1998BASI...26..297A

Bull. Astr. Soc. India (1998) **26**, 297-299

Solar physics using the Giant Metrewave Radio Telescope

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1. Introduction

GMRT which consists of 30 fully steerable parabolic dish antennas of 45 metre diameter each (Swarup et al. 1991), is nearing completion, about 80 kms north of Pune. Sixteen of the thirty antennas have become nominally operational; the remaining ones are expected to be completed by early 1997. GMRT will operate in the 50-1500 MHz frequency range and will provide the largest collecting area among all radio telescopes in the world in this range. Further, depending on the choice of its six operating frequencies at 50,150,235,327,610 and 1000-1420 MHz, it will have high angular resolutions ranging from several arcminutes to a few arcseconds and integration times as small as 40 ms to several seconds, thus providing excellent competitiveness and complimentarity to the large radio telescopes like VLA and Arecibo in the radio regime and to the satellite borne X-ray instruments like Yohkoh, Ulysses and SOHO. It will also compliment the Gauribidanur radio heliograph.

In the case of solar radio observations, for different observing frequencies, various heights in the solar corona get sampled and hence one can reconstruct the three dimensional structure of the coronal layers and their evolutionary activity. All activity on the Sun arise from complex magnetic fields which often leads to violent releases of energy in the form of flares, prominences and mass ejections from the corona (CME's). The activity also leads to radio emission either because of the resultant plasma oscillation, gyroresonance or thermal brehmsstrahlung. The radio output from the Sun is highly variable, being 'Quiet' to a very disturbed Sun, producing massive flares, bursts etc., besides, there is also the slowly varying component (SVC) due to thermal noise or non thermal noise storm continua. High resolution intensity maps of solar active regions at decimetre and metre wavelengths can supply information on coronal temperature and density and together with circular polarization maps are the best way to infer solar magnetic fields.

Multiwavelength observations show that impulsive hard X-rays, microwave and type III burst all arise from a common source of electron acceleration; but in order to better understand the relation between microwave bursts and meter-decameter activity, a good imaging instrument, like GMRT, with high enough resolution is required in these spectral ranges (Kundu 1996). The microwave data indicates magnetic field activity, while the longer wavelength data gives information

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1998BASI...26..297A

on injection and acceleration mechanisms (Kucera et al. 1993; Trottet et al. 1994). Kundu & Lang (1985) have shown how emissions at 2,6 and 20 cms originate at different heights within coronal loops that join sunspots of opposite magnetic polarity. They show that the emission comes from hot dense plasma that is trapped within the loops that connect the underlying sunspots.

Another fascinating aspect on the Sun is the generation and evolution of coronal holes (CH) that are large scale open field regions of low density and reduced temperature. CH at low radio frequencies show puzzling features (Sheridan & Dulk, 1980). Unlike at X-ray wavelength, where there is almost no detection in the CH region, the holes at 160 MHz show only a 20-25 reduction in brightness; but more interestingly, at 80MHz, the holes have enhanced brightness by about 30 also find that the radio, HeI 10830 contours and X-rays contours do not show enough agreement. While it is clear that Bipolar Magnetic Field regions control the birth and evolution of CH, more detailed studies are required.

Two other major areas of interest are the SVC's and CME's. Alissandrakis and Lantos (1996) show that radio emission due to SVC's at low frequencies (150 MHz) are more associated with neutral lines of photospheric magnetic field than H-alpha filaments. However, better resolutions are needed in the radio images, as will be provided by GMRT. CME's are large magnetic bubbles or structures that have been ejected from the Sun into the corona and the inter-planetary medium. Radio astronomical observations are being made from Ooty, Nagoya and Cambridge to find the connection between CME's, flares and the interplanetary shock structures (Manoharan 1998; Balasubramanian et al. 1998).

In summary, multiwavelength observations of Sun are providing fascinating details of energetic activity on the Sun. The areas that deserve high spatial and temporal resolution and wide frequency coverage are many, as briefly outlined above. Although GMRT is being built as a high sensitivity, high resolution instrument, mainly for galactic and extragalactic astronomy, it is also ideally suited for radio imaging of Sun at long wavelengths. Hence, one should be able to probe the solar corona and transition layers with unprecedented detail using GMRT.

Acknowledgement

GMRT is being built by NCRA-TIFR, under the guidance of Prof.G.Swarup. I thank him and all my colleagues who are involved in this arduous task.

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1998BASI...26..297A

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