Mid-IR Polarization of Protoplanetary Disks

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Polarization is an important observational technique for studying the orientation of magnetic fields and the properties of dust in protoplanetary disks.

In the mid-IR, polarization can result from dichroic absorption, emission and/or scattering. Regarding the dichroic absorption and emission, polarization arises from the differential cross sections of non-spherical dust grains, with directions parallel and perpendicular to the grain's symmetry axis. We adopt the package DDSCAT (Draine & Flatau 2013), to calculate these cross sections for astronomical silicates (Draine & Lee 1984) and ice-coated silicate grains for a range of axial ratios. We find that the polarizing capability of dust grains strongly depends on dust composition and geometry. Different dust compositions have different polarization profiles and larger oblateness leads to an increased degree of polarization. Our predicted mid-IR polarization can be as high as ~ 10%, while at sub-mm, it is ~ 1%, which is comparable to observed values. Assuming a hydrostatic disk model and the partly dust alignment (reduction factor R=0.6) in the magnetic field, with the temperature distribution calculated from the Monte Carlo radiative transfer code RADMC (Dullemond et al. 2010), we present the polarization distributions expected for various magnetic field morphologies (e.g., classical hour-glass, toroidal and poloidal). Scattering, previously regarded as negligible in the mid-IR, is taken into consideration in our modeling. Although we only consider scattering from spherical dust grains, dust polarizes light by scattering very efficiently and therefore scattering should no longer be ignored in the mid-IR. Our results suggest that dust size distribution and the scale height of the disk are significant parameters accounting for the fractional polarization from scattering.

As an illustration, we compare our modeling with mid-IR polarimetric images of AB Aur from *Canaricam* GTC at 10.3 μm. AB Aur is a well-studied Herbig Ae star surrounded by a disk inclined at ~20 deg from face-on. Our observations show a centrosymmetric pattern (i.e., the signature of polarization from scattering, appearing at the distance ~ 1 arcsec from the central star) superimposed on a uniform pattern (from emission, dominating at the inner disk). We show how our model can reproduce this observation and how polarization can constrain the dust properties, e.g., size. This research was supported in part by NSF grants AST-0903672 and AST-0908624 to CMT.