Chiaroscuro: From Pericenter Glow to Apocenter Enhancement—Illuminating the Secular Structure of Dusty Planetary Systems

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Asymmetries are routinely observed in circumstellar dust disks, such as those seen at beta Pictoris, epsilon Eridani, AU Microscopii, HD107146, etc. Two broad categories of phenomenon are often invoked to explain these asymmetries: asymmetric scattering of starlight by dust (due to forward scattering which makes the near side of an inclined disk appear brighter than the far side) and planetary perturbations (which can organize the dust orbits in nested, elliptical streamlines). Furthermore, the nature of a dusty disk's asymmetric appearance is wavelength dependent. When viewed via the disk's thermal emission, stellar heating of dust near periapse leads to the pericenter glow feature seen in images of dust-disks (Wyatt et al 1999). However maps of reflected starlight of a disk reveal an apocenter enhancement, due to dust loitering near apoapse (Marsh et al astro-ph/0501140). The aim of this work is to address these two broad categories, and to illustrate how it is possible to distinguish their effects in the appearance of a circumstellar dust-disk. To model the effects of planetary perturbations, we consider for now only single-planet systems, and we neglect the effects of radiation forces on the dust. We also assume that the planet's secular perturbations are the dominant disturbance in the disk. To account for the disk's asymmetric scattering of starlight, we use a Henyey-Greenstein function to describe the phase function for dust grains. Using this simple model, a disk's asymmetry is governed by just three parameters: the planet's eccentricity e, the disk's inclination i, and the light scattering parameter g. Comparison of synthetic optical-depth maps of dusty disks generated using our models can then be used to discriminate between these two competing phenomenon. We will also present a simple analytic expression that relates the disk's surface brightness profile to e, i and g, and will also present early results from a more generalized multi-planet treatment.

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