THE UNIVERSITY OF WESTERN ONTARIO

FACULTY OF GRADUATE STUDIES

CERTIFICATE OF EXAMINATION

Chief Advisor	Examining Board
______________________	______________________
Advisory Committee	______________________
______________________	______________________
______________________	______________________

The thesis by

Peter Gordon Brown

entitled

Evolution of two Periodic Meteoroid Streams: The Perseids and Leonids

is accepted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

Date______________________ ______________________

Chairman of Examining Board

Abstract

Observations and modelling of the Perseid and Leonid meteoroid streams are presented and discussed. The Perseid stream is found to consist of three components: a weak background component, a core component and an outburst component. The particle distribution is identical for the outburst and core populations.

Original visual accounts of the Leonid stream from 1832 – 1997 are analyzed to determine the time and magnitude of the peak for 32 Leonid returns in this interval. Leonid storms are shown to follow a gaussian flux profile, to occur after the perihelion passage of 55P/Tempel-Tuttle and to have a width/particle density relationship consistent with IRAS cometary trail results. Variations in the width of the 1966 Leonid storm as a function of meteoroid mass are as expected based on the Whipple ejection velocity formalism.

Four major models of cometary meteoroid ejection are developed and used to simulate plausible starting conditions for the formation of the Perseid and Leonid streams.

Initial ejection velocities strongly influence Perseid stream development for the first ~five revolutions after ejection, at which point planetary perturbations and radiation effects become important for further development. The minimum distance between the osculating orbit of 109P/Swift-Tuttle and the Earth was found to be the principle determinant of any subsequent delivery of meteoroids to Earth. Systematic shifts in the location of the outburst component of the Perseids were shown to be due to the changing age of the primary meteoroid population making up the outbursts. The outburst component is due to distant, direct planetary perturbations from Jupiter and Saturn shifting nodal points inward relative to the comet. The age of the core population of the stream is found to be $(25\pm10)\times10^3$ years while the total age of the stream is in excess of 10^5 years. The primary sinks for the stream are hyperbolic ejection and attainment of sungrazing states due to perturbations from Jupiter and Saturn. Ejection velocities are found to be tens to of order a hundred m/s.

Modelling of the Leonid stream has demonstrated that storms from the shower are from meteoroids less than a century in age and are due to trails from Tempel-Tuttle

coming within $(8 \pm 6) \times 10^{-4}$ A.U of the Earth's orbit on average. Trails are perturbed to Earth-intersection through distant, direct perturbations, primarily from Jupiter. The stream decreases in flux by two to three orders of magnitude in the first hundred years of development. Ejection velocities are found to be <20 m/s and average ~5 m/s for storm meteoroids. Jupiter controls evolution of the stream after a century; radiation pressure and initial ejection velocities are significant factors only on shorter time-scales. The age of the annual component of the stream is ~1000 years.

To my parents, Bob and Kathy

Co-Authorship

This thesis contains material from previously published manuscripts and manuscripts accepted for publication co-authored by: J. Jones and J. Rendtel. Copyright releases, declarations of co-author consent and detailed descriptions of co-author contributions are given in Appendices A. Herein I describe my personal contribution to individual chapters which are based on co-authored material:

Chapter 3. Observations of the Perseid Meteor Shower

I performed the final analyses, computations and wrote the manuscript.
I did not collect the original information or develop the procedure for the initial data reductions.

Chapter 4. Development and Application of a Numerical Model of the Formation and Evolution of the Perseid Meteoroid stream

I performed all the simulations and analysis, added planetary tables and other refinements to the numerical integrator, included other ejection routines to the cometary ejection program and wrote the manuscript.
I did not write the original integrator and cometary ejection programs.

Acknowledgements

Great credit goes to my supervisor, Jim Jones. He has been a continual source of inspiration, encouragement and most importantly patience. His expert advice and understanding made this work both possible and thoroughly enjoyable.

Thanks are due to colleagues who have each helped in their own way; in particular Rainer Arlt, Martin Beech, Margaret Campbell, Kerry Ellis, Bob Hawkes, Wayne Hocking, Juergen Rendtel, Milos Simek and Alan Webster.

Lastly, thanks go to Aquarid, Leonid, Lyrid, Orionid, Meteors, and Perseid for doing all the work over the last five years.

Table of Contents

List of Tables

List of Figures