AGREEMENT OF EXPERIMENT AND THEORY IN HOMOGENEOUS NUCLEATION.

Y. Kimura[1]*, K. K. Tanaka[2], H. Miura[1] and K. Tsukamoto[1]. [1]Tohoku University. E-mail: ykimura@m.tains.tohoku.ac.jp. [2] Hokkaido University.

Introduction: Classical nucleation theory has been widely used to describe dust formation in ejecta gas from evolved stars, supernovae and possibly in a plume after energetic shock in primitive solar nebula, whereas the classical theory always has large gaps with experiments. For example, homogeneous nucleation rates of droplets were measured as a function of temperature and supersaturation using ethanol and nonane [7, 8]. They calculated temperature and supersaturation ratio in the chamber from the initial temperature and pressure, and homogeneous nucleation rate was determined after the drops have grown to visible size to count the number after taken by camera. The nucleation rates were different in several orders of magnitude from the classical nucleation theory. Recently, it has been shown that semi-phenomenological nucleation theory, which was proposed by Dillmann & Meier (1991) [3], can explain the result of molecular dynamic simulation of nucleation at relatively low temperature for liquid and solid [4,5]. We made a new chamber with interferometer to measure the homogeneous nucleation environment and compared actual number of formed particles with that calculated by semi-phenomenological nucleation theory.

Experiments: The newly constructed smoke chamber can produce nanometer sized particles via homogeneous nucleation after vaporization of a starting material. Mach-Zehnder type interferometer is also prepared together with the chamber and it can detect the changing of temperature and gas density as a difference of an optical path length. The interferometer is able to detect a small difference of refractive index as small as 10^{-6}. Using the non-contact method, homogeneous condensation temperature and supersaturation of smoke particles are directly determined. The size and number of produced particles were observed by transmission electron microscope and compared with the calculated values.

Results: Preliminary experiment using manganese demonstrated that semi-phenomenological nucleation model shows good agreement with the experiment for the nucleation temperature, size and number of formed particle, when we give initial temperature, pressure and time scale of supersaturation increase for nucleation from the experiment. Accordingly, we conclude the semi-phenomenological nucleation theory is useful for describe nucleation events even at such relatively higher temperature environments. Sticking coefficient and the surface free energy at the temperature of super cooling, i.e., lower than equilibrium temperature, can be obtained from the experiment and calculation. Those values are applicable to dust formation.

References: [1] Schmitt, J. L., Adams, G. W. and Zalabsky R. A. 1982. *J. Chem. Phys.* 77:2089-2097. [2] Adams, G. W. Schmitt, J. L. and Zalabsky, R. A. 1984. *J. Chem. Phys.* 81:5074-5078. [3] Dillmann, A. and Meier, G. E. A. 1991. *J. Chem. Phys.* 94:3872. [4] Tanaka, K. K. et al. 2005 *J. Chem. Phys.* **122**, 184514. [5] Tanaka, K. K., Tanaka, H., Yamamoto, T., Kawamura, K. 2011. *J. Chem. Phys.* 134, in press.