Nucleation in nonideal rapidly cooling vapor

Perevoshchikov E E and Zhukhovitskii D I[@]

Joint Institute for High Temperatures of the Russian Academy of Sciences, Izhorskaya 13 Bldg 2, Moscow 125412, Russia

[@] dmr@ihed.ras.ru

Injection of the high energy density into condensed matter leads to formation of the regions of dense expanding plasma, where it rapidly cools down. As a result of recombination, neutrals are released, which leads to nucleation associated with the formation of liquid or solid microparticles. Such a process can occur in formation of submicron dust component in the complex plasma. Non-ideality of the vapor at binodal and, in particular, in the metastable region is largely due to formation of the clusters consisting of less than ten monomers. Thus, the universal cluster vapor equation of state obtained in [1] within the framework of the two-parameter nucleation model [2] shows the best agreement with molecular dynamics (MD) results. In this work, we develop an analytical approach to the kinetics of nonstationary nucleation taking into account the non-ideality of the condensing vapor and the size dependence of the cluster surface tension [1]. In particulaar, we show that the difference between the proposed theory and the classical nucleation theory increases with decreasing cooling rate. The proposed theory predicts the presence of a metastable state while the classical nucleation theory indicates a labile state. The analytical results are in qualitative and quantitative agreement with MD simulation for the nucleation in Lennard–Jones system at a fixed cooling rate. Under conditions of rapid cooling in the absence of a carrier gas, MD simulation reveals qualitative differences in the evolution of the system as compared to the isothermal case. For a dense system, formula for the critical cluster size yields highly overestimated result due to superheating of larger clusters.

[1] Zhukhovitskii D I 2016 *J. Chem. Phys.,* **144** 184701

[2] Perevoshchikov E E and Zhukhovitskii D I 2024 *JETP* **65** (in press)