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# Physical and chemical evolution of dust grains in protoplanetary disks

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It is thought that in protoplanetary disks dust particles grow in size by sticking together and settle toward as well as migrate toward the central star. These processes are key to understand the first steps of the planet formation. The dust particles evolve not only through such physical processes but also through some chemical processes in the disks, and then lead to the solid materials in our Solar System.

For example, the gas in the disk surface is heated up to several hundreds to a few thousand Kelvin due to the photoelectric heating on dust grains induced by the UV irradiation from the central star. Carboneous grains are chemisputtered by atomic oxygen in such hot gas. This kind of process is one of the possible mechanism for decreasing the carbon to silicate ratio in solid materials, which are often seen in the inner Solar System.

Meanwhile, the gas particles are frozen onto the dust grains and react with each other on the grain surfaces in cold and dense regions in the midplane of the outer disks and/or in the molecular cloud cores. Complex organic molecules are thought to be formed through such reactions in space. Some of the surface molecules remain on the grains and lead to icy materials like comets in our Solar System. The others go into the gas-phase via thermal- and/or photo-desorption, and then the formation process of these molecules can be diagnosed through spectroscopic observations of protoplanetary disks.

I shall review these theoretical studies on the physical and chemical evolution of dust particles in the protoplanetary disks in this talk.

Keywords: protoplanetary disks, dust evolution