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The impact of dust grain porosity on the appearance of protoplanetary disks

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We present a theoretical study of porous dust grains in protoplanetary disks (Kirchschlager & Wolf 2014). In the analysis of observations of protoplanetary disks the dust phase is often assumed to consist of spherical grains, allowing one to apply the Mie scattering formalism. However, in reality the shape of dust grains is expected to deviate strongly from a sphere. We investigate the impact of porous dust grains on the temperature distribution and observable appearance of protoplanetary disks for dust grain porosities up to 60 %. Therefore, we perform radiative transfer modeling to simulate the temperature distribution, spectral energy distribution, and spatially resolved intensity and polarization maps. The optical properties of porous grains are calculated using the method of discrete dipole approximation. We find that grain porosity has a strong impact on the spectral energy distribution and scattered light maps. If compared to the case of compact, spherical grains, the flux in the optical wavelength range is increased for porous grains. The profile of the silicate peak at $\sim 10\,\mu$m strongly depends on the degree of grain porosity. Moreover, the temperature distribution shows significant changes in the direction perpendicular to the midplane which might have an effect on the processes of grain growth and disk evolution. Furthermore, simulated polarization maps reveal an increase of the polarization degree by a factor of $\sim$ four when porous grains are considered, regardless of the disk inclination. The polarization direction is reversed in selected disk regions, depending on the wavelength, grain porosity, and disk inclination. Several possible explanations of this effect are discussed with the result that the multiple scattering explains the effect best. Moreover, a correlation between the polarization reversal and the scattering properties of single dust grains is derived.