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Effect of dust porosity on scattered light images of protoplanetary disks

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The dust porosity is a key quantity that characterizes how dust particles grow to form planetesimals in protoplanetary disks. We study how the dust porosity affects scattered light images of protoplanetary disks in near-infrared wavelengths. It is known from near-infrared observations that some protoplanetary disks are faint and show red color in the scattered light. Large fluffy dust aggregates have been considered as a potential candidate to explain these observed properties (Mulders et al. 2013).

We perform radiative transfer calculations of protoplanetary disks taking the dust porosity into account, where optical properties of fluffy dust aggregates are obtained by using a rigorous method, T-Matrix Method (TMM) and approximate methods, a modified mean field theory (MMF, Tazaki & Tanaka, submitted) and the effective medium theory (EMT). It is found that when a commonly used method, EMT, is used to obtain optical properties of fluffy dust aggregates, the disk becomes faint and shows reddish color in the scattered light. However, when a rigorous method, TMM, is used to obtain the optical properties, the disk becomes relatively bright and shows gray or slightly blue color. By using the MMF method, we show that even if the aggregate radius is increased up to mm-size, the disk tends to show relatively bright and gray color. As a result, our results suggest that red and faint protoplanetary disks in the scattered light indicate the presence of large compact aggregates at the surface layer of the disks rather than large fluffy dust aggregates.

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