COMETARY ORIGIN OF THE ZODIACAL CLOUD AND ANTARCTIC MICROMETEORITES

D. Nesvorny[1] and P. Jenniskens[2]. [1]Southwest Research Institute. E-mail: davidn@boulder.swri.edu. [2]SETI Institute.

Introduction: The zodiacal cloud is a thick circumsolar disk of small debris particles produced by asteroid collisions and comets. Their relative contribution and how particles of different sizes dynamically evolve to produce the observed phenomena of light scattering, thermal emission, and meteoroid impacts were unknown.

Method: Until now, zodiacal cloud models have been phenomenological in nature, composed of ad-hoc components with properties not understood from basic physical processes. Here we present a zodiacal cloud model based on the orbital properties and lifetimes of comets and asteroids, and on the dynamical evolution of dust after ejection. The model is quantitatively constrained by IRAS observations of thermal emission, but also qualitatively consistent with other zodiacal cloud observations, with meteor observations, with spacecraft impact experiments, and with properties of recovered micrometeorites [1].

Results: We find that particles produced by Jupiter-family comets (JFCs) are scattered by Jupiter before they are able to orbitally decouple from the planet and drift down to 1 AU. Therefore, the inclination distribution of JFC particles is broader than that of their source comets and leads to good fits to the broad latitudinal distribution of fluxes observed by IRAS. We find that 85-95% of the observed mid-infrared emission is produced by particles from JFCs and <10% by dust from long period comets. The JFC particles that contribute to the observed cross-section area of the zodiacal cloud are typically ~100 um in diameter. Asteroidal dust is found to be present at <10%. We suggest that spontaneous disruptions of JFCs, rather than the usual cometary activity driven by sublimating volatiles, is the main mechanism that liberates cometary particles into the zodiacal cloud.

The Earth impact speed and direction of JFC particles is a strong function of particle size. While 300 um to 1 mm sporadic meteoroids are still on eccentric JFC-like orbits and impact from antihelion/helion directions, which is consistent with the aperture radar observations, the 10-300 um particles have their orbits circularized by PR drag, impact at low speeds and are not detected by radar. Our results imply that JFC particles represent ~85% of the total mass influx at Earth. Since their atmospheric entry speeds are typically low (14.5 km/s mean for 100-200 um with ~12 km/s being the most common case), many JFC grains should survive frictional heating and land on the Earth's surface. This explains why most micrometeorites collected in antarctic ice have primitive carbonaceous composition.

References: [1] Nesvorny D. et al. 2010. *Astrophysical Journal* 713:816–836.