MODELING INTERPLANETARY DUST FLUXES TO THE OUTER PLANETS A. R. Poppe[1], [1]Space Sciences Laboratory, University of California at Berkeley, Berkeley, CA, 94720 (poppe@ssl.berkeley.edu)

Introduction: The outer solar system is diffused with sub-millimeter sized dust grains from a combination of several sources, including Edgeworth-Kuiper Belt (EKB) objects, Jupiter-family comets (JFC), and Oort Cloud comets (OCC) [1,2]. These grains are influenced by gravity from the Sun and the giant planets, solar radiation pressure, solar wind and Poynting-Robertson (PR) drag, and the electromagnetic Lorentz force [3]. Depending on the characteristics of the source bodies and the grain production method(s), different families of grains achieve unique density and velocity distribution equilibria in the outer solar system. In turn, objects in the outer solar system, including planets, planetary satellites, planetary rings, and other small bodies are constantly bombarded by an influx of micrometeoroids with fluxes and velocity distributions dependent upon their density equilibria. We report here on a modeling and data comparison effort to constrain the distributions of micron-sized dust grains in the outer solar system and their influx into the various outer planetary systems.

Dust Grain Dynamics Model: We make use of a previously-established dynamical code to model the spatial, velocity, and size evolution of dust grains launched in the outer solar system [4]. The code includes the effects of gravitation, solar wind and PR drag, and the electromagnetic Lorentz force. The code also includes the effects of solar wind sputtering and sublimation on the instantaneous grain size. Dust grains are started in the simulation with orbital parameters characteristic of their parent bodies and are traced until they are either ejected from the solar system, are sputtered or sublimated away, or enter the extreme inner solar system (< 1 AU). Previous results have simulated the Edgeworth-Kuiper Belt component of the outer solar system dust complex and fit the model to observations made by the Pioneer 10 meteoroid detector and the New Horizons Student Dust Counter [4,5]. Figure 1 shows the equilibrium dust density for 10 μm silicate EKB grains in the ecliptic and vertical planes, respectively. Our modeling is now in the process of being extended to grains in the outer solar system derived from both Jupiter-family comets and Oort-Cloud (or Halley-type) comets [6]. Based on previous modeling work, we expect that these two dust grain populations will be dominant approximately inside the orbit of Saturn; however, we will investigate this further as a function of grain size.

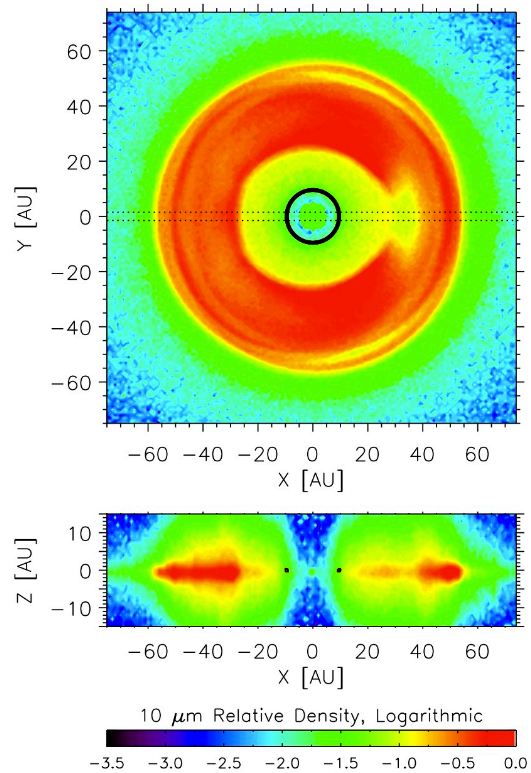

Figure 1: The equilibrium density of 10 μm Edgeworth-Kuiper Belt dust grains in the ecliptic and vertical planes, respectively [8]. The orbit of Saturn is marked in solid black for reference.

We also have begun investigating the role that dust grain sputtering and sublimation have in changing in the equilibrium dust grain densities [7]. For EKB grains, solar wind sputtering plays a small role in altering grain size, while sublimation plays almost no role since the EKB grains spend most of their lifetime in the outer solar system. In contrast, JFC and OCC grains are distributed deeper inside the solar system and more strongly affected by sputtering and sublimation. For example, Figure 2 shows the equilibrium dust grain size distribution in the vicinity of each of the giant planets (and overall) for grains initially launched as 50 μm JFC grains. The initial dust grain size distribution is significantly altered via the process of sputtering and sublimation and must be taken into account in further modeling of dust grain fluxes into the outer planetary systems. We will extend this preliminary work to all three grain families for all grain sizes and discuss the implications.

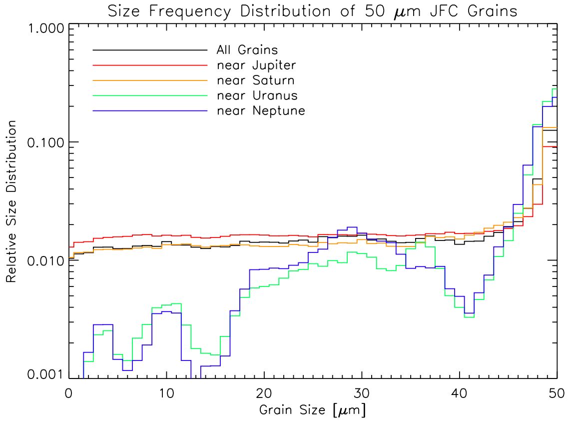

Figure 2: The dust grain size distribution of Jupiter-family comet (JFC) grains in the vicinity of each of the outer planets initially launched as 50 μm grains.

Planetary Influx: Given the equilibrium density and velocity distributions of each dust grain type (EKB, JFC, OCC) and an appropriate normalization to observational data, the influx of micron-sized grains into each of the outer planetary systems (including their satellites, rings, and atmospheres) can be calculated. Observational data will come from both the Pioneer 10 and 11 missions [9] and the New Horizons Student Dust Counter, which has recently reported measurements out to approximately 20 AU [4]. We have performed this analysis for the Edgeworth-Kuiper Belt dust flux into Saturn and found that the calculated influx is significantly different in mass distribution and total mass influx than that found by extrapolating the interplanetary dust flux at 1 AU (from [10]) to the outer solar system [8]. We will extend this analysis to both different families of dust grains in the outer solar system and to all of the outer planets. Finally, we will discuss the implications of these newly-calculated mass fluxes on several physical phenomena in the outer solar system that are driven and/or influenced by interplanetary dust influx.

References:

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