# Direct determination of a sticking probability in a nucleation event based on microgravity experiment and its formation process of iron dust

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Nucleation governs characters of an initial solid product from an ejecta gas of an evolved star. Nucleation theory can expect the characters such as condensation sequence, number density, polymorph, crystal habit, size and size distribution of the cosmic dust. Then, physical parameters of cosmic minerals are important for their precise expectation. In particular, surface free energy and sticking probability are most affected. However, the parameters are uncertain. Surface free energy of minerals with a same size range of cosmic dust (100 nm or less) and sticking probability during a nucleation (atomic/molecular coagulation process) have prevented explanation of formation process of cosmic dust based on nucleation theories. For instance, size dependence of a surface free energy has been reported using $TiO_2$ nanoparticles [1] and a very small sticking probability of zinc, $\sim 10^{-5}$, has been obtained by microgravity experiment [2] against sticking probabilities of close to unity obtained by ground based experiments.

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 [3]. 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.

Three 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 $2.0 \times 10^4$ Pa or $4.0 \times 10^4$ 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. Based on semi-phenomenological nucleation theory, we determined a sticking probability of iron during a homogenous nucleation by the microgravity experiment and ground-based experiments. The value is significantly small and corresponding to that of the previous value of Zn obtained by microgravity experiment [2] against with most of values by ground based experiment.

**[1]** H. Zhang, B. Chen, J. F. Banfield, *Phys. Chem. Chem. Phys.* **11**, 2553 (2009).
**[2]** B. P. Michael, J. A. Nuth III, L. U. Lilleleht, *Astrophys. J.* **590**, 579 (2003).
**[3]** Y. Kimura et al. *Crystal Growth & Design* **12,** 3278 (2012).