

Sticking probability for homogeneous nucleation of iron dust

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Nucleation theories have been used to understand the condensation sequence, number density and size of cosmic dust in a gas outflow of dying stars or a gas plume after shock wave heating in the primitive solar nebula. However, it has been well known that nucleation rates obtained by nucleation theories and by experiments have a large difference. We believe that the reason is uncertainties of the physical parameters of nanometer sized particles. Therefore, it is still not successful to explain the characters of cosmic dust by a nucleation theory. To determine the physical parameters of nanoparticles and evaluate nucleation theories, we constructed an in-situ observation system of temperature and concentration during homogeneous nucleation in vapor phase using interferometry for both of ground based and microgravity experiments.

Nanoparticles are formed from a supercooled vapor after evaporation by electrical heating in a controlled gas atmosphere. Using the new system in lab, we succeeded to determine surface free energy and sticking probability of manganese nanoparticle from timescale for gas cooling and condensation temperature based on nucleation theories [1]. In this laboratory experiment, convection of gas atmosphere caused by thermal heating generates heterogeneity of nucleation environment, such as temperature and concentration profiles around evaporation source. If same kinds of experiments are performed in microgravity, evaporated vapor defuses uniformly and the temperature profile becomes concentric around the evaporation source. As the result, nucleation will occur at concentric position. Then, we can obtain physical properties with relatively smaller error bars and then we may be able to evaluate nucleation theories more precisely. Therefore, we also performed a microgravity experiments using an aircraft and the sounding rocket S-520-28 launched on December 17th, 2012.

We prepared specially designed Mach-Zehnder-type interferometers with an evaporation chamber and camera recording systems to fit the space and weight limitations of the rocket. Three systems, named DUST 1 to 3, with same configuration except evaporation source and gas pressure in the chamber were installed into the nosecone of the rocket. The evaporation source and gas atmosphere were tungsten and gas mixture of oxygen (4000 Pa) and argon (36000 Pa) for DUST 1, iron and argon (20000 Pa) for DUST 2, and iron and argon (40000 Pa) for DUST 3. The experiments were run sequentially and automatically started from 100 s after launch of the rocket. The evaporation source of iron was electrically heated under microgravity. Evaporated iron vapor was diffused, cooled and condensed in the gas atmosphere. The temperature and concentration at the nucleation site are determined from the movement of the fringe in the interferogram. Here, we will show the results of the homogeneous nucleation and determine the sticking probability of iron atoms into a nanoparticle based on nucleation theories. The results will be compared with that by ground based experiment.

[1] Y. Kimura, K. K. Tanaka, H. Miura, K. Tsukamoto, Direct observation of the homogeneous nucleation of manganese in the vapor phase and determination of surface free energy and sticking coefficient, *Crystal Growth & Design*, **12** (2012) 3278-3284.

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