STUDIES IN RADIO ASTRONOMY

Thesis presented

by

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to the

Gujarat University
for the Ph.D. Degree

DECEMBER 1973

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S T A T E M E N T

The occurrence of spectral type III bursts (fast drift bursts) was first recognized by Wild (1950) from the frequency-time behaviour of the dynamic spectra at meter wavelengths. They are characterized by their short duration and a rapid drift from high ($\simeq$ 600 MHz) to low ($\simeq$20 KHz) frequencies. It is generally accepted that these bursts are excited by fast streams of particles ejected into the solar corona.

Type III bursts were initially found to be unpolarized (Payne-Scott and Little 1952). Subsequent work showed that type III bursts are partially elliptically polarized. The measurements of polarization characteristics of type III solar radio bursts at meter and decameter wavelengths are important in the understanding of the coronal magnetic fields associated with the generating mechanism and also for the study of the intervening magneto-ionic medium.

An experiment to study the polarization characterstics of solar radio bursts of spectral type III at decameter wavelengths has been conducted by the author at the Physical Research Laboratory, Ahmedabad. The apparatus consists of a time-sharing radio polarimeter which measures the four Stokes parameters that completely define the state of polarization of the incoming radiation.

The polarization observations, relating to type III radio bursts, taken during the period from 1969 to 1973 can be divided into three distinct parts. The first part of the work, reported in this thesis, deals with the measurements of polarization characteristics of type III burst radiation at 25 MHz with 20 KHz bandwidth. The second part refers to the polarization measurements made simultaneously at two closely-spaced frequencies, namely, 34.993 and 34.997 MHz. At both these frequencies, the bandwidth used was 800 Hz. The last part includes measurements of the polarization parameters of type III burst radiation at 35 MHz simultaneously in two bandwidths, namely, 7.5 and 12.5 KHz, in order to compute the total Faraday rotation suffered by the radiation in passing through the intervening magneto-ionic medium.

Theoretical considerations suggest that the total Faraday rotation suffered by the type III burst radiation at 35 MHz should at least be of the order of 10^5 radians after passing through the solar corona and the earth's ionosphere. If such a large value of Faraday rotation at 35 MHz can really turn out, then it would be impossible to explain the occurrence of linearly or highly elliptically polarized solar radio bursts in the presence of coronal scattering and finite source thickness. Thus it is important to make an experimental determination of the total amount of Faraday rotation suffered by the type III burst radiation.

Our observations indicate that the total Faraday rotation at 35 MHz is of the order of 10^3 radians which is two orders of magnitude less than the theoretical value. An attempt has been made by the author to find out if the magneto-ionic mode coupling can explain this discrepancy. It has been found that the mode coupling alone is not sufficient to explain the difference between the experimentally observed and the theoretical values of the Faraday rotation. An alternative explanation based on the idea that the type III radiation is generated at the second harmonic of the local plasma frequency, rather than the fundamental appears to resolve this difference. Our explanation is consistent with the theory of generation of type III solar radio bursts developed by the Russian workers.

It has been suggested in literature that a partially elliptically polarized radiation can be represented in terms of superposition of two fully polarized but mutually incoherent signals, one circularly polarized and the other linearly polarized signal. We made an attempt to test for the validity of this representation for type III burst emission and the results are incorporated in this thesis.

The data processing was carried out by the author on the IBM 1620 and 360-44 computers at the Physical Research Laboratory, Ahmedabad.

The thesis is divided into six chapters as follows:

In the first chapter we have reviewed our present state of knowledge of solar type III bursts. Since this thesis is mainly related to the polarization characteristics of type III solar radio bursts, it may appear that the first chapter does not have direct relevance, to the main subject matter of the thesis. Still, we felt that a review of the current knowledge about type III solar radio bursts may serve as a useful introduction to the type III burst radiation in general.

The second chapter contains a brief review of the present knowledge of the polarization characteristics of type III solar radio bursts. The effect of the Faraday rotation on polarization measurements and its significance in relation to the source region and the intervening magneto-ionic medium are discussed.

The third chapter gives the experimental details of a two-bandwidth (7.5 and 12.5 KHz) time-sharing radio polarimeter at 35 MHz. Various electronic circuits are discussed in detail. The operational procedure and the effects of ground reflections on the measurement of the Stokes parameters are also dealt with.

The fourth chapter gives the single bandwidth polarization measurements at 25 and 35 MHz. For the sake of comparison, the polarization data obtained at the National Research Council, Canada at 74 MHz in 1963 are also incorporated. The main results reported here are the comparison of various polarization parameters obtained at 25 and 35 MHz with that obtained at other frequencies by different workers. A type III event which occurred on July 14, 1969 has been discussed in detail. Also included in this chapter is the comparison of polarization parameters obtained at two closely spaced frequencies, namely, 34.993 and 34.997 MHz.

The measurements of the Faraday rotation suffered by type III burst radiation at 35 MHz have been described in the fifth chapter. The interpretation of the results of the Faraday rotation is also included in this chapter. Finally, the problems, of the occurrence of linearly polarized type III bursts in terms of two mutually incoherent signals (100 per cent circularly and linearly polarized radiation) are also discussed.

The sixth chapter summarizes the conclusions drawn from the present investigation, and some suggestions for future work.

In this thesis we have presented new results on the Faraday rotation measurements of type III burst radiation and the polarization parameters at two closely-spaced frequencies. This has proved quite useful for understanding the nature of the source of type III bursts and the propagation characteristics of the intervening magneto-ionic medium. This work has also been accepted for publication (Bhonsle and Mattoo, 1973).

In addition, the author has also worked on radio star scintillations during his tenure as a Ph. D. student. We have not included this work in this thesis. This work is published and can be found in the following references:

1. Bhonsle, R.V., Alurkar, S.K., Narayanan, K., and Mattoo, S.K. 1970, J. Tel. Comm. Engrs., 17, 217.

2. Mattoo, S.K., and Bhonsle, R.V. 1971, Indian Journal of Pure and Applied Physics, 9, 601.

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S.K. Mattoo — (S.K. MATTOO)

POLARIZATION STUDIES OF TYPE III SOLAR
RADIO BURSTS AT DECAMETRIC WAVELENGTHS

D E D I C A T I O N

TO MY UNCLE
PANDIT NIRANJAN NATH MATTU

ACKNOWLEDGEMENTS

It would be impossible to acknowledge adequately all the persons who have helped me directly or indirectly during my tenure as a Ph. D. student. Nevertheless, certain persons have given generously their time and efforts and deserve at least my explicit thanks.

First of all the author thanks his thesis adviser, Professor R.V. Bhonsle, who at various stages of the work presented here kindly offered constructive guidance. Countless discussions with him were invaluable. I also had the benefit of stimulating and close interaction which he has given me in the preparation of this thesis.

I express my sincere thanks to Prof. D. Lal and Prof. K.R. Ramanathan for their keen interest in the solar radio astronomy programme at Physical Research Laboratory, Ahmedabad.

For the operation and construction of the radio polarimeter, the work of Sohanlal is gratefully acknowledged. Without his help and cooperation much of the work presented here could not have been done. K. Narayanan provided a useful technical expertise at the initial stage of the instrumentation and R. Sharma designed and fabricated the antenna systems used. The author acknowledges his debt for their efforts, advice and comments. For the maintenance of the radio polarimeter, the efforts of M.V. Dalal are highly appreciated.

I have the pleasant duty of recording my indebtedness to Dr. S.K. Alurkar, who has read the whole of the manuscript with the greatest care and removed many blemishes which might have escaped less vigilant eyes. Discussions with him were useful.

My thanks are due to A.H. Desai who was always available to render me assistance. He helped me in the reduction of the data. I am also appreciative of him as a decorator of my thesis.

The author wishes to express his special appreciation to V. Badarinadh, A.D. Bobra, N.S. Nirman, H.S. Sawant and P. Venat for their enthusiastic cooperation and careful voluntary work.

Dr. (Miss) Anna Mani of India Meteorological Department provided me with balloons for carrying out the antenna and ground reflection measurements. I express my gratitude to her.

I thank the personnel of the Computing center, Workshop and the Draughting and Photography section for their cooperation. Mr. K.S. Dholakia has put in his best to make photographs presentable. R.M. Panchal and J.A. Panchal have helped in hardware developments.

The financial support was received from the Ministry of Education and Department of Atomic Energy, Government of

India and for the last two years from Department of Space, Government of India.

I thank D. Stephen for his beautiful and speedy typing of several versions of this thesis from my illegible original manuscripts.

I have received praiseworthy help and moral support from D.K. Wali of Nuclear Fuel Complex, Hyderabad and R.K. Kaul and Iqbal Kaul of High Altitude Research Laboratory, Gulmarg. The author expresses his sincere thanks to all of them.

It is a pleasure to acknowledge that I undertook the Ph. D. course at the suggestion of Prof. H. Razdan of Nuclear Research Laboratory, Srinagar. He has watched the progress of the work presented here with keen interest. I am indebted to him for helpful advice he used to give whenever occasion demanded.

Whatever value this work may have, however, must be attributed in large part to my mother and sisters, who consistently encouraged and consoled in my efforts, and often turned despair into renewed hope.

S.K. Mattoo
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C O N T E N T S