微小重力下におけるアルミナの均一核生成過程の赤外スペクトルその場測定
In-situ IR measurement in homogeneous nucleation process of alumina under μG environment

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Homogeneous nucleation process from vapor is characterized by the ratio between time scales for supersaturation increase and for source collision expressed as Λ[1]. Under the physical condition with the same Λvalue, homogeneous nucleation process has been regarded to follow the same process. At the dust forming front around evolved stars, Λvalue has been calculated to be $\sim 10^{3-5}$ from total pressure and velocity of stellar wind. In contrast, Λvalue of $\sim 10^{0-2}$ is known for the gas evaporation method which is one of the simplest experimental methods to produce dust analogues via homogeneous nucleation [2, 3].
In-situ IR measurement during nucleation of nanoparticles in the gas evaporation method proved multi-step formation of metal oxide from vapor to crystalline via liquid droplet in our ground based experiment [4]. Using our advanced technique, we measured IR spectra of nucleating alumina and its evolution while nanoparticles are free-flying under μG environment in which Λapproximates to the value at dust formation region. Specially designed experimental apparatus equipped with dispersive IR spectrometer was loaded to S-520-30 sounding rocket by which the apparatus carried to altitude of 312 km. We also performed ground based experiment combined with FT-IR.
IR spectra of nucleating alumina measured in ground based experiment showed broad absorption extending >11 μm. Formed nanoparticles were observed by TEM and identified to δ-alumina. In contrast, sharp absorption centered at 13 μm was appeared in μG experiment. This 13 μm band is one of the most indicative features of corundum (α-alumina) sphere. Corundum is the most plausible candidate for the origin of unidentified 13 μm feature which is often observed for oxygen rich AGB stars with low-mass loss rate [5, 6]. Polymorphic behavior of alumina in homogeneous nucleation process at different Λwill be the key to understand astronomical dust formation.

Reference

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