D. (APPENDIX) REPORT OF WORK DONE IN U.S.S.R. IN IMPROVING EQUIPMENT AND METHODS IN USE FOR RADIOASTRONOMICAL STUDIES

(prepared by V. V. Bazykin)

In 1960–1963, work on new radio-astronomical equipment and radio-telescopes was carried out at Lebedev Physical Institute, Academy of Sciences of U.S.S.R., Main Astronomical Observatory, Academy of Sciences of U.S.S.R., Institute of Radio Physics and Electronics, Academy of Sciences of Ukr. S.S.R., Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation of Academy of Sciences, U.S.S.R.

1. *Radio Telescopes*

Work on theory and design of radio telescopes for the decimetric and metric range was carried out. The theoretical work included the study of the pattern of an electrically controlled multi-dipole antenna located near the Earth surface. Necessary formulas for calculating directive gain of such systems were obtained.

Two large radio interferometers have been built and are now in operation. The first one, for the 10 to 20 Mc/s range, comprises two 24-dipole antennae which are 332 m apart along East-West line. The antenna of the telescope can be controlled in elevation within $\pm 90^\circ$ by introducing time delays, which ensures independent position of the pattern main lobe with the frequency. The second interferometer (for 20 to 40 Mc/s) has two 128-dipole broadband antennae also controlled in elevation within $\pm 90^\circ$. The antennae are so built that one has high resolution in right ascension and the other in declination. The separation of the centres of the antennae is about 650 m, the effective area of each antenna about 4000 m^2, the width of the lobe about 3°.

Theoretical studies of the reception pattern of electrically controlled multi-dipole antennae on the decimetric band located near the Earth surface were carried out. Formulae for calculating directive gain of such systems have been obtained (**1–6**).

Theoretical and experimental work was continued to study possibilities and properties of antenna with a reflector of varying shape, of which the large Pulkovo telescope built in 1956 is a prototype (**7, 8, 9**). The antenna of this type has marked advantages for radio astronomy since, due to its large area and broadband, it has high resolving power (both in right ascension and declination) and is free from saturation caused by weak sources (**10, 11**). Studies of electrical characteristics and spectrum of the space frequencies (**12, 13, 14**) have given the beam shape; it was shown that the vertical beam depends on the elevation, but not the effective area. The problem of turning main cross-section of the beam pattern and that of the space harmonic sensitivity were studied, and also the random error influence on the electrical characteristics of the varying shape antenna; the noise properties of the large Pulkovo radio telescope were measured (**15, 16**). The latter study supports the idea that a varying shape antenna could have an effective area 50 times larger than the tiltable paraboloid, which would give the same noise level.

Paper (**17**) is devoted to the polarization observations with a varying shape antenna, and describes methods of compensating parasitic polarization.

Further development of methods of tuning and adjusting varying shape antenna with nearby measurements of electrical characteristics were continued.

The influence of fluctuations in the atmospheric refraction on the electrical characteristics of large antenna was analyzed (**20**). It was shown that the first factor to be influenced is the effective area but not the beam shape.

The possibility of using effectively a varying shape antenna in the system of compound interferometer was studied theoretically and experimentally (**21, 22**).

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A simplified varying shape antenna for studying the solar radio-emission was constructed (**23**).

The exploration of possibility of using conical scanning for radio-astronomical observations was continued (**16**).

Paper (**24**) is devoted to automatization of calculations and reduction of radio-astronomical observation data.

Papers (**25, 26**) deal with the influence of the solar heat on the telescope reflecting surface.

Papers (**27, 28**) contain new proposals for hydration of radiotelescopes.

2. *Radioastronomical Equipment*

A correlation receiver for polarization exploration of discrete sources ($T = 0{\cdot}3°K$ with $f = 4$ Mc/s, $t = 20$ sec) and interferometer with radio link on a 5 km base have been designed.

In 1961, a 21-cm receiver for observation of interstellar neutral hydrogen at the large Pulkovo radiotelescope was completed. The receiver uses the principle of direct comparison radiometer, its sensitivity is about 1°K, with a 19 kHz bandwidth and a 8 sec time constant (**30**).

In 1961–1963, a number of instruments were manufactured for the investigation of the Sun on the centimetre wavelength. Among them are two polarimeters for 2 and 5 cm with an accuracy of about 0·5% in the circular polarization channel and of 1% to 3% in the linear polarization channel. These polarimeters were used for observation of the solar radio bursts.

The work on the radiometer polarization theory was continued (**31**). To study the relation between the spectral density of flux and the frequency a spectrometer was constructed. The spectrometer measures three spectral components with separation of several hundreds Mc/s near 3·04 cm. Its output registers sums of all components and their differences averaged for a period of 1 sec (**32**).

Highly sensitive radiometers were designed and used for observations. One of these radiometers uses direct amplification with travelling wave tubes on 3 cm, and gives a sensitivity of 0·3°K with 1 sec time constant and the other uses direct amplification with a parametric amplifier at the input (wavelength 3 cm, sensitivity 0·07°K with 1·6 sec time constant). Some individual units of the receivers as well as theoretical problems were worked out (**31, 33, 34, 35**).

A spectrograph for observation of the solar enhanced radio emission in 45 to 90 Mc/s band has been constructed. Continuous sweeping in the receiver frequency is ensured by magnetic variometer. The spectrograph operates with wide band cophase array antenna, tiltable in both co-ordinates (**36**).

Theoretical analysis of broadband phase modulators for radiometers was carried out. The radiometers were employed in the condition of considerable monochromatic interference, characteristic of the decimetre band (**37**).

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E. RADIO-ASTRONOMICAL EXPLORATION MADE IN U.S.S.R. USING ARTIFICIAL SATELLITES AND SPATIAL ROCKETS

The Earth surface radio-astronomy is limited to the frequency band from 1 cm to 20–40 m because of the Earth atmosphere. The only chance for considerable widening of this band lies in the use of artificial Earth satellites and of space rockets for the radio astronomical exploration.

E. A. Benediktov, G. G. Getmantsev and V. L. Ginzburg showed (**1**) that the radio-astronomical explorations with the use of artificial satellites and rockets may give new valuable data for radio astronomy.

Exploration on submillimetre, millimetre and short centimetre wavelengths may supply new data on the solar radio emission, the distribution of temperatures on the surface of the planets, the structure and electrical properties of their soils as well as on chemical composition of their atmosphere.