A SYNTHESIS STUDY OF THE RADIO SKY AT DECAMETRE WAVELENGTHS

By

K.S. DWARAKANATH

A THESIS SUBMITTED FOR THE DEGREE OF Doctor of Philosophy

IN THE FACULTY OF SCIENCE

Department of Physics
INDIAN INSTITUTE OF SCIENCE
Bangalore-560 012
SEPTEMBER 1980
DECLARATION

I hereby declare that the work presented in this thesis is entirely original, and has been carried out by me at the Raman Research Institute under the auspices of the Department of Physics, Indian Institute of Science. I further declare that this has not formed the basis for the award of any degree, diploma, membership, associateship or similar title of any University or Institution.

Department of Physics
Indian Institute of Science
Bangalore 560012
INDIA

K.S. Dwarakanath
(K.S. DWARAKANATH)
12 Sep 1989
I would like to thank Prof. G. Srinivasan, my thesis adviser, for introducing me to the excitements in astronomy. He has been my friend, teacher and guide and I have learnt a lot by working with him. His keen interest in my work and his help in the preparation of this thesis are also gratefully acknowledged.

The work described in this thesis was done at the Raman Research Institute. I am grateful to Prof. V. Radhakrishnan for all his support and encouragement during the course of this work.

The low frequency project at Gauribidanur is a joint venture of the Indian Institute of Astrophysics and the Raman Research Institute. The project owes its origin to Prof. Ch.V. Sastry and I would like to thank him for giving me an opportunity to work in it.

I would like to thank Prof. C. Uberoi for her help and keen interest in my work.

During the course of this work I have had several discussions with V. Radhakrishnan and Rajaram Nityananda on many wide ranging issues related to the work. I have learnt a great deal in these discussions. They have also taught me how to analyse a given problem in different ways. I convey my sincere thanks to them.

The antenna system used for the observations described in this thesis was built by the observatory staff at Gauribidanur. In particular, I would like to thank H.A. Ashwathappa, M.O. Modgekar, C. Nanje Gowda and G.N. Rajasekhar for their contributions.

The receiver system used for these observations was built by D.K. Ravindra and N. Udayashankar. Further help and co-operation
in setting up the receiver and the antenna system for observations was provided by G. Jayakumar and T.S. Ravishankar. I have immensely enjoyed working in their company. In addition, much of the help required in the maintenance of the array and in the observations was provided by H.A. Ashwathappa, C. Nanje Gowda, and G.N. Rajasekhar. My sincere thanks are due to all of them.

Countless hours of discussions with A.A. Deshpande, R.K. Shevgaonkar and N. Udayashankar have clarified many issues related to the telescope and to the methods of observation and data analysis. I am very grateful to them for giving so much of their time for solving many problems related to this thesis.

The thesis work involved a large amount of data handling and computing time. My sincere thanks are due to Jayanthi Ramachandran, P.A. Johnson, S. Krishna, R. Nandakumar and B.V. Nataraj of the computer section for accommodating my special requirements. A special word of thanks to P.A. Johnson for his quick and willing help both at the field station in Gauribidanur and in Bangalore.

I would like to thank Dipankar Bhattacharya for various discussions I have had with him and in particular regarding some of the issues discussed in Chapter 6 of this thesis. His help in producing the colour representations of the sky at 34.5 MHz is also gratefully acknowledged.

I am very grateful to K.R. Anantharamaiah, A.A. Deshpande, V. Radhakrishnan, Rajaram Nityananda, G. Srinivasan and N. Udayashankar for a critical reading of an earlier version of this thesis. Their suggestions have contributed greatly to the readability of the thesis.
My discussions with C.J. Salter were very helpful particularly regarding the 408 MHz all-sky survey. I would like to thank both him and C.G.T. Haslam for providing me the NOD2 software which has been used to represent the 34.5 MHz data in the form of contour maps.

The excellent library at the Raman Research Institute has been of great help and I would like to thank the library staff in general and A. Ratnakar in particular for this. I would like to thank Hanumappa for making copies of the thesis.

I would like to thank C. Ramachandra Rao for all the photographic work and Raju Verghese and P.S. Somasundaram for preparing the drawings.

I would like to thank Moksha Halesh for typing the thesis and Chitra Gokhale for her generous help in bringing the thesis to the final form.

During the course of this work I have enjoyed my stay in the Raman Research Institute Hostel. I would like to thank all my friends and colleagues who made this possible.
CONTENTS

SYNOPSIS

CHAPTER 1 INTRODUCTION

CHAPTER 2 THE GAURIBIDANUR RADIO TELESCOPE (GEETEE)

CHAPTER 3 THE OBSERVATIONS, DATA ANALYSIS AND CALIBRATION

CHAPTER 4 THE MAPS

CHAPTER 5 SOME WELL KNOWN SOURCES

CHAPTER 6 THE GALACTIC PLANE

BIBLIOGRAPHY

PUBLICATIONS
A SYNTHESIS STUDY OF THE RADIO SKY AT DECAMETRE WAVELENGTHS

K.S. DWARAKANATH

SYNOPSIS

This thesis describes an all-sky survey made at 34.5 MHz using the low frequency telescope situated at Gauribidanur, near Bangalore (latitude $13^\circ 36' 12''$ N).

The antenna system is made up of 1000 dipoles arranged in the shape of the letter $\mathbb{T}$ with a 1.4 km long East-West arm and 0.45 km long Southern arm. It has a collecting area of $\approx 18000$ m$^2$.

A 128 channel digital receiver system which was designed and built for the purpose of making an all-sky survey was used for the observations. Low frequency observations are rendered difficult due to the problems connected with the maintenance of large arrays, compounded by terrestrial interference, ionosphere and solar activity. In order to minimise these problems the telescope was used in the transit mode and by doing 1-D synthesis along North-South, the entire sky has been mapped in one day's time. This survey covers the Declination ranges of $-36^\circ$ to $+64^\circ$ and the complete 24 hours of Right Ascension. The synthesized beam has a resolution of $21''$ along the Right Ascension and $33''\times\text{Sec}(\delta - 14.1)$ along the Declination, $\delta$. The sensitivity of the survey is 4 Jy ($1\sigma$). Special care has been taken to ensure that the antenna responds to all angular scale structures and is suitable for studies of both point sources and extended objects.

The problems in deconvolving the large angular scale maps which also contain the background emission are discussed in detail. A modified method of the conventional CLEAN has been adopted to deconvolve the dirty maps which contain both the point
sources and the background. This method leaves the extended emission unaltered.

The results of the survey are presented in the form of contour maps. The representation that has been chosen makes it easy to compare with the already available all-sky survey at 408 MHz. A smoothed (to 2') map of the observed sky at 34.5 MHz is also presented, several large scale features in it are identified and their spectra between 34.5 MHz and 408 MHz have been estimated. Some new features previously unobserved at low frequencies have also been identified.

A comparative study of a few sources observed previously by the same telescope, but in the single beam mode, has been made. Problems with the earlier single beam observations are pointed out.

The main astrophysical discussion in the thesis centers around the discrete absorptions seen at 34.5 MHz. The nature of the gas causing these absorptions is discussed at some length. It is argued that this gas is nearby and can explain most of the galactic ridge recombination lines observed in the H166α and H272α lines. This has thrown some light on the long-standing puzzle about the gas producing the galactic ridge recombination lines. The low frequency survey has picked up the near-by diffuse gas seen in HOC but which is not seen in the high frequency continuum surveys.