Evidence of Three Body Resonance in Meteoroid Streams

A. Sekhar (1, 2), D. J. Asher (2), J. Vaubaillon (3), M. Hajduková (4), J. Tóth (5), R. Rudawska (6), R. Soja (7)
(1) Centre for Earth Evolution and Dynamics, University of Oslo, Norway (aswin.sekhar@geo.uio.no), (2) Armagh Observatory, United Kingdom (3) IMCCE, Paris Observatory, France (4) Astronomical Institute, Slovak Academy of Sciences, Slovakia (5) Comenius University, Slovakia (6) ESA/ESTEC, Netherlands (7) University of Stuttgart, Germany

Introduction

There have been various examples of two body mean motion resonances (MMR), [1][2][3][4][5][6], in different meteoroid streams. Many of these Jovian two body MMRs are known to have caused observed meteor outbursts and storms on Earth in the past and have been widely reported and studied,[7][8][9][10], although enhanced activity from two body MMRs involving other planets has not been directly observed so far. Nevertheless there are previous works exploring them theoretically, especially the ones related to Saturnian MMR,[11][12], and Uranian MMR,[13], in meteoroid streams. However the occurrence of three body MMR in real solar system bodies is a much rarer phenomenon although there are many resonant sweet spots in the solar system in an abstract mathematical sense. The first example of real solar system bodies showing three body MMR is the Laplacian resonance involving the Galilean satellites, namely Ganymede, Io and Europa,[14]. In this work, we find the first dynamical evidence of a three body MMR in the context of meteoroid streams.

Stream Dynamics

The existence of three body resonant structures in the Perseid stream is confirmed from our integration study. The configuration is close to 1:4:10 MMR for orbital periods of Perseid particle, Saturn and Jupiter respectively. Typically these meteoroid particles get trapped in this three body resonance for about 2 kyr. The simulations were able to establish the effectiveness of this resonance in retaining compact dust trails for a long time, in contrast to the wider scattering of the non-resonant particles in the orbit phase space.

Linking Theory and Observations

This resonant property in turn indicates that one could expect intense meteor activity on Earth in future from this newly found resonance. Further predictions are planned in this direction so that meteor observers can be alerted. Real observation of an enhanced meteor activity from this unique three body resonance mechanism would help to compare with well observed meteor outbursts from known two body MMRs in the past. Linking the theoretical predictions with real observations,[15][16], would help to gain more insight into the dynamics of three body MMR in stream structures which have not been explored before.

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