CONDENSATION TAKES PLACE IN FAR FROM EQUILIBRIUM CONDITION

Y. Kimura[1]*, K. Tsukamoto[1] and T. Maki[2]. [1]Tohoku University. E-mail: ykimura@m.tains.tohoku.ac.jp. [2] Olympus Corporation.

Introduction: When cosmic dust particles are formed directly from gas phase in homogeneously, it must condense under super- or hyper- cooling in nonequilibrium state. This situation should be common in ejecta gas of evolved stars, supernovae and possibly in a plume after energetic shock in primitive solar nebula. Therefore, nucleation and growth conditions of nanoparticles should be understood to model the evolution of cosmic dust particles, which are actually nanometer order. Nevertheless, there is no quantitative data, such as degree of supersaturation, condensation temperature and waiting time for nucleation, concerning a homogeneous condensation from a gas phase.

Here, we will show a first achievement of in-situ visualization of nucleation and growth environments of smoke nanoparticles using Mach-Zehnder type interferometer. Using the noble non-contact method, homogeneous condensation temperature and supersaturation of smoke particles are directly determined.

Experiments: One of the best methods of producing dust analogues in gas phase is the smoke experiment, which is termed the gas evaporation method. When an evaporant is initiated in an inert gas, rising smoke from the evaporation source can be observed. The evaporated vapor subsequently cools and condenses homogeneously in the gas atmosphere, i.e., solid particles are obtained directly from the gas cloud [1].

We constructed a new smoke chamber attached with specially designed optics, which can detect the difference of refraction index of gas atmosphere as small as 10^{-6}. For preliminary experiment, we make a WO_3 smoke by heating of a tungsten wire with 0.2 mmϕ and 70 mm depth in a mixture gas of Ar (9×10^3 Pa) and O_2 (1×10^3 Pa).

Results and discussion: Tungsten has been evaporated as oxide at the source temperature ~1400^{o}C, which measured by pyrometer and occasionally thermocouples for double check. Evaporated oxide molecules are subsequently cooled following the convection current produced by hot source and WO_3 particles have been condensed and formed the smoke. Since there is no heterogeneous nucleation cite, solid grains were obtained homogeneously from the gas cloud. Therefore, quite high supersaturation environment has been required to condense. The evaporated tungsten oxide vapor is concentrated at the interface between interior WO_3 vapor rich atmosphere and outer mixture gas. Their condensation temperature can be determined from the interferogram and is as low as 600^{o}C, which is significantly lower than their equilibrium temperature. We analyzed the produced smoke particles using TEM and recognized the formation of WO_3 single crystal nanoparticles with 20-200 nm in diameter. This first achievement suggests the difficulty of homogeneous condensation of cosmic dust particles.

References: [1] e.g., Kimura, Y. et al. 2008. *ApJ.* **684**:1496-1501.