Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

PPS004-01 会場:101 時間:5 月 27 日 14:15-14:30

Two-dimensional Paths of Particles in the Solar Nebula: Irradiation Exposure and Processing

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The dynamic evolution of a protoplanetary disk is critical to understand as it determines the physical and chemical environments in which planet formation would take place. Along with the dynamical evolution of the disk as a whole, solids within the disk undergo dynamical evolution, leading to the large-scale transport and redistribution of materials throughout the solar nebula. It is this dynamical transport that is needed to explain the presence of high-temperature minerals in the Stardust sample collected from Comet Wild 2 and the preservation of CAIs in the solar nebula for periods of millions of years.

The extent of transport that has been inferred for these primitive materials suggests that solid particles would be exposed to a wide array of physical and chemical environments within the solar nebula–environments in which the minerals in the particle could be destroyed, undergo chemical alteration, or be physically altered due to exposure to high-energy particles and photons. As such, the solid materials that we see in comets and chondritic meteorites should not be considered the products of a given formation environment, but rather each grain was shaped by the integrated path it took through the solar nebula.

I have developed a Monte Carlo Model that tracks the radial and vertical motions of solids throughout a protoplanetary disk, allowing the entire, pressure, temperature, and irradiation history to be determined. Such information is critical to determining the extent and types of chemical processing that different grains would have experienced. For example, gas-solid reaction kinetics can be compared to the residence time of particles in regions where such reactions could occur. Further, the formation of organics can require the cycling of icy grains from the deep interior of the disk to the surface where they would be exposed to irradiation by energetic particles. I will report early results from studies of these types.

キーワード: solar nebula, meteorites, comet, irradiation
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