A Young, Forming Zodiacal Cloud Dust Band; Observations and Dynamical Model. A.J. Espy[1], S.F. Dermott[1], T.J.J. Kehoe[1], and S. Jayaraman[2], [1]University of Florida, Department of Astronomy, 211 Bryant Space Science Center, P.O. Box 112055, Gainesville, FL 32611-2055, USA, email: ashley@astro.ufl.edu, [2]Planetary Science Institute, 1700 East Ft. Lowell, Suite 106, Tucson, AZ 85719-2395, USA.

Abstract:

When an asteroid is disrupted, the larger pieces remain on similar orbits and constitute an asteroid family. The smaller products of the disruption (10 microns – a few mm) are initially on orbits similar to the parent body, but decay into the inner solar system under the effect of Poynting-Roberston (P-R) drag. Before these particles encounter the mean-motion resonances in the main belt and the secular resonances at the inner edge of the main belt, their dynamics are controlled by Jupiter. Since they retain their proper orbital elements from the parent body and Jupiter's domination causes them to share common forced elements, only their node is dispersed around the sky. These similar orbits allow for the existence of the dust band structure discovered by IRAS [1]. There are currently three known dust band pairs that have been linked to specific sources [2] [3], one at 9.35 degrees due to the Veritas family and two central band pairs, one of which is due to the Karin cluster and other likely to the Themis family. Additional dust bands have been postulated, both by Sykes [4] in the IRAS (Infrared Astronomical Satellite) data and by Reach [5] in the COBE (Cosmic Background Explorer) data. However, several factors prevented these possible pairs from being investigated further. In some cases it was due to the lack of sufficient signal-to-noise ratio in the observations and in other cases it was due to the fact that no well-matched sources had yet been identified. The recent discovery of several new, very young asteroid clusters [6] opens up new possible sources of the dust bands, since these disruptions have not yet lost much of their dust through removal by P-R drag, collisions, or radiation pressure. In order to search for fainter dust bands, we co-added virtually all the pole-to-pole intensity scans of the IRAS data set using a method for correcting the variations of the latitude of peak flux in the observations made at different solar elongation angles and different ecliptic longitudes of the zodiacal cloud [7]. This process, through the significant increase in signal-to-noise that is produced, revealed the existence of a solar system dust band at ~17 degrees inclination in the line-of-sight flux profiles. We believe this to be a confirmation of the M/N pair originally suggested by Sykes.

Additionally, we see this new dust band at some but not all ecliptic longitudes, providing strong evidence for a partial solar system dust band; that is a very young dust band in the process of formation. In order to determine the parent body of this band, we create a full dynamical model of the formation of this dust band to constrain the parameters of a source body capable of producing the structure. The full dynamical model is based on the dynamical evolution of the dust band particles from the disruption event. As the dust particle orbits decay under P-R drag and the differential precession of the nodes of their orbits spreads them around the ecliptic, a dust band begins forming. The model includes particle sizes from 10-1000 microns in diameter. Comparison of the model to our co-added IRAS observations allows us to put bounds on the parameters of the parent body, including the node location and the amount of dispersion in the node which gives, for a range of semi-major axes, an age to the disruption event that produced the partial band.

We start the modeling with Emilkowalski as the possible source, but also investigate all regions of parameter space to determine the constraints on the source body. Due to the fact that this is a very young dust band, it is possible that the source is some yet undiscovered family or cluster. Also, because the precession rate of the node varies across the main-belt region, it is highly dependent on the semi-major axis of the source body. Thus, we investigate the ranges of ages and semi-major axis locations that could produce the band structure. We determine a likely source is the Emilkowalski cluster based on its age and inclination [7]. The timescale for formation of a dust band at the location of Emilkowalski [6] is ~10^5–10^6 years and the age of this cluster is ~ 2 x 10^5 [6], making it likely that this source would not yet have produced a complete band.

References:

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