Sample recovery of microgravity experiments using sounding rockets opens up new sciences

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In order to understand how cosmic dust particles form in the gas outflow from evolved stars, we have performed microgravity experiments using S-520 sounding rockets of JAXA. In the microgravity condition during a parabolic flight of the rocket, cosmic dust particles are synthesized from a hot vapor in a specially designed experimental chamber and its nucleation environment is observed by means of a double-wavelength Mach–Zehnder-type laser interferometer. The deviation of the interference fringes tell us the nucleation temperature and concentration, which are similar nucleation conditions of natural cosmic dust particles formed around evolved stars such as supernovae and asymptotic giant branch stars [1]. After the experiment, the S-520 rocket fall onto the Pacific Ocean and sink into the water together with the produced particles. Based on the result of this in-situ observation, nucleation theory determines either sticking probability or surface free energy. Both physical parameters of nanometer sized particles are crucial to expect formation of cosmic dust particles. Nevertheless, we have only a data of bulk surface free energies and expect one for sticking probability to discuss material evolution in the universe. In a previous project using the sounding rocket S-520-28, we succeeded to determine a sticking probability of iron nanoparticles and show the difficulty of the formation of metallic iron dust in the ejecta of a supernova [1]. If we could recover the produced particles, surface free energy can also be determined after measurement of the particle size using a transmission electron microscope. Then, formation of cosmic dust particles can be expected more precisely using nucleation theories and our insights on the material evolution accompanying with stellar life will be deeper.
In addition, time-resolved infrared spectra of the particles during nucleation and growth under the microgravity environment have also been measured to understand the origin of infrared features astronomically observed. We succeeded to observe infrared spectra of alumina particles in intermediate state in a project using the sounding rocket S-520-30. Unfortunately, however, the polymorph of the produced alumina particles could not be determined because the sample is into the deep ocean. Currently, to recover the sample and payload after sounding rocket experiments, we have to find international corroborators in US or Europe. Actually, we and other Japanese scientific teams are making working groups and started projects of international collaborations under some complex systems. If a flying boat will be served in a Japanese scientific community and can be used to recover the payload, our characteristic sciences in Japan will be opened up more easily and progressed more rapidly.

[1] Y. Kimura, K. K. Tanaka, T. Nozawa, S. Takeuchi, Y. Inatomi, Pure iron grains are rare in the universe, Science Advances, 3 (2017) e1601992. DOI: 10.1126/sciadv.1601992..

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