ASTRONOMY AND SPACE SCIENCE
eds. M.K. Tsvetkov, L.G. Filipov, M.S. Dimitrijević, L.Č. Popović,
Heron Press Ltd, Sofia 2007

# RAPS – Radio Astronomy Projects in Sofia

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**Abstract.** In 2005 the RAPS team began development of low budgetary radiotelescopes for monitoring of solar activity and processes in the system "solar wind – earth magnetosphere" in order to improve the development of radioastronomy instrumentation, international cooperation and education in Radioastronomy in Bulgaria. We present the current state of our activities and first observations of radio emission at X band (8–12 GHz) from the Sun; from Crab nebula, obtained with 1.5 m parabolic antenna plus commercial satellite detector. Also extremely low frequency (ELF) radio signals at 2 Hz, observed with horizontal ferrite antenna and a low frequency radio detector are shown.

The sun-earth environment is the region of space extending from the surface of the sun out to, and including, the earth's ionosphere and magnetic field. This environment is dominated by electromagnetic radiation and electrically charged particles from the sun. It is subject to change as events on the sun, such as solar flares, blast streams of radiation and energetic particles towards the earth. The sun-earth environment has a wide range of effects on many aspects of everyday life. Changes to conditions in the sun-earth environment are often called "space weather" and these changes can cause significant damage to communications systems.

Space weather results from changes in the speed or density of the solar wind, the continuous flow of charged particles from the sun past the earth and into interplanetary space. This flow distorts the earth's magnetic field, compressing it in the direction of the sun and stretching it out in the anti-sun direction. Fluctuations in the flow of solar wind cause variations in the strength and direction of the magnetic field measured near the surface of the earth. Abrupt changes in this dynamic medium are called geomagnetic disturbances.

At the same time the earth's ionosphere (the electrified layers of the upper atmosphere that extends from about 70 to 500 km in altitude) can be severely disturbed by flows of charged particles in the region. This is important because the ionosphere acts as a "mirror", reflecting High Frequency (HF) signals and allows cheap and convenient communication over long distances. High frequencies are significant for military communications, emergency services, broadcast industries, marine and aviation operators. Communications on other frequencies, from VLF to MW, are also affected, making space weather and its prediction valuable to the communication systems operators. Many other phenomena are associated with space weather.

Space weather originates from the sun and depends on the solar cycle. Several solar features and events are connected with space weather. First, solar flares are huge outbursts of energy seen on earth at many wavelengths from visible light right through to the radio spectrum, and from space in X-ray observations. They are the outcome of the release of stored energy as the magnetic fields of sunspots become twisted and distorted due to the differential rotation of the sun. If the complexity of the magnetic field is sufficiently large, the energy can be released in an explosive event – a solar flare. Along with the production of electromagnetic radiation, the flare can be associated with the ejection of clouds of charged particles into the solar wind. This process is called a coronal mass ejection and may occur with flares or with other types of events. The result of the material reaching the earth is a geomagnetic/ionospheric storm. Coronal holes, another type of solar feature connected with space weather, are extremely large regions in the solar corona – the outer atmosphere of the sun. They are regions of reduced temperature and density and are the locations of magnetic field lines which are open into interplanetary space. Coronal holes contribute high speed streams to the solar wind which, if they reach the earth, also produce space weather disturbances.

The appearance of the "quiet time" solar atmosphere at radio wavelengths is governed by the plasma parameters (temperature, density, and magnetic field strength) and the radiation mechanisms that generate the radio emission (free-free emission, gyroresonance emission, and plasma emission). The various manifestations of solar activity are driven by the total amount of magnetic flux emerging through the photosphere into the chromosphere and corona, and its temporal and spatial distribution. For reasons not clearly understood, solar activity ebbs and flows over a cycle of about 11 years.

The 10.7 cm Solar Flux is a measurement of the integrated emission at 10.7 cm wavelength from all sources present on the disc. It is almost completely thermal in origin, and directly related to the total amount of plasma trapped in the magnetic fields overlying active regions. This in turn is related to the amount of magnetic flux. A comparison made over more than a solar activity cycle show that there is indeed a linear correlation between the 10.7cm Solar Flux and the total photospheric magnetic flux in active regions. Because of the huge increase in electron density at the chromosphere, radio emission becomes optically thick due to free-free emission at heights higher than the solar minimum region, even at the highest frequencies. Therefore, radio observations pertain only to the upper chromosphere and higher. By this reason if we start at the chromosphere and move outward in the solar atmosphere this will be equivalent to starting at the highest frequencies and moving to lower frequencies. In principle we may obtain more information observing also the 1 m (300 MHz) flux, coming from upper chromosphere and higher ($<$100 000 km above the photosphere), as well at the 10 m (30 MHz) flux, coming from the corona ($\approx$600 000 km above the photosphere).

We proceed from the assumption above and we constructed prototypes of small solar radio telescopes for two wave ranges – 1 m, with spiral antenna, and for X band, with parabolic antenna. In 2006 some test observations with the prototypes of the small radio telescopes were made. Our conceptions and the prototype of the radiotelescope for X band radioflux have been presented earlier by Ilchev *et al.* (2006) [1].

Figure 1 shows the prototype of the radio telescope for X band, based on 1.5 m parabolic antenna. The test with a commercial satellite TV detector shows that the solar flux is observable even with of-the-shelf receivers. The system is enough sensitive even for detection of Crab nebula flux, as it is shown in Figure 2.

Figure 1. The prototype of the 1.5 m radiotelescope for monitoring of the X band solar flux, now equipped with commercial satellite detector.

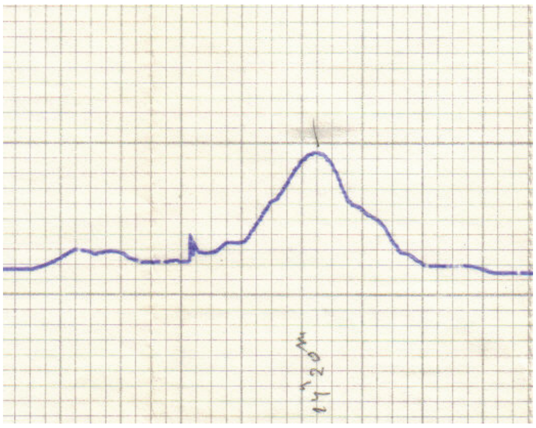

Figure 2. Radio flux of the passage of the Crab nebula, observed with 1.5 m radiotelescope.

In the present time our team is in a process of development of low noise detectors for standard 10.7 cm wavelength observations. RAPS team is also monitoring the extremely low frequency (ELF) radio signals, with $<$10 Hz and $>$30 000 km. They correspond to the large-scale phenomena in the ground and the void between the ground and the ionosphere. The specific frequency of this void, known as the Schumann's resonance, is about 8 Hz. The ELFs are caused probably by the fluctuation of the solar wind, bolids, ultra-high energy cosmic particles, power lightings and earthquakes. The ELF phenomena are various and complicated for investigation. Generally, the ELF signals appear as sporadic wave packets at intervals of some decades of seconds, with duration a few seconds. Our first registrations were made with a horizontal ferrite antenna and a low

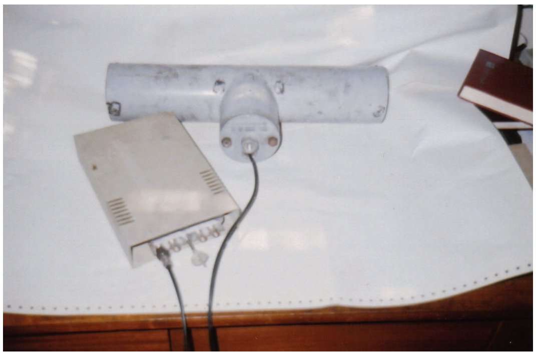

Figure 3. The prototype of the device for monitoring of the ELFs signals, consisting of ferrite antenna and ELF radio detector.

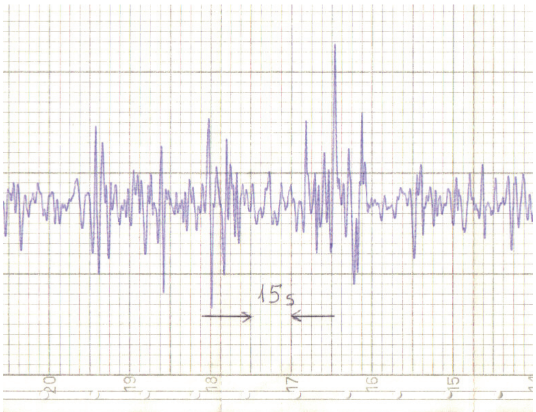


Figure 4. Flux registration of four ELF signal packets separated by 30–40 s, observed in the range 0.5–15 Hz with maximum sensitivity at about 2 Hz.

frequency radio detector, constructed in agreement of the design of Diedrich (2004) [2]. One typical registration of ELF signals is shown in Figure 3.

In close future the RAPS team purposes are to design radioastronomy instrumentation at different frequency bands, to automate measurements and data storage, to gain skills in analysis of radio spectra to foster radioastronomy education and international cooperation in multidisciplinary space related sciences.

## References


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[2] K. Diederich (2004) Unknown ELF signals, `http://news.cqham.ru/articles/detail.phtml?id=473`.