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Solar radio bursts near the low frequency limit of ground based observations

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Abstract. The low frequency observations of the transient radio emission from the Sun are limited to frequencies $\gtrsim$ 30 MHz in a majority of the ground-based solar radio observing stations. Similar observations from the space-borne instruments are limited to frequencies $\lesssim$ 14 MHz. This paper describes an attempt to extend the low frequency cut-off in the solar observations from the Gauribidanur radio observatory ($\approx$ 77° E; 14° N) near Bangalore[1] down to $\approx$ 15 MHz Ramesh et al. (1998); Ebenezer et al. (2007); Ramesh et al. (2008); Ramesh (2011), and thereby minimize the prevailing gap with observations from the space platforms.

1. Antenna design and measurement set-up

A conical log-spiral (CLS) antenna Dyson (1965) was designed and fabricated in-house for the present work. The antenna has VSWR $\lesssim$ 2 in the frequency range $\approx$ 10 – 85 MHz. Its characteristic impedance is $Z_{oa} \approx 100\ \Omega$. The antenna was mounted vertically pointing towards the local zenith. The output is connected to a RF cable through a 2:1 balun transformer. The latter is used to minimize the impedance mismatch that arises when connecting the 'unbalanced' RF cable ($Z_{oc} \approx 50\ \Omega$) to the 'balanced' antenna Kraus (1988). Table 1 gives the parameters of the CLS antenna. The RF signal from the antenna followed by the balun flows through a high pass filter ($f_h \approx$ 15 MHz) to minimize the radio frequency interference (RFI) over the corresponding frequencies. The filtered signal is then amplified $\approx$ 30 dB and transmitted to the receiver room via coaxial cables buried $\approx$ 1m below the ground. In the receiver room, the RF signal is connected to a commercial spectrum analyzer. The latter is interfaced to a computer using standard GPIB interface Ebenezer et al. (2007). The sweep time of the spectrum analyzer is $\approx$ 250 ms, and 401 data points are obtained with a frequency resolution of $\approx$ 200 kHz over the aforementioned frequency range.

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[1] http://www.iiap.res.in/centers/radio

Table 1. CLS antenna parameters.

Frequency range	≈ 10-85 MHz
Half-cone angle (θ_0)	≈ 15°
Base diameter (D)	≈ 5 m
Truncated diameter (d)	≈ 2.8 m
Height of the frustum (h)	≈ 4.1 m
Slant height of the frustum (l)	≈ 4.25 m
Pitch angle of the spiral (α)	≈ 80°
Half-power beamwidth (E-plane & H-plane)	≈ 70°
Effective collecting area (A_e)	$\approx 0.7\lambda^2$
Gain	≈ 9 dB

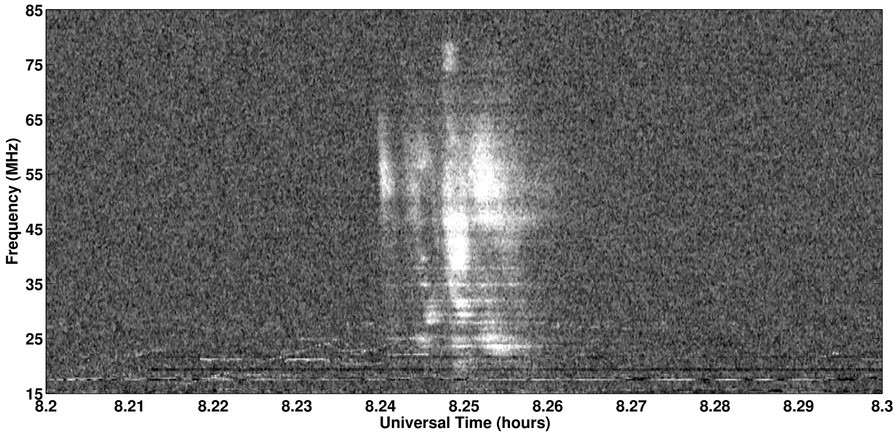

Figure 1. Dynamic spectrum of the solar radio burst observed with the CLS antenna on 05 February 2013.

2. Observations and Summary

Figure 1 shows the dynamic spectrum of a fast drift solar radio burst observed withe CLS antenna on 05 February 2013, down to $\lesssim$ 19 MHz. The burst was associated with a SF/C6.3 class Hα/soft X-ray flare during the period ≈ 08:12-08:22 UT from the active region NOAA 11669 located at N09 E63 on the Sun that day[2]. Corresponding observations with the WIND-WAVES spectrograph from space at frequencies < 14 MHz indicate that the above burst extended till ≈ 30 kHz[3]. Figure 2 shows the time profiles of the burst at 30 MHz, 19 MHz (both observed from Gauribidanur) and 13

[2]www.swpc.noaa.gov

[3]http://www-lep.gsfc.nasa.gov/waves

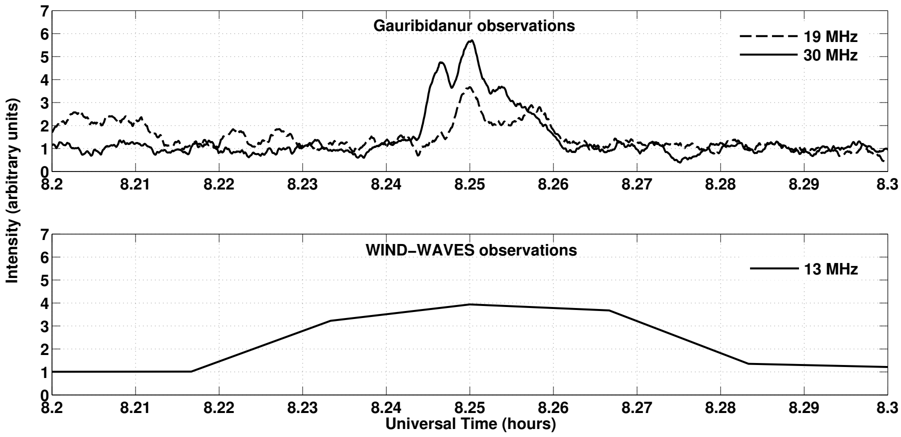

Figure 2. Time profiles of the solar radio burst of 05 February 2013 at different frequencies. The time resolution is ≈ 1 s and ≈ 1 m for the observations in the upper and lower panels, respectively.

MHz (observed from space). The fine structures noticeable in the burst at 30 MHz seem to gradually disappear towards the lower frequencies. Solar radio emission at different frequencies originate at different radial distances in the solar atmosphere. So the presence/absence of the fine structures mentioned above are most likely related to the nature of the coronal structures present at the corresponding layers in the solar atmosphere. An understanding of these adjacent different layers in the solar corona in a near-continuous manner is one of the main reasons why the prevailing frequency gap between the solar radio burst observations with ground-based instruments and those on space platforms should be reduced. Presently we are working on a FPGA-based digital receiver system for data acquisition with multi-bit resolution. This is expected to improve the sensitivity, temporal and spectral resolutions.

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