating facilities for investigation of artificial ionospheric disturbances: in Tromso (Norway), Arecibo (Puerto Rico), and Fairbanks (Alaska, United States). The Sura is distinguished by its middle latitudes and by a wider band of frequencies, simultaneous independent use of transmitters, and by the scanning antenna pattern. It is possible to apply the facility for studies of the mesosphere, magnetospheric turbulence and solar wind as well as cosmic radiation in a poorly investigated long-wave part of the decameter band. The second heating facility, Zimenki, located 125 km from the Sura opens a unique possibility of ionosphere (interference) heating by opposite radio waves. An acoustic part of the Sura had been at the Zimenki facility. Widening the Sura operating band with an additional antenna system of 15–25 MHz makes the facility competitive with the Jicamarca facility (United States), to provide the largest height range of all the world's radars, and its usage as a radar in radio acoustic probing will make it possible to compete with the MU-radar (Japan).

Main scientific results

New methods of investigation of circumterrestrial space have been developed:

- Generation of low-frequency radiation at modulation of ionospheric currents by powerful radio waves, in particular, to study wave parameters of the mesosphere.
- Radio wave scattering by artificial periodic inhomogeneities, to obtain data on ionospheric parameters in the height range 60–400 km.
- Formation of artificial ionospheric turbulence at complicated time-frequency modes to study turbulence dynamics and mechanisms of plasma radiation.
- Radar studies of magnetospheric ion-sound turbulence.

New data have been obtained on:

- Coefficients of molecular and turbulent diffusion at ionospheric altitudes.
- Artificial turbulence, radio emission and ionospheric air glow.
- Influence of artificial disturbances on characteristics of ionospheric radio wave propagation, in particular, in ionospheric wave guides.
- Non-thermal radio luminosity of the local interstellar medium.
- Low-frequency spectra of the most powerful discrete radio sources of cosmic radiation in the northern hemisphere.
- Turbulent regions of the auroral magnetosphere.

Basic papers

L.M. Erukhimov, S.A. Metelev, E.N. Myasnikov, N.A. Mityakovand, and V.L. Frolov (1987), Artificial ionospheric turbulence (review). *Sov. Radiophys.*, Vol. 30, pp. 156–171.

P.P. Belyaev, D.S. Kotik, S.N. Mityakov *et al.* (1987), Generations of electromagnetic signals at combination frequencies in the ionosphere. *Sov. Radiophys.*, Vol. 30, pp. 189–205.

L.G. Genkin and L.M. Erukhimov (1990), Interplanetary plasma irregularities and ion acoustic turbulence. *Phys. Rep.*, Vol. 186, pp. 98–148.

P.A. Bernhardt, W.A. Scales, S.M. Grach, A.N. Karashtin, D.S. Kotik, and S.V. Polyakov (1991), Excitation of artificial air-glow by high power radio waves from the “Sura” ionospheric heating facility. *Geophys. Res. Lett.*, Vol. 8, pp. 1477–1480.

T.B. Leyser, B. Thidé, S. Goodman *et al.* (1992), Narrow cyclotron harmonic absorption resonances of stimulated electromagnetic emission in the ionosphere. *Phys. Rev. Lett.*, Vol. 68, pp. 3299–3302.

A.V. Gurevich, A.M. Babichenko, A.N. Karashtin, and V.O. Rapoport (1992), HF sounding of the auroral magnetosphere. *J. Geophys. Res.*, Vol. 97, pp. 8623–8696.

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Current financial support

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Grant of the American Acoustical Society.

Scientific and technical personnel

2 researchers and 10 technicians.

Possibilities for international exchange

There are four specialists from the Naval Research Laboratory (United States) for 3 weeks work at the facility this year.

Vacancies for accommodation of foreign scientists: 6 man-year.

General information

The facility is located near a small town Vasil'sursk, 140 km east of Nizhny Novgorod.
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VLBI NETWORK QUASAR

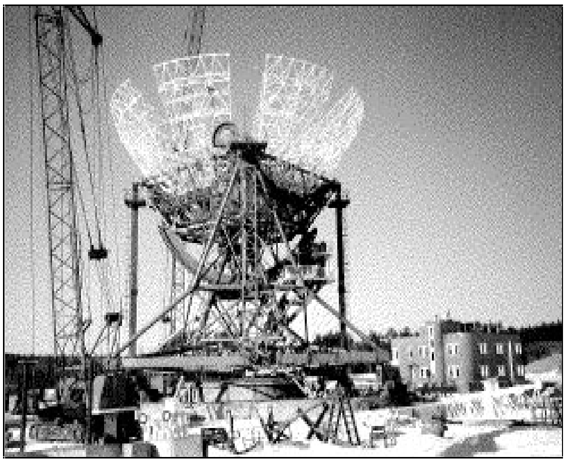
Institute of Applied Astronomy

Commissioning of the first stage: 1994; of the second stage: end of 1995–beginning of 1996.

The first part of the Quasar Network consists of three operational stations and a Centre of Control and Data Acquisition and Processing, equipped with the MARK-III correlator.

Fields of science

Astronomy, geophysics, geodesy, space navigation, metrology (astrometry: geometrical and kinematic properties of the Universe, equipment and methods of astronomical observations; geology: tectonics, investigation of the Earth's crust and upper mantle).



32-m radio antenna at Svetloe

Fields of research

- High-precision fundamental celestial and terrestrial co-ordinate systems; the Earth's rotation and global geodynamics; relation between optical and radio co-ordinate systems.
- Space research of global tectonic motions of the Earth's crust and global tectonic models; heralds of earthquakes; the Earth's gravity field and crust deformations; experimental research of tectonic kinematics.
- Design and construction of new telescopes; development of high-sensitive receivers; development of methods and facilities for ground-based and space astrometry.

Main characteristics

Angular resolution for radio source co-ordinates, mas	0.1
Angular resolution for image mapping, mas	0.3
Accuracy of the terrestrial reference system, mm	1
Accuracy of the Earth's rotation parameters:	
Pole co-ordinates, mm	3
UT1, ms	0.03
Time resolution, h	6
Atomic time scale synchronisation, ps	50

Each Quasar Network station is equipped with:

- Radiotelescope with fully steerable 32 m antenna and high-sensitive receivers for 1.35, 3.5/13, 6, and 18/21 cm wavelength (will be operational in 1995–96).
- GPS and GLONASS receivers.
- SIRIUS system for VLBI observations of GPS and GLONASS satellites.
- Atomic time service.
- Wide-band satellite communication system for data transmission.

Each station includes:

- laboratory building with rooms for observers.
- technical buildings and engineering services.

Major advantages

This is the only VLBI network in Russia with stations equipped by various facilities for time and co-ordinate measurements as well as by data-transmission systems, to provide wide-scale research in Eurasia.

Current research

Establishment of the terrestrial reference frame on the basis of the regular VLBI and GPS/GLONASS observations, determination of the Earth's rotation parameters and orbits of navigation satellites, atomic time scale synchronisation, investigation of tectonic movement in Caucasus–Crimea and Baltic regions.

Possible research

Network for VLBI investigations as part of a global international network to solve the tasks in geodynamics and global tectonics.

Main scientific results

High-precision GPS measurement were made in the framework of international projects to tie the local co-ordinate system with the international terrestrial reference system and to establish the first epoch for further investigation of local and global movements of the Earth's crust. Atomic time scale synchronisation was performed experimentally using a duplex method. VLBI observations of navigation satellites were carried out with real-time data processing. Earth rotation service was organised on the base of VLBI and SLR data processing.

Basic papers

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A.V. Ipatov, I.A. Ipatova, and V.V. Mardyshkin (1994), Cryogenic Cooled Receivers for the QUASAR Network VLBI Technology. *Progress and Future. Observational Possibilities*. Terra Sci. Tokyo, p. 200.

Current financial support

International Project WEGENER/MEDLAS (Working Group of European Geoscientists for the Establishment of Network for Earth Science Research/Mediterranean Laser-tracking Project): Research of the crustal movement and deformations in Eurasian region, in co-operation with the Institute of Applied Geodesy (Germany).

International Project BSL (Baltic Sea Level): Investigation of the geoid, gravity field, Baltic sea level and surface topography, post-glacial rebound, crustal deformation in the Baltic region, in co-operation with the Special Study Group of International Association of Geodesy and Delft University of Technology (Netherlands).

International Project DOSE (Dynamics of the Solid Earth): Investigation of crustal deformation on the basis of GPS observations, in co-operation with NASA (United States) and the Onsala Space Observatory (Sweden);

International Earth Rotation Service: Determination and investigation of the Earth rotation and establishing of the celestial and terrestrial reference frames.

International Project “Simeiz-Geodynamics”: Investigation of systems of the network QUASAR and of methods of processing VLBI observations at the international station Simeiz, in co-operation with NASA (United States) and the Crimean Astrophysical Observatory (Ukraine).

International Project DORIS: Establishing of terrestrial reference frames, in co-operation with the National Geographic Institute (France).

Scientific and technical personnel

40 researchers and 60 technicians.

Possibilities for international exchange

Vacancies for accommodation of foreign scientists: 15 man/year.

General information

Operational stations are located: Svetloe—Priozerskij District, Leningrad Region, about 90 km from St. Petersburg; Zelenchuk—near Zelenchukskaya Village, Karachaevo-Circassia, North Caucasia; Badary—Kyrenskij District, Buryatskaya Republic, 250 km from Irkutsk.

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