Radiative transfer modeling of fluffy dust disk

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Planetesimals are formed from dust grains in protoplanetary disks; however, the theory of planetesimal formation involves many problems. Recent theoretical studies suggested that the fluffy dust aggregates can form planetesimals via coagulation, but their presence has not yet been confirmed by observation. We study how the presence of fluffy dust aggregate affects on the appearance of protoplanetary disks in near-infrared wavelength using 3D radiative transfer calculations.

We develop light scattering model of fluffy dust aggregates based on the Rayleigh–Gans–Debye (RGD) theory whose validity is tested using a rigorous method, T-Matrix-Method (Tazaki et al. 2016). We implement our light scattering model into the radiative transfer code, RADMC-3D (Dullemond et al. 2012). First, we show that when the effective medium theory, or a commonly used method, is applied to calculate light scattering of fluffy dust aggregates, the scattered light luminosity of protoplanetary disks becomes an order of magnitude fainter than that obtained by the RGD-theory. Secondly, we perform radiative transfer modeling of the GG Tau circumbinary ring. As a result, we find that fluffy dust aggregate can reproduce observed disk luminosity, brightness asymmetry and high degree of polarization for the GG Tau ring simultaneously, while compact dust grains model fails.