Nucleation Experiments of Iron Dust under Microgravity

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Cosmic dust forms from a super cooled vapor in an ejecta gas from a dying star. The condensation sequence, number density and size of the cosmic dust can be expected using nucleation theories. Then, the undetermined physical parameters of materials with the same size range of cosmic dust (100 nm or less) have prevented explanation of formation process of cosmic dust based on nucleation theories. Recently, we constructed an experimental system using interferometry, which can be determined temperature and concentration simultaneously at nucleation site in vapor phase. Using the new system, we succeeded to determine surface free energy and sticking probability of nanoparticle from timescale for gas cooling, condensation temperature and resulting particle size based on nucleation theories **[**Kimura et al. *Crystal Growth & Design* **12** (2012) 3278**]**. To understand a formation process of cosmic iron dust more precisely, in addition to ground based experiment, we performed a microgravity experiment using a specially designed double wavelength Mach–Zehnder-type interferometers with an evaporation chamber and a camera recording system installed into the sounding rocket S-520-28.

The working chamber was a stainless-steel cylinder with an internal diameter of 6.5 cm and a length of 15 cm, containing three viewports for optical observation and temperature measurement of the evaporation source by pyrometer, two ports for thermocouple, which measure a temperature at the end of the evaporation source, and electrodes. The cylinder was evacuated through a valve by a combination of a turbo-molecular pump (50 L/s) and a scroll type dry vacuum pump. Because the refractive index of the argon buffer gas (>99.9999% purity) used in producing the iron nanoparticles is very low [$(n - 1)Ar = 5.266 \times 10^{-5} \pm 0.016 \times 10^{-5}$ at 632.8 nm and 293.15 K for 2.0×10^4 Pa], the evaporation source was prepared certainly parallel to the evaporation source and as long as possible to increase the column density, which is advantageous for the detection of tiny changes in the refractive index. With this experimental setup, we could detect a difference in refractive index of less than 1×10^{-6}, which, for example, corresponds to the difference in temperature from 298 K to 301 K for Ar gas at 2×10^4 Pa.

The experiments were run sequentially and automatically started from 100 s after launch of the rocket. Iron vapor was evaporated by electrical heating of an evaporation source in an Ar gas atmosphere of 2.0×10^4 Pa or 4.0×10^4 Pa. Evaporated iron vapor was diffused, cooled and condensed in the gas atmosphere. The temperature and concentration at the nucleation site are determined from the changing of the refractive index, which is obtained from a movement of the fringes in the interferogram. Here, we will show the first results of the microgravity experiment and ground-based experiments for comparison.