Experimental Studies on Dust Formation in Space

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Crucial processes for the formation and evolution of solid in circumstellar environments are the dust growth from vapor and the solid-gas reaction. For instance, various dust particles, such as amorphous/crystalline silicates, oxides, and carbonaceous species, observed around evolved stars by infrared spectroscopy should be formed from gas. Circumstellar grains have been observed in chondrites as presolar grains with isotopic anomalies. It has been believed that condensation of solids occurred in the proto solar disk as well. Fluffy-shaped CAIs (Ca-, Al-rich inclusions), amoeboid olivine aggregates (irregular shaped aggregates of Mg-rich olivines), and metallic iron grains in CH chondrites may be condensates formed in the proto solar disk. Condensation with accompanying separation of solids also played an important role in making volatility-controlled chemical diversities in solar-system materials.

Although equilibrium condensation calculations provide a set of stable minerals under a certain physical and chemical condition, condensation does not necessarily occur in equilibrium in time-variant circumstellar systems, where pressure, temperature, and gas chemistry vary with time. It is of much importance to understand the kinetic aspect of dust formation processes. In this talk, I will review experimental studies on condensation, evaporation, and solid-gas reaction kinetics of dust analogues such as magnesium-silicates and metallic iron to summarize our current knowledge. I will also talk about our recent progresses on experimental studies and discuss what we experimentalists need to do next.