Observations of the Solar Radio Emission with the Callisto Spectrometer

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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.

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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 located.

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>51.8° N</td>
</tr>
<tr>
<td>Longitude</td>
<td>103.2° E</td>
</tr>
<tr>
<td>Altitude above sea level</td>
<td>800 m</td>
</tr>
<tr>
<td>Local time</td>
<td>GMT + 8 h</td>
</tr>
</tbody>
</table>
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 front end 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