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RATAN-600: past, present, future

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The older radio astronomy, the more anniversaries we celebrate. Let us number those referred to SAO.

Following the terms of S. Eh. Khajkin, one of the founders of experimental radio astronomy in Russia, this year we celebrate the centennium since the time the first radio telescope, "Thunderstorm recorder" of A. S. Popov, capable of recording electromagnetic non-artificial waves, was created. Generally speaking, radio waves opened "two windows" for mankind: in the sphere of interconnection between peoples, and between humanity and the surrounding World. As has recently been found out the first patent for the invention of wireless contact between people had been granted long before the experiments of Markoni, Popov and others. A. S. Popov however, was the first to be granted the patent for the device ensuring connection with "natural phenomena".

After that the effective range of the "radio window" underwent a skyrocketing extension, and for the first slightly over 30 years it advanced from atmospheric phenomena to the Milky Way (legal onset of radio astronomy) and 30 years ago reached its limit – "singularity", the moment of origin of the Universe, after the interpretation of the 3K background as the relic radiation left after the epoch of "Big Bang".

The radio astronomers of SAO have a history of their own commencing from the Pulkovo radio astronomy. Here are some dates.

- 1956 — first observations with the RATAN-600 prototype — Big Pulkovo Radio Telescope (BPR);
- 1974 — first observations with the South sector of the RATAN-600;
- 1976 — completion of construction of the RATAN-600.

It will not be too overstated to say that without advances in Pulkovo, without actual astrophysical results of the 1950s–1960s the radio telescope RATAN-600 would never come to exist. Here are some of them.

Sun. Pioneer detection of strong polarization of spots at the cm wavelengths was reported by Kaidanovsky et al. (1956), investigations into this phenomenon by the method of solar eclipse were carried out in 1956 (Korol'kov and Soboleva, 1957) and later. Systematic multifrequency studies at the BPR were also performed. All this formed a foundation for the construction of models of active regions and estimation of magnetic field in them (Korol'kov et al., 1959). Acquisition of qualitatively fresh data on the structure of the Sun in the cm range with a resolution of 1 arcmin, which was then an all-round record (Ikhsanova, 1958).

Moon. First detection of linear radio polarization on the Moon, which permitted the most accurate estimates of the dielectric properties of the lunar surface to be made (Soboleva, 1962).

Planets. Demonstration of the validity of the "hot" model of Venus from the first BPR estimates of radio brightness distribution over its disk (Korol'kov et al., 1963), a year before MARINER-II was launched for the same purpose. A little later this model was shown to agree at 8 mm with the models requiring 100 atmosphere pressures at its surface.

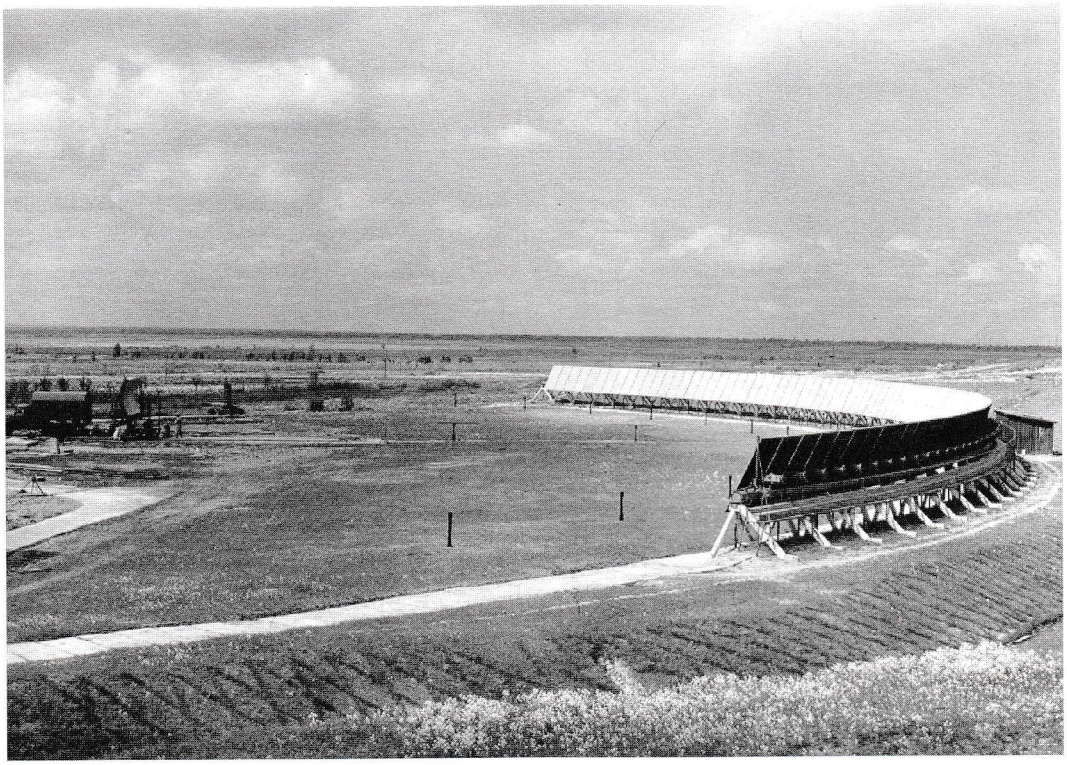
Solar wind. Jupiter's radiation belts were found to be deformed in polarized radiation, which was the first (and unexpected) indication that the wind permeates as far as the orbit of Jupiter (Gol'nev et al., 1964).

Galaxy. First morphological multifrequency investigations of the Galaxy nucleus and separation of the structures by mechanisms of radiation, solution of the famous problem "Drake Belts" (Egorova et al., 1964). Compiling the first morphological catalogue of all major Galaxy sources (Gol'nev et al., 1965) and others, determination of their physical parameters, detection of new supernova remnants (W44). Mapping the sky in the 21 cm line with a so far record resolution.

Metagalaxy. First direct resolution of the classical object Cygnus A into components, first data on the structure of a number of objects with polarized radiation (used by M. Ryle when constructing the model of radio galaxies) (Soboleva, 1963), first optical identifications of a number of famous objects, 3C345, 123, 279 and others.

Cosmology. First deep search for anisotropy of the 3K background and detection of serious discrepancy with the theory of those days (Parijskij and Pyatunina, 1970).

One of outstanding discoveries in radio astronomy of the 1960s (the only in Russia) was the revealing of hydrogen recombination lines by A. F and Z. V. Dravskikh in 1963 (Dravskihk et al., 1964) (subsequently confirmed by R. L. Sorochenko in 1964), which had been predicted by N. S. Kardashev. For deeper insight into the history of Pulkovo Radioas-



The Big Pulkovo Radiotelescope

tronomy school see the book of Kaidanovsky (1985).

Unfortunately, the scientists I cannot conceive the RATAN-600 and its staff without are not alive, namely:

- S. Eh. Khajkin who gave birth to a school of radio astronomers ("Pulkovo school");
- N. F. Ryzhkov, one of the first Pulkovo radio astronomers of the 1950s, a scholar of S. Eh. Khajkin and the founder of his own school: Gosachinskij, Zhelenkov, Morozov, Grachev and others. N. F. Ryzhkov was the supervisor of nearly all spectral studies both at Pulkovo and RATAN-600;
- D. V. Korol'kov, a student of S. Eh. Khajkin and the creator of his own school: Berlin, Timofeeva, Ipatov, Bogod and others, who, in turn, have their scholars: Nizhelskij, Mardyshkin, Shatilov and others, who have students of their own: Tsybulev, for instance, should be referred to the fifth generation!;
- O.N. Shivris, S.Eh. Khajkin and N.L. Kaidanovsky's student, contributed largely to the theory of variable profile antennas' (VPA) geometry. He replaced N. L. Kaidanovsky as the Chief designer of the RATAN-600. Since the late 1960s stanitsa Zelenchukskaya was, in fact, the residence of O.N. Shivris in spite of bad conditions of life of that time. He supervised the work on construction of the radio telescope.

Name also some main persons who took part in the development and putting in operation of the RATAN-600.

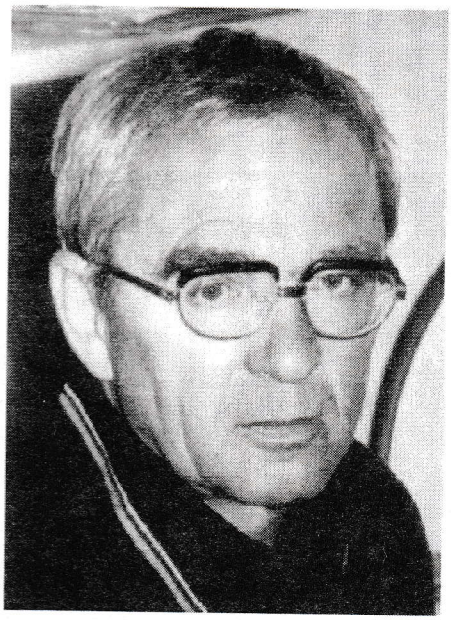
S.Eh. Khajkin

N. L. Kaidanovsky, S. Eh. Khajkin's coauthor of the idea of variable profile antenna who had held the post of the Chief Designer nearly until the radio telescope was placed in service. N. L. Kaidanovskij has been taking interest in the RATAN-600 affairs suggesting fresh procedures of its use.

A. B. Berlin, who took over the duty of the Chief

N.F. Ryzhkov

O.N. Shivris



D.V. Korol'kov

Designer of the RATAN-600 and devoted himself to the problem of fitting the radio telescope with high-sensitivity radiometers. His wife, G. Timofeeva, played a particular part in the introduction of parametric amplifiers in radio astronomy.

A. Kopylov, whose sketches were used to develop nearly all mechanical parts of the RATAN-600.

V. Gol'nev, the designer of over 20 high-sensitivity measuring devices used to obtain quite a few results at Pulkovo and RATAN-600. His wife, N. Golneva, took part in the first geodetic surveys while the telescope was under construction.

G. S. Golubchin and Eh. I. Korkin were concerned with the development of automatic control systems of all generations and realizing contact with industry in all directions. G. Golubchin initiated automatization of the control system, which has later been carried on to advantage by G. Zhekanis.

A. A. Stotskij, who had been engaged for many years in the development of methods of high-precision mechanical alignment of the antenna, which were then reduced to practice.

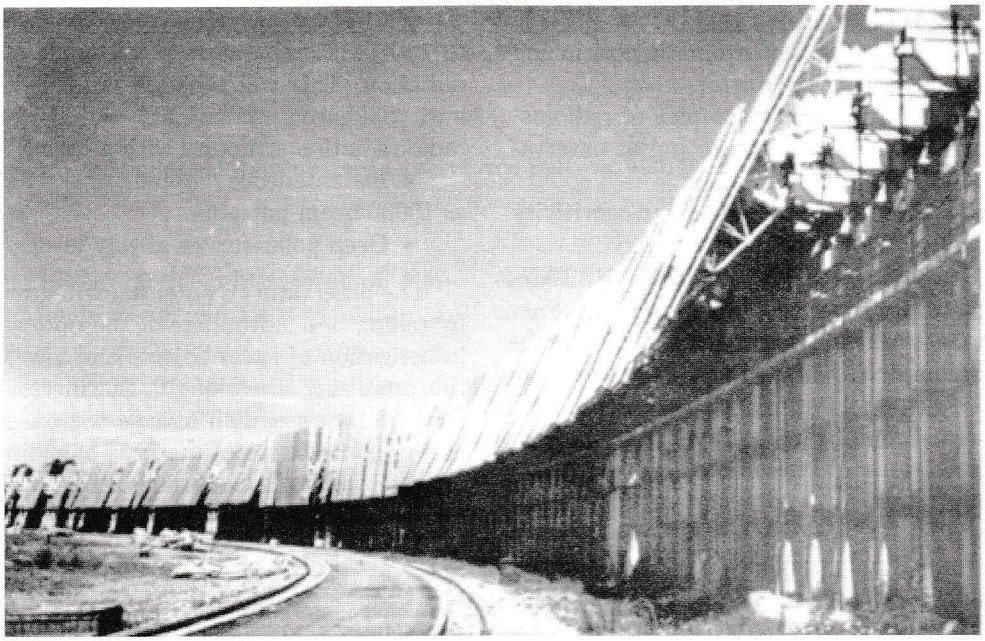
L. M. Gindilis, who acted for over 10 years as a Moscow representative of the RATAN-600 and the first head of the SSAI laboratory at the radio telescope. It will be recalled here that it is the integration of the Pulkovo and Sternberg State Astronomical Institute projects ("KRAUS"and "VPA") that promoted the approval of the project at all levels of authorization.

A few words about the people from other establishments of St. Petersburg intimately concerned with the RATAN-600.

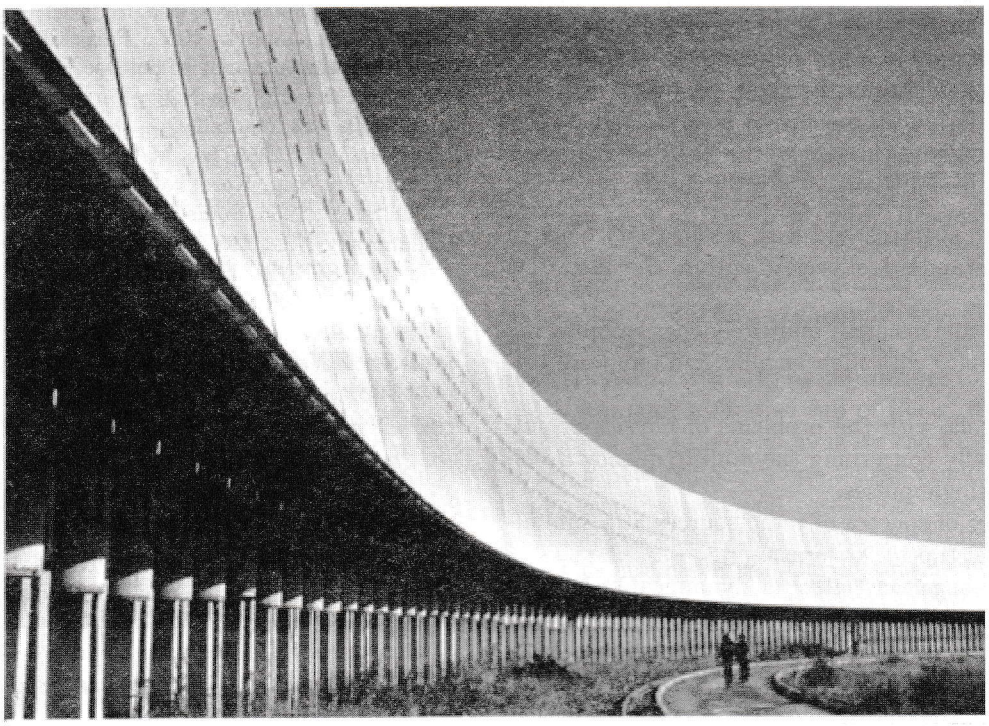
N. A. Esepkina — the founder of the rigorous VPA field theory, first in the vector and then in the tensor form. All the problems in electrodynamics that spring up at the RATAN-600 have been discussed with her. Over the past few years she has been active in the introduction of new hybrid techniques for analysis of radiations (AOS), promoting the involvement of the Polytechnical Institute (St. Petersburg Technical University) in handling RATAN-600 problems.

G. B. Gel'freikh has largely determined the strategy of solar investigation at the radio telescope. His wife, P. Afanasieva, was the pioneer of astrometric investigations at the RATAN-600.

Below is presented a list of major suggestions for



The radiotelescope just after construction



After accurate tunning by research groups

realization of principal potentialities of the telescope.

1. Utilize as full as possible the capabilities of INTERNET.

2. Implement the project "ZENITH" converting the RATAN-600 into a 1000-element array with a large field of view and round-the-clock monitoring.

3. Implement the project "RADIOHELIOGRAPH" for 3D IUQV investigations of the Sun.

4. Develop a limiting sensitivity spectrograph spanning the entire wavelength range of the telescope.

5. Make the correction mirror (as part of the design) to be moved on arc rails.

6. Realize a many-hour (all sky) and arbitrarily large (circumpolar regions) acquisition of signal.

7. Create a special limiting sensitivity complex for systematic work of many years on "Sakharov's

programme".

8. Design a system for the automatic positioning of the RATAN-600 secondary mirrors.

9. Design a multifrequency complex of radiometers with a common phase centre for pulsar observations.

10. Create a three–five–frequency high-sensitivity complex for polarization investigations.

11. Realize automatic alignment of the RATAN-600 mirror.

12. Boost the work on the creation of matrix high-sensitivity radiometers to make full use of the super-large aberration-free field of the telescope.

13. Create a system for recording VHF signals in proportion to the level of interferences.

14. Go on with the work on maximum cooling the radio telescope.

15. Carry out, if only partially, the plan of development of radio facilities of the SAO.

The rate of fulfilment of the above proposals is primarily dependent on the amount of funding of the SAO, but it must be adequate to keep up the RATAN-600 on the "main sequence" of the world's major instruments, if only in a few parameters.

The implementation of these proposals will advance considerably the solution of important astrophysical problems, in which the RATAN-600 may prove to be useful. Itemize some of them.

- Radio spectroscopy with a sensitivity close to the world standard expected within the next few years.
- Two-dimensional multifrequency monitoring of solar activity with high angular and temporal resolution.
- Contact with the problems of physics of pulsars, especially concerning the multifrequency investigation of single pulses.
- Study of spectra of radio sources at a submillijansky level (up to "saturation").
- High-accuracy patrol of dynamical spectra of large (up to 1000) samples of sources.
- Deep polarization studies of background radiations and separate objects.
- Multifrequency surveys of huge sky regions up to 1 μK with separation of all kinds of background radiation. This will make it possible to investigate into "Sakharov oscillations" and study the Galaxy radio radiation structure with a higher accuracy.
- Instantaneous mapping of sky regions as large as 10000 beam patterns.
- Deep polar survey at μJy level.

The observatory's potential will grow appreciably by taking best advantage of the optical facilities for investigation of radio objects and vice versa. One of the promising directions is the investigation of objects of a very early Universe with a strong optical and radio radiation of the type of radio galaxies and quasars. Joint, RATAN-600–BTA, study of pulsars and bursters are also planning.

References

Dravskikh Z.V., Dravskikh A.F., Kolbasov Yu., 1964, Astron. Tsirk., No. **305**, 2

Egorova T.M., Gosachinskij I.V., Ryzhkov N.F., 1964, IAO-URSI Symp. No. **20**, 191

Gol'nev V.Ya., Lipovka N.M., Parijskij Yu.N., 1964, Reports of the Academy of Sciences, **157**, 554

Gol'nev V.Ya., Lipovka N.M., Parijskij Yu.N., 1965, Astron. Zh., **42**, No. 5, 902

Ikhsanova V.N., 1958, Izv. MAO, **21**, 29

Kaidanovsky N.L., Korol'kov D.V., Soboleva N.S., Khajkin S.Eh., 1956, Solnechnye dannye, No. **4**,

Kaidanovsky N.L., 1985, in: History of Radioastronomy in the USSR (in russian), Kiev, 141-161

Korol'kov D.V., Soboleva N.S., 1957, Solnechnye dannye, No. **1**, 149

Korol'kov D.V., Parijskij Yu.N., Soboleva N.S., 1959, Solnechnye dannye, No. **9**, 65

Korol'kov D.V., Parijskij Yu.N., Timofeeva G.M., Khajkin S.Eh., 1963, Reports of the Academy of Sciences, **149**, No. 1, 65

Parijskij Yu.N., Pyatunina T.B., 1970, Astron. Zh., **47**, 7, 1337

Soboleva N.S., 1962, Astron. Zh., No. **6**, 1124

Soboleva N.S., 1963, Reports of Academy of Sciences, **153**, No. 3, 555