Grain alignment in protoplanetary disks

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Recently, ALMA has so far been revealed polarimetric properties of protoplanetary disks in (sub-)millimeter wavelengths. However, the origin of polarized light in these wavelengths is still controversial. In order to understand how polarized light is produced in these wavelengths, we apply the theory of radiative torque (RAT) alignment for studying protoplanetary disks around a T-Tauri star and perform 3D radiative transfer calculations to provide the expected maps of polarized radiation to be compared with observations, such as with ALMA. We revisit the issue of grain alignment for large grains expected in the protoplanetary disks and find that mm-sized grains at midplane do not align with magnetic field as the Larmor precession timescale for such large grains becomes longer than the gaseous damping timescale. Hence, for these grains the RAT theory predicts that the alignment axis is determined by the grain precession with respect to the radiative flux. As a result, we expect that the polarization will be in the azimuthal direction for a face-on disk. It is also shown that if dust grains have superparamagnetic inclusions, magnetic field alignment is possible for (sub-)micron grains at the surface layer of disks, and this can be tested by mid-infrared polarimetric observations.

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