THE PROGRAM OF SETI STUDIES IN THE USSR

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SETI studies are carried out in the USSR since early 1960s. In 1962, the book "Universe. Life. Intelligence" by I.S. Shklovsky was published /1/. In 1964, N.S. Kardashev's paper "Transmission of information by extraterrestrial civilizations" /2/ appeared in the Astronomicheskij Zhurnal. In the same year, the first Soviet National Conference on Extraterrestrial Civilizations was held in the Byurakan Astrophysical Observatory, Armenia /3/, which evaluated the status of the problem and outlined the directions of investigations. From mid-1960s the experimental searches for ETI signals began. In 1965 G.B. Sholomitsky /4/ carried out detailed studies of variability of the radio source CTA 102 in connection with the presumed artificial nature of this source /2/. In 1968 in the Radiophysics Research Institute in Gorky under the guidance of V.S. Troitsky, the observations aiming to search for narrow-band signals from solar-type stars were initiated /5/. Up to present time, more than ten experimental works have been made in the USSR on the search of ETI signals in radio and optical ranges. These include the search for narrow-band signals from solar-type stars, the search for sporadic /including also pulsed/ radio emission from an unknown direction with omnidirectional antennas, studies of peculiar radio and optical sources, studies of statistical structure of the signal from some sources. In 1973, the Program for the studies of the CETI problem was elaborated in the USSR /6/. A survey of experimental and theoretical studies carried out in the USSR is contained in the review paper by L.M. Gindilis /7/.

The prospects for experimental SETI studies in the USSR in the nearest future are associated with the OBZOR /"Survey"/ system, the construction of the radio telescope RT-70 and its

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insertion as the ground-based antenna into the system of the cosmic interferometry.

The system OBZOR is being designed in the Radiophysics Research Institute /Gorky/ under the guidance of V.S. Troitsky /8/. The system is presumed to consist of several tens of radio telescopes operating at the wavelength of 52 cm. The beamwidth of each antenna will be about 15^{0}; the total system will cover the whole sky. The receiving system will provide the reception of both circular and linear polarization; each receiver will have 10 channels with the bandwidth 200 KHz /the total analysed bandwidth is 2 MHz/; flux sensitivity for each channel is 10^{-19} W m^{-2}. Together with the multiaerial system, it is planned to use two radio telescopes with omnidirectional dipole antennas. One of them will be equipped with a multichannel receiver of high spectral resolution /the channel bandwidth is 100 Hz/, its sensitivity will be 10^{-20} W m^{-2}. The other one is intended for the measurement of the Stokes parameters of the received radio emission, its sensitivity will be 10^{-19} W m^{-2}. The system OBZOR is an additive one and will be incremented gradually. It is planned to be operational with 20 beams in early 1990s, and by mid-1990s the number of beams will increase to 100.

In sensitivity and channel number, OBZOR is behind such projects as SERENDIP, SENTINEL etc. Its advantage is, however, in the complete simultaneous sky coverage which is very important in the case when the direction of the signal arrival is a priori unknown. As compared to the earlier all-sky searches conducted in the USSR with omnidirectional antennas, OBZOR will have a considerably improved sensitivity and will allow to identify with more certainty different types of signals /terrestrial interference, artificial satellites, ionospherics, the Sun, etc./.

The RT-70 radio telescope is being created by the Space Research Institute, Academy of Sciences of the USSR, with the participation of some other institutions /including Sternberg Astronomical Institute/. RT-70 is being erected in the mountains of Uzbekistan, at the altitude of 2300 m. This will be a fully steerable radio telescope with the mirror of 70-meter diameter, operational in the millimeter-wavelength range, down to 1 mm /9/.

Into this range falls the region near 1.5 mm which is, according to N.S. Kardashev /10/, optimum for SETI. In particular, the positronium line λ 1.47 mm lies in this region. RT-70 will be equipped with a 1.47-mm receiver with the noise temperature 100 K and bandwidth 1 GHz, allowing to register both pulsed signals and monochromatic ones /10^7 channels with the 1-Hz bandwidth/.

Another research branch at RT-70 is connected with the search for Dyson spheres and other astroengineering costructions in the millimeter-wavelength range. At the temperature of these structures 300 K, the maximum of their radiation lies near 20 μm. Therefore, the best search conditions are realized in the infrared region. However, the thermal radiation of such "hot" structures may be detected at radio wavelengths as well. Its intensity decreasing with the wavelength as λ^{-2}, it is advisable to search at the shortest radio waves. For the "cold" Dyson spheres with the temperature close to that of the cosmic background 2.7 K, the radiation maximum lies near 2 mm /11/, i.e. within the RT-70 working range.

Additional opportunities arise when using RT-70 as part of the Earth-space interferometer in the RADIOASTRON project. The resolution of this interferometer will be 10^{-6}". The radio image obtained with this resolution will allow to detect engineering structures with the dimensions of 10^2 km from a distance of several parsecs, or Dyson-sphere-type constructions from a distance of 10^5 pc, exceeding considerably the size of our Galaxy /12/.

V.I. Slysh in /11/ proposed to analyze the IRAS Point Source Catalogue in order to select the most suitable candidate sources for a subsequent SETI study. The Dyson-sphere-type objects are presumed to have a characteristic Planckian spectrum with the temperature not exceeding ~300 K. V.I. Slysh has compiled a preliminary list of 5 sources; the method of further investigation was suggested. Natural objects of a similar type are gas-dust envelopes of red giant stars which are characterized as well by the strong emission in the hydroxyl radio lines at the wavelength of 18 cm. This emission was recently detected from the strongest infrared source IRAS 17411-3154 in the V.I. Slysh's list /13/. Other objects are planned to be observed with the VLA. The anticipated SETI features are the absence of OH lines and the presence of radio continuum with the Rayleigh-Jeans spectrum.

To detect the infrared radiation from Dyson spheres and to measure their spectrum, the new space telescope, being designed at the Space Research Institute, Academy of Sciences of the USSR, may be used. This telescope, with the 1-meter mirror and with deep cooling of the mirror and receivers, will provide a high sensitivity in the wavelength region from 20 μm to 2 mm /14/

During some years, optical SETI was carried out at the 6-meter BTA telescope of the Special Astrophysical Observatory, Academy of Sciences of the USSR, North Caucasus, under the guidance of V.F. Shvartsman /15/. V.F. Shvartsman's premature decease interrupted this work. We hope that his colleagues and followers will find forces to continue this search.

During the last years, besides the professionals, amateur institutions engage themselves to SETI. The project called AELITA /after the name of a beautiful Martian woman from A. Tolstoy's novel of the same name/ has been elaborated at the Astronomical Observatory of the Young Pioneers' Camp "Orlyonok", at the Black Sea Coast. For the realization of this project, the Special Astrophysical Observatory of the Academy of Sciences of the USSR has granted to "Orlyonok" a 3-meter aerial of the solar radio telescope. The aerial allows to track a source at any declination from -23° to $+23^{\circ}$. In the survey regime with the fixed aerial, it allows to cover at the 21-cm wavelength the quoted region of the sky with the halfbeamwidth step in 23 days; the whole cycle will thereafter be repeated. Thus, the equatorial region of the sky, constituting about 40 per cent of the whole celestial sphere, will be continuously monitored. When a suspicious source is detected, the antenna will be switched to the tracking regime. The receiver for the AELITA project is being designed by the Institute of Radiophysics and Electronics of the Academy of Sciences of the Armenian SSR under the contract with "Orlyonok".

It may be anticipated that the realization of the planned projects will allow to make a progress in SETI. However, the whole affair should not be reduced to the radio signals search only. A serious comprehension of the problem is necessary, as was indicated by one of the founders of SETI Professor I.S. Shklovsky.

The problem of Extraterrestrial Intelligence is, in its essence, common to all mankind; therefore, international cooperation in this domain is so important. This cooperation may include a reasonable combination of both national search programs and international projects.

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