MEDIUM FREQUENCY RADAR STUDIES OF METEORS

By

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Thesis

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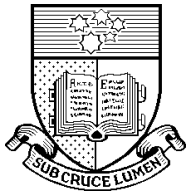

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To my parents

The important thing is not to stop questioning. Curiosity has its own reason for existing. One cannot help but be in awe when one contemplates the mysteries of eternity, of life, of the marvelous structure of reality. It is enough if one tries to comprehend only a little of this mystery every day.

—*Albert Einstein*

I want to reach that state of condensation of sensations which constitutes a picture.

—*Henri Matisse*

Contents

Abstract

This thesis details the application of a medium frequency (MF) Doppler radar to observations of meteoroids entering the Earth's atmosphere. MF radars make possible a greater height coverage of the meteor region (70 to 160 km) than conventional meteor radars. However this type of radar has generally been under-utilised for meteor observations, primarily due to the less than ideal radio environment associated with MF systems. This situation demanded selection of the most appropriate radar meteor techniques and in this respect a variety of techniques are evaluated for application at this frequency.

The 2 MHz radar system used in this study is located at the Buckland Park research facility (35.6°S, 138.5°E), near Adelaide, South Australia and is operated by the Department of Physics of the University of Adelaide. This radar has the largest antenna of any MF radar with 89 crossed dipoles distributed over an area of about 1 km in diameter. Beam forming is achieved by varying the phase to groups of elements of the array. The array was constructed in the 1960's, and while having several upgrades, a preliminary examination of the array and associated systems indicated that a significant amount of maintenance work would be required to enable the system to be used for meteor observations. It was also apparent that the software used with the radar hardware for atmospheric studies was not suitable for processing meteor data. Thus a major refurbishment of the radar hardware, as well as the development of appropriate software, was initiated.

The complete radar system was divided into its constituent components of antenna

array, transmitter, receiver and computer systems. The transmitter and receiver systems were examined and various improvements made including increasing total output power and enhancing beam steering capability. Time domain reflectometry (TDR) techniques were extensively used on the antenna array, as many feed cables showed the presence of moisture. New hardware in the form of a portable power combining system was designed, constructed and tested to further increase radar experimental capabilities. Techniques were developed that verified system performance was to specification.

Extensive night time observations of sporadic and shower meteor events were made over a two and a half year period. A particular study was made of the Orionids shower as well as other meteor activity on the night of 22 October 2000. Using the upgraded beam swinging features of the array, a narrow radar beam was used to track the shower radiant in an orthogonal sense so as to maximise the number of shower meteors detected. From each echo, various intrinsic meteoroid parameters were determined, including meteor reflection point angle-of-arrival using a five-element interferometer, echo duration and height; meteoroid speeds were determined using the Fresnel phase time technique.

Meteor echoes belonging to the Orionids radiant were selected using a coordinate transform technique. The speed was then used as an additional discriminant to confirm the Orionid shower members. A second radiant, observed at a slightly higher declination is classified as also part of the Orionid stream. The sporadic meteor component in the data set was examined and found to exhibit speeds much higher than expected for sporadic meteors at the time of the observations. However, these results are consistent with a selection bias based on meteoroid speed, that is inherent in radar observations.

The Orionid observations indicate that the refurbishment of the radar system and the introduction of new software for meteor analysis has been successfully achieved and that radar meteor studies can now be carried out routinely with the Buckland Park 2 MHz radar. Moreover it has been shown for the first time that meteoroid

speeds can be determined with a MF radar operating on a PRF as low as 60 Hz.

Originality declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.
I give consent to this copy of my thesis, when deposited in the University of Adelaide Library, being available for loan and photocopying.

Signed: ..... Dated: .....

Stephen I. Grant, B.Sc. (Hons)

Acknowledgements

In the course of research undertaken for a Ph.D. the ability to solve problems is of paramount importance. A primary aspect of this self-education is to recognise when a problem requires the development of an original solution and when an appropriate solution already exists. This helps to avoid the sometimes painful process of "re-inventing the wheel" when it is not necessary. Many times I discovered the best solution came from the knowledge and expertise of the people within the Department of Physics. It is here that I thank those people and others for their generous assistance throughout my candidature.

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A Ph.D. is different things to different people. I have found it a challenging time and one that has enabled me to develop and realise capabilities that I might not have otherwise uncovered. In this sense I have found you learn as much about yourself as the subject you study. To find out what I uncovered about atmospheric and meteor physics, please read on!