STUDIES IN SOLAR-TERRESTRIAL PHYSICS

BY
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C E R T I F I C A T E

I hereby declare that the work presented in this thesis is original and has not formed the basis for the award of any degree or diploma by any University or Institution.

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STATEMENT

A study of solar radio emissions during quiet and disturbed periods is important in understanding physical processes in the solar atmosphere and solar-terrestrial relationships. Three distinct components of solar radio emissions are well recognized which originate due to thermal and/or nonthermal processes. These are: (a) the quiet sun component, (b) the slowly varying component, and (c) the transient burst phenomena.

The most common feature of solar radio emission is a noise storm which occurs at coronal heights above the active centers and may last for a few hours to a few days. Metric and decametric noise storms consist of smooth background radio emission, with superimposed narrow band bursts; type I in the metric wavelengths, and type IIIb and type III at decametric wavelengths.

Systematic high resolution (in frequency and time) studies of solar radio noise storms at decametric wavelengths were planned at the Physical Research Laboratory in 1973 after the polarization measurements of short duration solar bursts were carried out on two closely spaced frequencies (4 kHz apart) near 35 MHz which showed fine structure in intensity and polarization. This led to the development of a High Resolution Spectroscope operating near 35 MHz, capable of revealing detailed fine frequency ($\sim$ 5 kHz) and time ($\sim$ 10 msec) structure of solar bursts.

With the help of this High Resolution Spectroscope, four new types of microscopic spectral features have been discovered viz., (a) "complementary bursts", (b) bursts showing curvature along the frequency axis, (c) chains of "dots", and (d) microscopic families of "U" bursts.

Spectral features of bursts (a) and (b) above are explained in terms of propagational effects such as trapping of electromagnetic radiation in duct-like cavities in the corona and/or group delays respectively. Spectral features of bursts (c) and (d) above are explained in terms of induced scattering of Langmuir waves to transverse waves by thermal ions. The linear dimensions of the source sizes for chains of "dots" and microscopic "U" bursts are estimated to be 10^3 to 10^4 Km respectively with an excess electron density over the ambient of 2 to 3 per cent, for an assumed exciter velocity of 0.3 c, where c is the velocity of light. Observed striations in microscopic families of "U" burst suggest the fine structure in the irregularities $\sim 10^3$ Km. Excess electron densities in these irregularities are of the order of 1-2 per cent. However, irregularities with excess fine frequency ($\sim$ 5 kHz) and time ($\sim$ 10 msec) structure of solar bursts.

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In order to investigate whether observed fine structure in decametric burst is originated at the source or is due to propagational effects, studies of dependence of spectral features on heliographic longitudes have been carried out and results are presented here. In order to investigate the relationship of associated type IIIb-type III burst, properties of these bursts are studied and discussed with reference to available theories.

A new varient of echo-type bursts **which** we have named as "Echo-like" events is reported. These echo-like bursts are characterized by two components. The observed time delays between the two components are from 0.6 to 6 sec. The central frequency of the second component can be shifted by as much as $\pm$ 300 kHz. By assuming independent exciters for the generation of "echo-like" bursts, it is possible to estimate the speed of irregularities in the corona around 2 $R_{\odot}$.

Studies of microstructures observed in the decameter noise storm bursts enables us to estimate the size, excess electron densities and the speed of the irregularities near 2 $R_{\odot}$. Thus, it is concluded that the high resolution spectroscopy provides a powerful tool to study the irregularities around 2 $R_{\odot}$ from the photosphere, which is not possible by other techniques such as IPS.

CONTENTS OF THE THESIS

The thesis contains five chapters as follows:

Chapter I reviews the solar noise storm phenomenon in metric and decametric wavelength ranges. Emphasis is given to the High Resolution Spectroscopic Observations in the decametric region, because of their relevance to the subject matter of the present thesis.

Chapter II contains description of the High Resolution Spectroscope at 35 MHz and discussion on performance of the system.

Chapter III deals with the observations of new spectral features which could be detected only because of high frequency and time-resolution attained in this spectroscope. As mentioned earlier, these new spectral features include "complementary bursts", chains of "dots", microscopic families of "U" and bursts showing curvature in the frequency axis. The bandwidth of "dot" emission provides an experimental evidence for the process, of conversion of Langmuir waves to transverse waves in the solar corona, by the induced scattering mechanism. Simultaneous occurrence of a microscopic

"U" burst and a chain of stria bursts, a rare combination, has been recorded. From this observation the length of an exciter (electron beam) has been estimated.

Chapter IV includes experimental data on solar decametric storms and bursts recorded between February 1974 and April 1976. Longitudinal dependence of duration of stria burst in type IIIb and polarization have been investigated in the case of two storms. Experimental evidence of change of degree of polarization observed in echo bursts is presented which confirms the prediction of Russian workers.

Chapter V deals with the implications of the results obtained leading to a possible model of decametric bursts and their relevance for the study of coronal irregularities.

In addition to this, since 1974 the author had an over-all responsibility for day-to-day observation and coordination of the radio astronomy experiments at the Campus of Space Applications Centre of ISRO, Ahmedabad.

Some work of the author which is not included in the thesis can be found in the following references:

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H I G H   R E S O L U T I O N   S T U D I E S
O F   S O L A R   D E C A M E T R I C
N O I S E   S T O R M S

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C O N T E N T S