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Radio spectrum measurements at the Gauribidanur observatory

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Abstract. During a campaign in December 2006, radio spectrum measurements over the frequency range 45-870 MHz were carried out at the Gauribidanur observatory, located about 100 km north of Bangalore. The spectrometer used for the above purpose was subsequently configured for radio spectral observations of the solar corona. This paper describes, (i) radio frequency interference over some of the frequency bands 'protected' for radio astronomy; and (ii) 'first' solar radio burst observation and the above instrument.

Keywords : Sun : corona, solar flares – radio observations – radio frequency interference (RFI)

1. Introduction

It is planned to carry out co-ordinated radio spectral observations of the solar corona from various locations around the world during the International Heliophysical Year 2007 (IHY 2007) and beyond, with near-identical backend receiver systems (http://ihy2007.org). In view of this, a measurement campaign was planned and organized between Indian Institute of Astrophysics (IIA), Bangalore and ETH, Zürich. The observations were carried out at the Gauribidanur observatory (Lat: $13°36'12''$ N and Long: $77°27'07''$ E), in the aftermath of the 2nd UN/NASA workshop on International Heliophysical Year and Basic Space Sciences, held at IIA Bangalore during 27 November - 1 December, 2006 (http:/www.iiap.res.in/ihy). The observatory is functional since 1976 and has different facilities for observations of Sun and other cosmic radio sources (Sastry 1995; http://www.iiap.res.in/centres_radio.htm).

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2. Measurement setup

A log periodic dipole (LPD) antenna with gain $\sim$ 8 dB and VSWR < 2 in the frequency range 30–1100 MHz was used as the receiving element (Figs 1 and 2). Its characteristic impedance is 50 Ω. After amplification of $\sim$ 45 dB by a wideband amplifier (kept near the antenna base), the RF signal was transmitted to the receiver building via a coaxial cable (buried $\sim$ 1 m below the ground level) of length $\sim$ 100 m. The attenuation in the cable is $\sim$ 1 dB at 40 MHz & 8 dB at 1000 MHz. The CALLISTO[1] spectrometer (e-C03 model) provided by ETH, Zürich was used as the backend receiver (www.astro.phys.ethz.ch/instrument/callisto/ecallisto/applidocs.htm; Benz, Monstein & Meyer 2005). It has a detector sensitivity of 25mV/dB and the output from the aforementioned amplifier was directly fed to it. The channel resolution of the spectrometer is 62.5 kHz and the radiometric bandwidth is $\approx$ 300 kHz. The sampling time is 1.25 ms per frequency-pixel and the integration time is $\approx$ 1 ms. The frequency information (in MHz) and the detector output (in mV) are stored as an ASCII file in a PC through RS-232 interface. Figs 3-8 show a spectral overview of a few 'protected' radio astronomy frequency bands [post World Administrative Radio Conference (WARC) in 1979] in Gauribidanur and Switzerland. These include primary, secondary and shared allocations. 0 dB is referenced to the background noise level given by a 50 Ω termination resistor at ambient temperature of about 20°C, in all the above figures.

3. Solar observations

The CALLISTO-Gauribidanur spectrometer was commissioned on 7 December 2006 and regular observations are being carried out since then. The daily observing period is 02:30-11:30 UT. Fig. 9 shows the dynamic spectrum of the 'first' transient solar radio emission observed with the above instrument on 10 December 2006. The event was associated with the B7.0/SF class X-ray/Hα flare from the active region NOAA 10930 (S06 E13), observed on that day (http://sgd.ngdc.noaa.gov/sgd/jsp/solarindex.jsp). Figure 10 shows the 'snapshot' radioheliogram obtained with the Gauribidanur radioheliograph (GRH, Ramesh 1998; Ramesh et al. 1998, 1999, 2006) during the aforementioned flare. The integration time used was 256 ms. Fig. 11 shows the variation in the flux density from the 'global' corona around the flare period. The measured peak flux was $\approx$ 6.2 sfu (sfu = solar flux unit = 10^{-22} W/m^2/Hz). The estimated 'apparent' brightness temperature (T_b) is $\approx 2.54 \times 10^7$ K. Note that we have used the term 'apparent' here since the actual source size is not known.

[1]Compound Astronomical Low frequency Low cost Instrument for Spectroscopy and Transportable Observatory

Figure 1. The LPD antenna used for the CALLISTO radio spectrometer at Gauribidanur observatory. The box in the foreground houses the amplifier mentioned in the text.

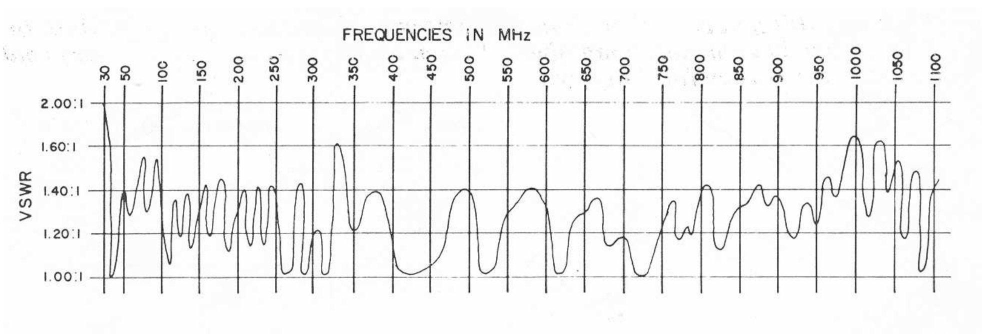

Figure 2. VSWR of the LPD antenna in Fig. 1.

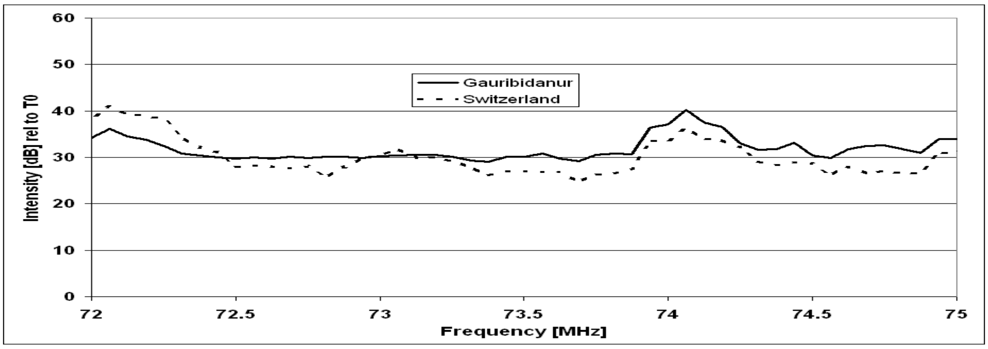

Figure 3. A comparison of the RFI situation in Gauribidanur and Switzerland in the frequency range 72-75 MHz. The band 73.0-74.6 MHz is shared by radio astronomers and fixed/mobile radio-communication users.

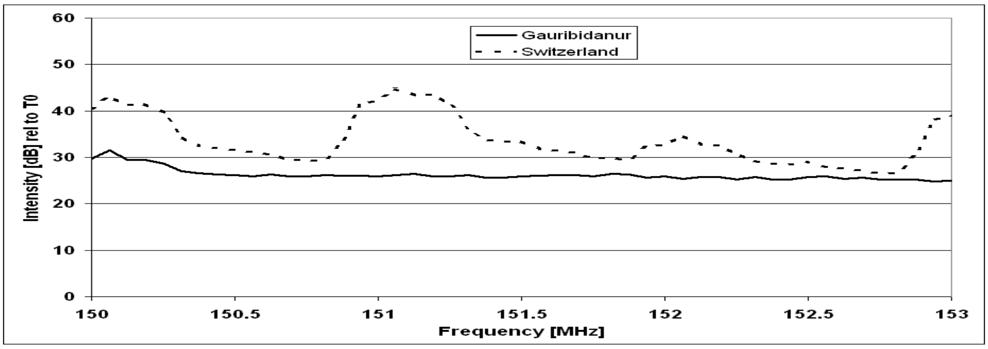

Figure 4. Same as Fig. 3, but over the band 150-153 MHz. Frequencies from 150.05 till 153.00 MHz are primarily allotted for radio astronomy observations.

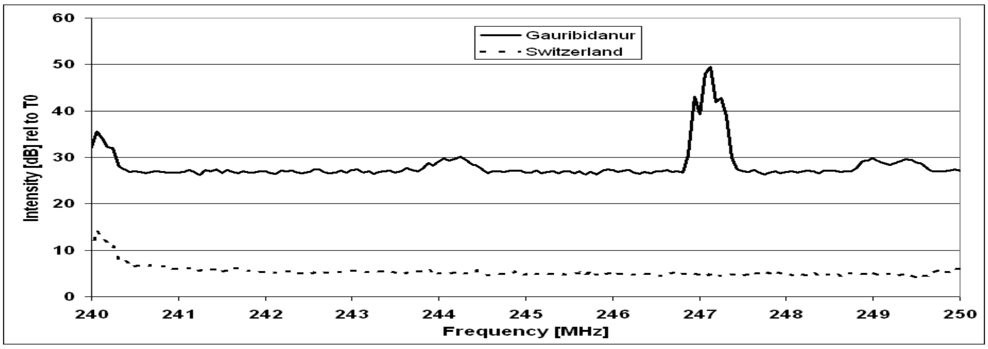

Figure 5. Same as Figs 3 & 4, but over the band 240-250 MHz. The large hump near 247 MHz in the Gauribidanur spectra is due to GRH local oscillator signal.

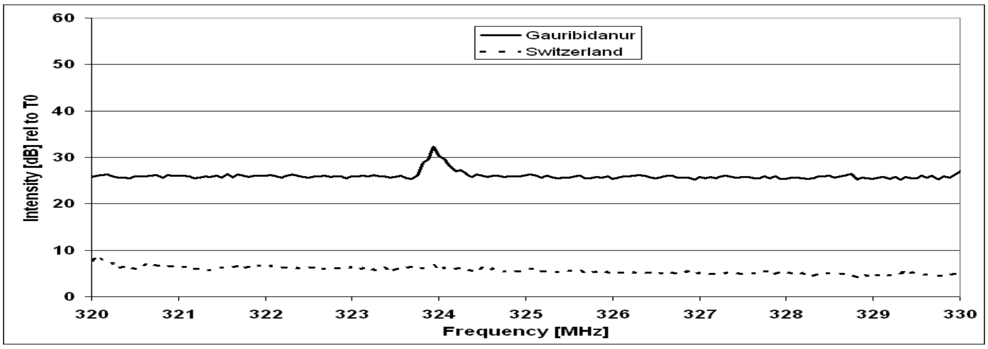

Figure 6. Same as Figs 3-5 but over the band 320-330 MHz. The spectral range 322.0-328.6 MHz is a primary radio astronomy band for Deutrium spectral line observations. The hump near 324 MHz is due to local interference at the Gauribidanur observatory.

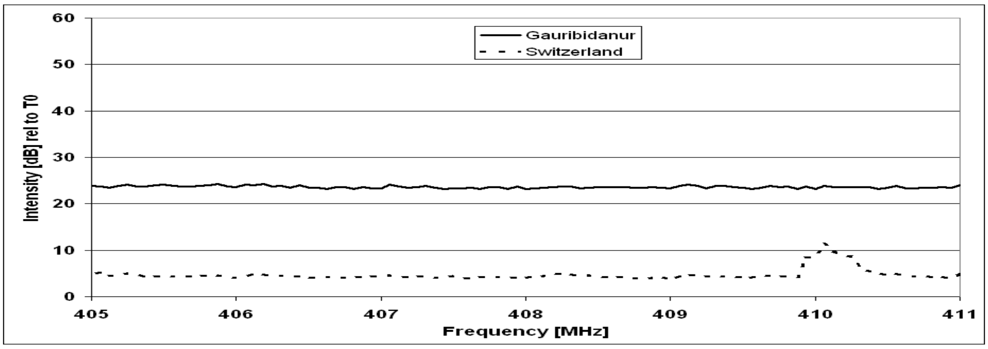

Figure 7. Same as Figs 3-6 but in the frequency range 405-411 MHz. The band 406.1-410.0 MHz is shared by radio astronomers with other authorized users.

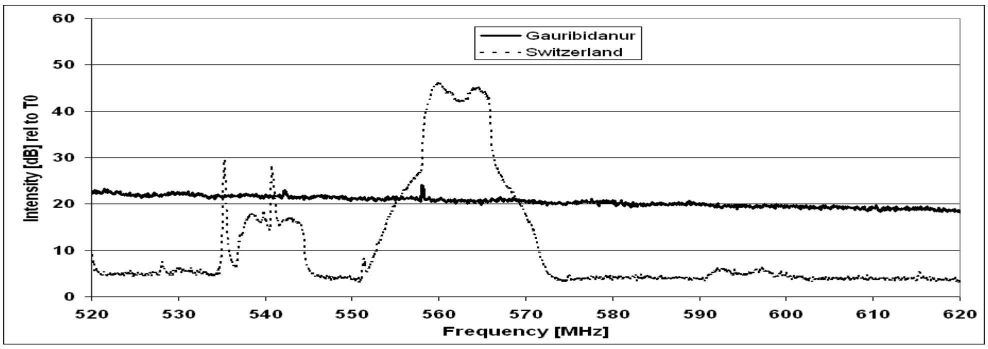

Figure 8. Same as Figs 3-7, but over the band 520-620 MHz. The broad regions of interference in the Switzerland spectra are due to digital TV transmission. The range 608-614 MHz is shared with broadcast services as mentioned above.

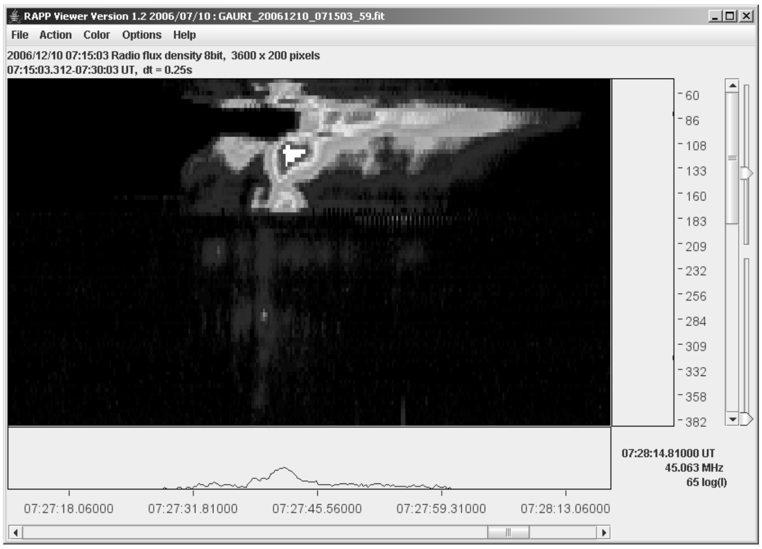

Figure 9. CALLISTO-Gauribidanur dynamic spectrum of the radio burst associated with the B7.0/SF class X-ray/Hα flare of 10 December 2006 from active region NOAA 10930 (S06 E13).

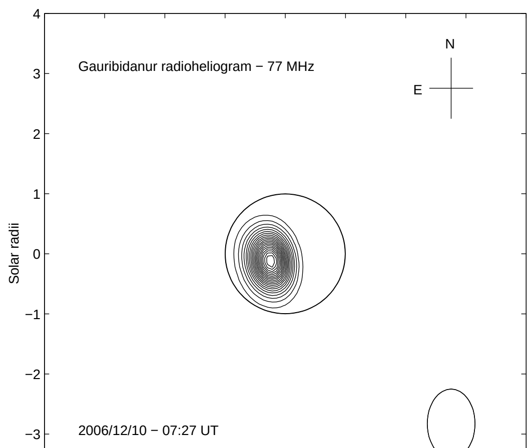

Figure 10. 'Snapshot' radioheliogram obtained with the GRH during the transient burst emission in figure 9. The integration time used was 256 ms. The estimated 'apparent' peak T_b is $\approx 2.54 \times 10^7$ K and the contour interval is 1×10^6 K. The open circle at the centre represents the solar limb. The ellipse at the bottom right corner indicates the GRH 'beem' at 77 MHz.

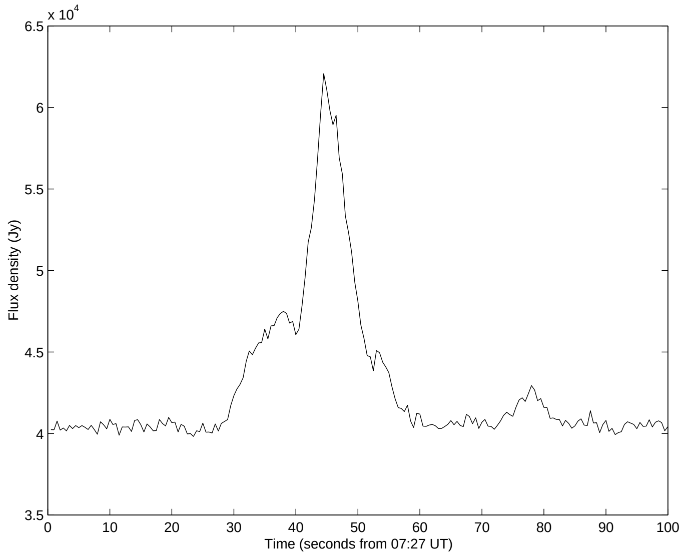

Figure 11. GRH observations of variation in the 'global' flux from the solar corona at 77 MHz, around the flare period mentioned in the text. The peak value is ≈ 6.2 sfu. The integration time used was 256 ms.

4. Conclusions

The CALLISTO spectrometer for observing radio burst emission from the solar corona during IHY 2007 and beyond, is in regular operation at the Gauribidanur observatory. This instrument, along with other CALLISTO's at different longitudes around the world (http://www.astro.phys.ethz.ch/instrument/callisto/RFSPEC2/) is expected to provide round-the-clock coverage of the Sun. A comparison of the RFI between Gauribidanur and Switzerland indicates that the former is comparitively a radio 'quiet' zone. The added advantage with the CALLISTO-Gauribidanur setup is that the location of the radio burst in the solar atmosphere can also be established, from the two-dimensional radioheliograms obtained with the GRH.

5. Acknowledgements

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