Dust characterization in planet-forming disks

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Dust coagulation is the first step in planet formation. Constraining the chemical, mineralogical, and physical properties of dust particles in planet-forming disks is a key objective in planetary science. Over the past decade, dust observations of protoplanetary disks have made remarkable progress across a wide range of wavelengths—from optical and near-infrared to millimeter—using facilities such as Subaru, VLT, JWST, and ALMA. These multi-wavelength observations have enabled us to probe various dust properties, including size distribution, porosity, and even chemical composition and mineralogy. In particular, polarimetric observations provide unique constraints on the morphology of dust grains, including their shape, porosity, and fractal structure.

Parallel advances in theoretical modeling have greatly enhanced our ability to interpret these observations. Although simulating the optical properties of more realistic particles—such as irregular and aggregated grains—usually requires considerable time and resources, it is now increasingly feasible. These results have been incorporated into radiative transfer simulations to model observational results of planet-forming disks.

In this review, I will summarize the current understanding of dust properties in planet-forming disks as inferred from recent observational and modeling efforts. I will also discuss the implications for grain growth and the early stages of planet formation, and outline future directions in the observational modeling of protoplanetary dust particles.