ISSN 0016-7932, Geomagnetism and Aeronomy, 2009, Vol. 49, No. 7, pp. 34–37. © Pleiades Publishing, Ltd., 2009.

Observations of the Solar Radio Emission with the Callisto Spectrometer

Kh. A. Monstein[a], S. V. Lesovoy[b], and A. I. Maslov[b]

[a] *Institute of Astronomy, Wolfgang-Pauli-Strasse 27, CH-8049 Zurich, Switzerland*

[b] *Institute of Solar–Terrestrial Physics, Siberian Branch, Russian Academy of Sciences, P. O. Box 4026, Irkutsk, 664033 Russia*

Abstract—In the framework of the program for setting the Callisto spectrometer network into operation, the spectral measurements were carried out at the sites of spectrometer locations in India and Russia in winter 2006. The results achieved at Badary, the site where the Siberian Solar Radio Telescope (SSRT) is located, are presented. The measurements were performed using a broadband log-periodic antenna connected to the Callisto spectrometer developed at the Institute of Astronomy (Zurich). The results of these measurements should explain whether spectral studies at frequencies below 1 GHz can be performed using such antennas or new antennas should be developed. The presented results are compared with the similar results obtained in Switzerland in the frequency intervals of interest for radio astronomy. Concerning electromagnetic noise, Badary is a better site for observing the Sun in the 50–800 MHz frequency range as compared to observatories in Switzerland.

PACS numbers:

DOI: 10.1134/S0016793209070056

1. INTRODUCTION

The program of measurement was planned and organized by the Institute of Solar–Terrestrial Physics (Irkutsk) and the Institute of Astronomy (Zurich) with regard to the tasks of the International Heliophysical Year and the SSRT upgrade. The measurements were carried out on December 11–15, 2006, in Badary, where SSRT is locted.

2. CALLISTO PROJECT

Callisto (Compound Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory) was conceived as a budget version of the network of solar spectrometers located in different regions of the Earth [Benz et al., 2004]. The main task of the project is to perform the round-the-clock observation of the solar radioemission in the 50–1000 MHz range. For this purpose, it is planned to place Callisto spectrometers at different longitudes. At present, the observations are performed with four spectrometers. One of them is located in Switzerland (Bleien); two spectrometers, in India (Bangalore and Ootacamund); and one spectrometer, in Russia (Badary, SSRT). Spectrometers in Costa Rica and Mexico are tuned. The obtained spectrometer data are available at the site http://www.astro.phys.ethz.ch/cgi-bin/showdir?dir=Observation_callisto. All spectrometers receive only one linear polarization. It is planned to receive two circular polarizations.

3. DESCRIPTION OF SSRT

SSRT is one of the largest astronomical instruments [Smolkov et al., 1986; Grechnev et al., 2003]. It is located in a picturesque wooded valley, which separates the East Sayan and Hamar-Daban mountain ranges, located at a distance of 220 km from Irkutsk. SSRT is a cross-shaped interferometer, which consists of two 128-element equidistant antenna arrays, oriented in the east–west and north–south directions. The diameter of each parabolic antenna is 2.5 m, and the distance between two adjacent antennas is 4.9 m. The main lobes of the SSRT fan antenna beam cover an angle that exceeds the visible angular size of the Sun at a wavelength of $\lambda = 5.2$ cm. The length of each antenna array is 622.3 m. The geographical coordinates of Badary are given in Table 1.

4. INSTRUMENTATION

We used a standard CLP5130 log-periodic antenna, which receives a linear polarization (Fig. 1). The frequency range of this antenna is 50–1300 MHz. The antenna was connected to the KUHNE KU515B

Geographical coordinates of Badary

Latitude	51.8° N
Longitude	103.2° E
Altitude above sea level	800 m
Local time	GMT + 8h

Fig. 1. Callisto log-periodic antenna.

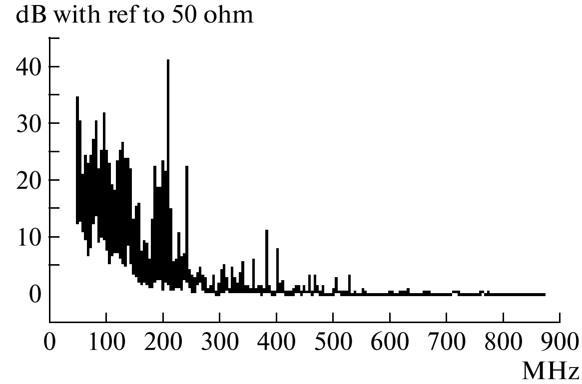

Fig. 2. Total frequency band of Callisto from 45 to 870 MHz with a step of 62.5 kHz.

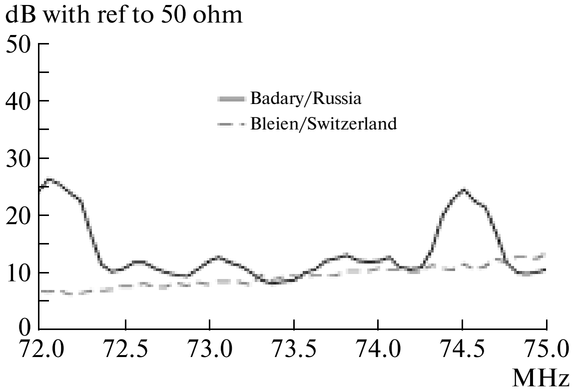

Fig. 3. The noise level at Badary is higher because of the influence of the SSRT equipment. The band 73–75 MHz is used in radio astronomy.

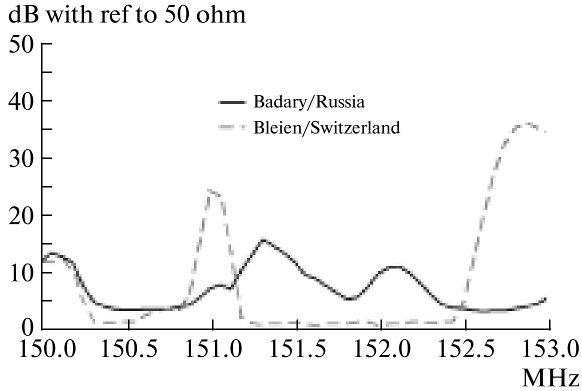

Fig. 4. The noise level at Bleien is considerably higher than at Badary. The band 150–153 MHz is reserved for radio astronomy.

preamplifier with a gain of 20 dB. The preamplifier backend was connected to a RG-213 low-loss coaxial cable, which fed the signal to the control building. The Callisto spectrometer with a sensitivity of 25 mV/dB, control cables, and coaxial connectors were granted by the Institute of Astronomy, Zurich. The spectral resolution depends on the receiver passband (300 kHz) and the step of the local oscillator tuning (frequency interval between channels, 62.5 kHz). Switching between channels takes 1.25 ms with a time constant of about 1 ms. In the data file of the entire band survey, the frequency and detector output are given in megahertz and millivolts, respectively. The data are stored in a usual ASCII file, which can be analyzed by means of any electronic table software, e.g., Excel (Fig. 2) or IDL. Callisto is synchronized with a GPS time signal receiver; the frequency of the synchronization signal is 1 MHz. The calibration data in the entire frequency range for analyzing the electromagnetic situation were obtained at Badary on January 22, 2007, and in Bleien (50 km south from Zurich) on January 25, 2007. These data are readings recorded with a matched 50-Ohm load at the preamplifier frontend and with a connected antenna in the absence of a signal from the Sun. Using these data, we selected the noiseless frequency channels. Callisto makes it possible to look through the channels in accordance with the preset list; in other words, the step between the channels may be unequal. Manmade noise, caused by the operation of digital circuits, has the line spectrum. The capability to survey channels from the list instead of a fixed interval allows us to avoid such noise.

5. RESULTS

The spectra measured in the entire reception band (see Figs. 2–9) were divided into seven sub-bands in order to better comment the results of an analysis. The

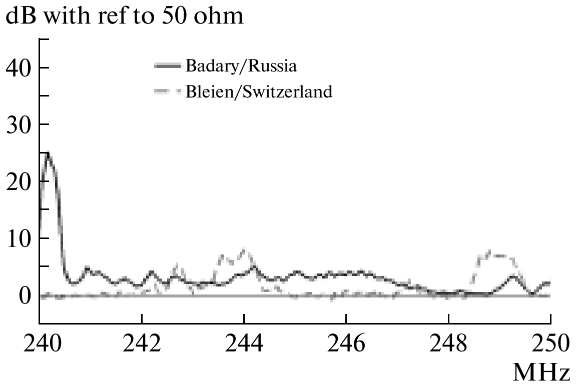

Fig. 5. At 240 MHz the noise level at Badary is 20 dB higher than at Bleien due to crosstalk with the equipment and preamplifier.

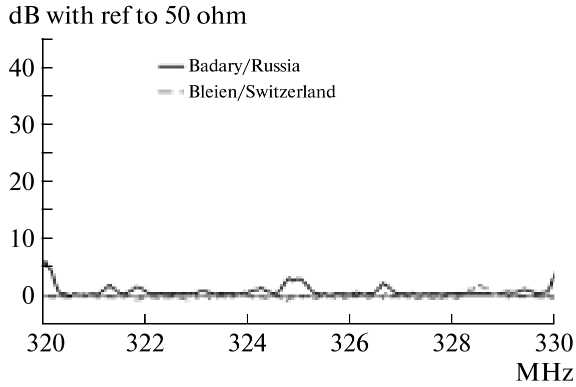

Fig. 6. A quiet range. The band 322–328.6 MHz is used to observe the deuterium line.

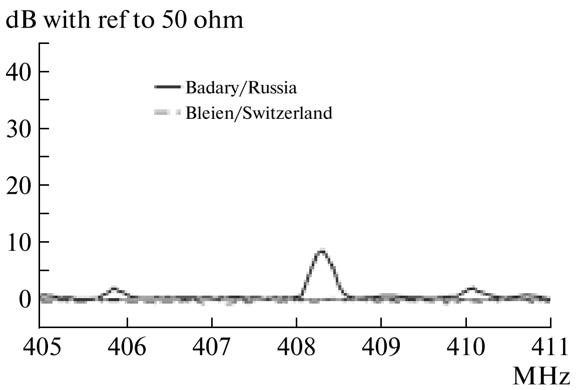

Fig. 7. Noise at 408 MHz at Badary. The band 406–410 MHz is free for observations.

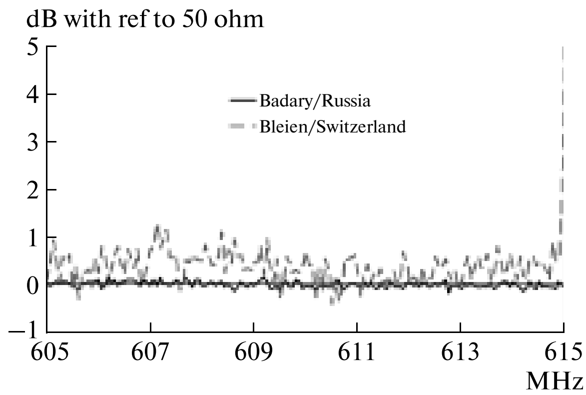

Fig. 8. A relatively low noise level at Badary and Bleien. The band 608–614 MHz is free for observations.

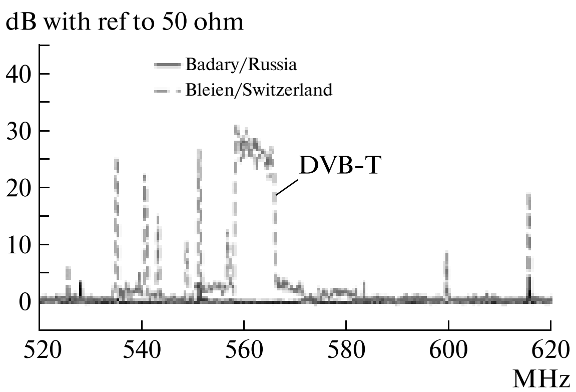

Fig. 9. In Switzerland the band 550–575 MHz is occupied by digital television. At Badary, this band is free.

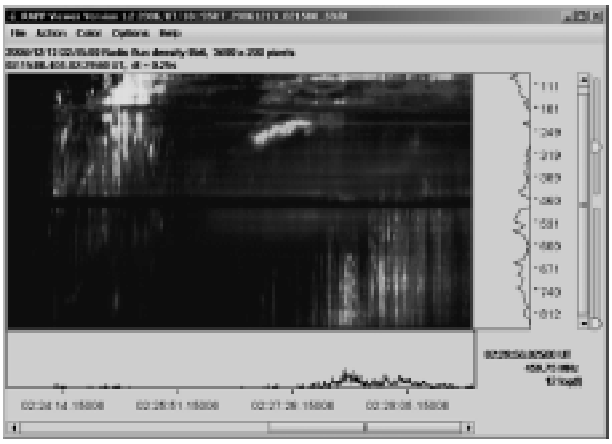

Fig. 10. The flare of December 13, 2006, in the active region NOAA 4600, recorded by the Callisto spectrometer at Badary.

comments are given in the figure captions. In Fig. 2 the complete spectrum includes 13 200 channels with a step of 62.5 kHz. In all figures shown below, the 0-dB level corresponds to the level of noise produced by the matched 50-Ohm load at an ambient temperature of 20°C. In the Russian version, a preamplifier (20 dB) is used; in Switzerland a preamplifier cannot be used because of nearby powerful transmitters that saturate Callisto.

6. CALLISTO OBSERVATIONS OF A POWERFUL FLARE

During the installation and testing of Callisto, the Sun was very active. At that time, Callisto recorded a pair of flares. The most powerful flare was observed in the active region NOAA 7740 (X-ray importance X3.4) between 0214 and 0230 UT on December 13, 2006 (Fig. 10). By that time, strong noise had been eliminated from the reception band. The possibility of such elimination is the main advantage of the tunable Callisto spectrometer.

7. CONCLUSIONS

Badary is an ideal site for a broadband solar spectrometer because of the absence of broadband noise such as digital television. All frequencies, reserved for radio astronomy tasks, are still free of noise. Strong noise is mostly caused by the radiation of the SSRT equipment. We recommend screening all components of the local oscillators and intermediate-frequency paths in order to prevent from leaking of their radiation into the Callisto antenna. To reduce noise, we also strongly recommend moving the log-periodic Callisto antenna as far as possible from the SSRT control building.

ACKNOWLEDGMENTS

We are grateful to Hansueli Meyer for preparing the software for the Callisto RISC processor and to Christina Pöpper for creating Perl scenarios that automated the data exchange between Badary and the Institute of Astronomy. Kh. A. Monstein is especially grateful to Professor Hans J. Haubold (UN Office for Outer Space Affairs) for useful pieces of advice and the help in settling problems with the Russian customs.

REFRENCES

O. Benz Arnold, C. Monstein, and H. Meyer, *Callisto, a New Concept for Solar Radio Spectrometers* (Kluwer Academic Publishers, 2004).

G. Ia. Smolkov, A. A. Pistolkors, T. A. Treskov, et al., Astrophys. Space Sci. **119** (1), 1 (1986).

V. V. Grechnev, S. V. Lesovoi, G. Ya. Smolkov, et al., Solar Phys. **261** (1-2), 239 (2003).