NUCLEATION OF THE DENSE HOT VAPOR UPON ITS RAPID COOLING

Perevoshchikov E.E.,[1,2] ***Zhukhovitskiy D.I.***[*1]

[1]*JIHT RAS, Moscow, Russia,* [2]*MPEI (TU), Moscow, Russia*

[*]*dmr@ihed.ras.ru*

The input of high energy density in the condensed matter results in formation of the regions of the dense expanding plasma, where plasma undergoes rapid cooling. The resulting recombination produces neutrals that can nucleate to form liquid- or solidlike microparticles. Similar processes can occur in the nucleating alkali metal plasma under the near-critical region conditions. In this work, the size and number density of the produced microparticles as well as other nucleation parameters are estimated.

We assume that vapor nonideality at the binodal and, in particular, in the metastable region, is largely due to the formation of clusters comprising less than ten monomers. Thus, this region is sufficiently separated from the critical cluster region, where the typical critical cluster size is about dozens and more, and the metastable state of the vapor is formed. Under such conditions, the number density of monomers that defines the nucleation rate can be noticeably decreased due to the cluster formation. To solve the nucleation problem, we integrate the moment equations [1], and the effects of the vapor density and the cluster surface tension size dependence are taken into account within the framework of the two-parameter model [2]. We demonstrate that the difference between the results of our theory and the classical nucleation theory neglecting both the density and cluster size effects is increased rather than decreased as the cooling rate is decreased. For the first time, we have found the conditions under which our theory predicts a metastable state while the classical nucleation theory points to a labile state. The analytical results are in a qualitative and quantitative agreement with the molecular dynamics simulation of transient nucleation in the Lennard-Jones system for the fixed cooling rate.

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