Geodetic and Astrophysical Study at the Simeiz VLBI Station

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Abstract

This report gives an overview about the geodetic and astrophysical activities at 22-m radio telescope RT-22 (Simeiz). We summarize briefly the status of Simeiz station as an IVS Network Station.

1. General Information

The Simeiz VLBI Station (also known as CRIMEA in the geodetic community), operated by Radio Astronomy Laboratory of Crimean Astrophysical Observatory of the Ministry of Education and Sciences of Ukraine, is situated on the coast of the Black Sea near the village of Simeiz 20 km west of the city of Yalta in Ukraine.

RT-22, the 22-meter radio telescope, which was put into operation in 1966, is among the 10 most efficient telescopes in the world. Various observations in the centimeter and millimeter wave ranges have been performed with this telescope and will be performed in the near future. First VLBI observations were performed in 1969 on the Simeiz (RT-22) to Green Bank (RT-43, USA) intercontinental baseline. RT-22 is equipped with radiometers at the 92 cm, 18 cm, 13 cm, 6 cm, 3.5 cm, 2.8 cm, 2.3 cm, 2.0 cm, 13.5 mm, and 8 mm wavelengths.

Figure 1. Simeiz VLBI station, 22-m radio telescope RT-22.

RT-22 is a fully steerable paraboloid, 22 m in diameter, with a focal length of 9.525 m. The rms surface accuracy is 0.15 mm. The horizontal axis is shifted by -1.8 ± 0.2 mm relative to the

azimuthal axis. The operating ranges of turning angles are -210° to 210° in azimuth and -3° to 90° in elevation. The maximum slew rate of the antenna is 1.5°/sec.

RT-22 is used for multifrequency regular monitoring of active galactic nuclei; for the exploration of solar and stellar activity; for VLBI observations within the frames of international astrophysical, geophysical, and radar programs; for the exploration of water vapor, hydroxyl, methanol, and SiO cosmic masers; as well as for spectral observations in the range of frequencies from 85 GHz to 115 GHz; i.e., it is used to study the most challenging problems of modern astrophysics and natural history.

2. Effective Area of the Antenna of the 22-m Radio Telescope RT-22

Forty years of intensive observations with the 22-m radio telescope RT-22 CrAO and studying its characteristics at millimeter wavelengths demonstrated a fairly high quality of the instrument. Based on the results of calibrator observations at 13.5 mm and 8.2 mm wavelengths in 1985 and 2010, the dependence of the effective area of the RT-22 CrAO antenna on ambient temperature and elevation was determined. The obtained results confirm a high quality of the RT-22 antenna at millimeter wavelengths. A high accuracy of the reflector surface makes it possible to observe at millimeter wavelengths right to 2 mm. At 8.2 mm wavelength, the effective area changes by no more than 5% when the antenna is moved from zenith to 15° elevation angle. The effective area of the RT-22 antenna decreases by $\sim 7\%$ when the ambient temperature deviates by 10°C from the value $T_0 = 17.5$°C. Large antennas, intended to operate at maximum frequencies, should be built either taking into account the climatic conditions of the antenna sites or taking measures to provide thermal stability of the antenna.

3. Current Status and Activities

During 2011 the Space Geodesy and Geodynamics stations regularly participated in the following international network programs: IVS, the International GNS Service (IGS), and the International Laser Ranging Service (ILRS).

From 1 January through 31 December 2011, Simeiz VLBI station participated in twelve 24-hour geodetic sessions. Simeiz regularly participated in the EUROPE and T2 series of geodetic sessions.

The results for the RT-22 Simeiz coordinates were compared with the monthly averages of the long-term measurements of the Black Sea tide gauge stations, located in Odessa, Ochakov, Sevastopol, Yalta, and Katsively. All items of sea level measuring have a different water flow, which gives the opportunity to explore global geodynamic processes and their dependence on solar activity cycle. The spectrum of sea level variations in different points indicates the presence of periods of one to eleven and twenty-two years. Using wavelet analysis the periods for each tide gauge station are estimated separately.

Use of the Simeiz antenna is shared with the “Radioastron” program:

1. The catalog of sources for flight program “Radioastron”.
Observations of sample sources from the preliminary “Radioastron” catalog were obtained at 22.2 and 36.8 GHz with the RT-22 radio telescope of the Crimean Astrophysical Observatory. We have determined the distribution of the source spectral indices between these frequencies [1]. The

distributions of the spectral indices of the RT-22 sample have more important dispersion of the distribution than in the WMAP catalog (between 23 and 33 GHz) due to input parameters of sample sources from the "Radioastron" catalog. We have plotted the $log(10\Delta N/N_0) - logS$ dependence down to the flux levels of about 0.1 Jy using the survey data near 22 GHz. There is a reduction in the density of cosmological sources in relation to non-evolving Euclidean universe (Figure 2). The variability of individual sources in connection with flare activity is considered.

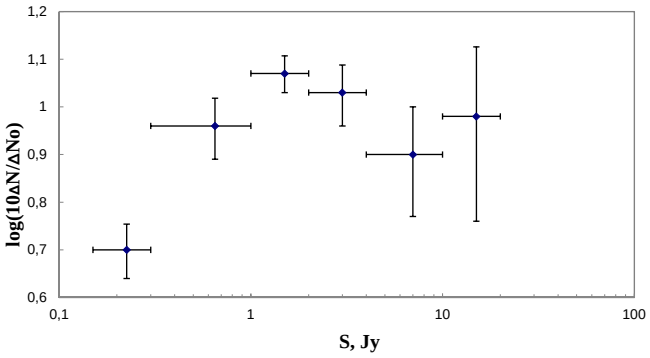

Figure 2. The differential statistical dependency logN-logS.

2. The RT-22 of CrAO: scientific program elaboration and performance of ground-based VLBI test experiments within the framework of the project "Radioastron".
The Earth-space science program "Radioastron" includes high-resolution (microseconds of arc) studies of the morphology and dynamics of the circumnuclear regions of sources of powerful energy. In accordance with the scientific cooperation between Ukraine and Russia, the study is carried out using the 22-m radio telescope RT-22 of the Crimean Astrophysical Observatory. The research program provides the investigation with highly sensitive radiometers at frequencies of 22 GHz and 36 GHz. This makes it possible to obtain spectral characteristics of the sources near 22 GHz, which is the fundamental frequency of the experiment "Radioastron". To realize the project, the scientific program is developed, a substantial part of which is the study of compact structures in extragalactic sources, and groundbased VLBI test experiments are conducted [2].

3. The testing of the ground-based segment of the "Radioastron" mission. The Simeiz - Pushchino interferometer at wavelengths of 6 and 1.35 cm.
In accordance with the scientific cooperation between Ukraine and Russia a series of studies was done for the preparation of the operation of the ground segment of the "Radioastron" mission. Using the 22-m radio telescope RT-22 (Crimean Astrophysical Observatory) the scientific program of measurements was prepared, a substantial part of which is the study of the compact structures in the extragalactic sources, as well as the structure and spatial distribution of H2O galactic masers. For testing the model of the ground segment of "Radioastron", RT-22 of Crimean Astrophysical Observatory in Simeiz and RT-22 of the PRAO in Pushchino jointly conducted groundbased VLBI test experiments. As a result of data processing using the ASC LPI correlator the amplitude and phase of the cross-correlation functions were obtained and calibrated, and the available coherence time was estimated [3]. The results of the experiment demonstrate readiness of RT-22 (CrAO) to participate in further joint radiointerferometric sessions, including those of the "Radioastron" project. The modernization of the Simeiz station was opened up by the possibility of beginning

research of systematic and complex polarization of star forming regions.

4. The testing of the ground-based segment of the "Radioastron" mission. The Simeiz - Evpatoria interferometer at wavelengths of 6 and 18 cm.
In accordance with the scientific cooperation between Ukraine and Russia a series of studies was performed for the preparation of the operation of the ground segment of the "Radioastron" mission. Using the 22-m radio telescope RT-22 the scientific program of measurements was prepared, a substantial part of which is the study of the compact structures of the extragalactic sources. For testing the model of the ground segment of "Radioastron", RT-22 of Crimean Astrophysical Observatory in Simeiz and RT-70 (P-2500) in Evpatoria jointly conducted groundbased VLBI test experiments at 6 cm and 18 cm [4]. As a result of data processing using the ASC LPI correlator the amplitude and phase of the cross-correlation functions were obtained and calibrated, and the available coherence time was estimated (Figure 3).

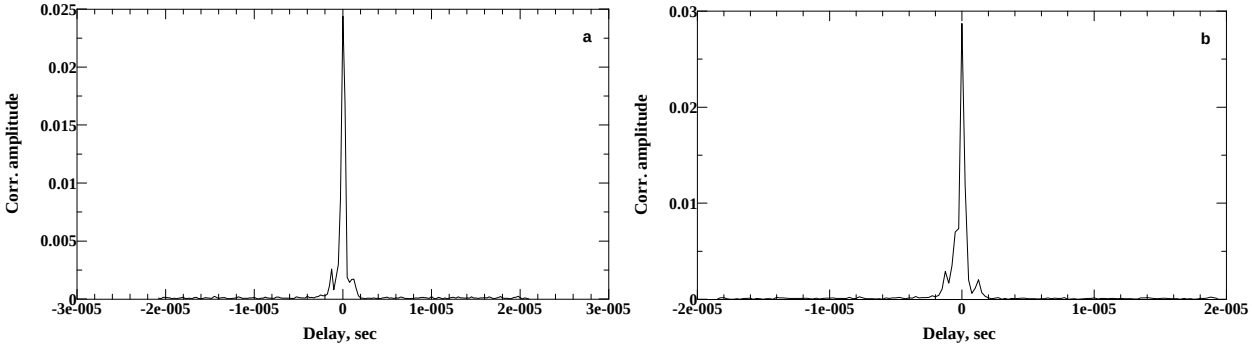

Figure 3. Simeiz-Evpatoria, 6 cm. a) 3C279, t=300 sec, $S/N > 400$ sec; b) 3C286, t=180 sec, $S/N = 440$ sec.

The results of the experiment demonstrate the readiness of RT-22 and RT-70 to participate in space-ground Very Long Baseline Interferometer sessions of the "Radioastron" project.

4. Future Plans

Our plans for 2012 are the following: to put into operation the VLBI Data Acquisition System DBBC, upgrade the laser of SLR Simeiz-1873 station, and set up a new GPS station near Simeiz VLBI station.

References

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