Condensation shock wave in supersaturated gas

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For continuous modeling of the volume condensation process in a high-speed metastable gas flow, kinetic models of cluster formation, as well as condensation and evaporation on nanoscale liquid droplets are required. Due to the limitations and inaccuracy of such models, it is sometimes preferable to use the direct molecular dynamics (MD) modeling method to obtain reliable results [1].

In our work, we consider the process of volume condensation of supersaturated pure argon, as well as argon-neon mixture, when they inflow with supersonic speed in a long straight channel of constant cross-section. The atoms are removed at the end of channel, and a steady-state flow regime, in which the spatial profiles of the quantities do not change over time, is gradually established for each initial temperature. Then the simulation data is accumulated and averaged over time, which makes it possible to obtain accurate profiles of the temperature and velocity of two-phase flow, as well as to track the evolution of the cluster size distribution.

It is shown that the gas temperature and pressure increase downstream due to cluster formation, which leads to slow deceleration of the flow. Thus, the local sound speed increases within the flow, and may become less than the local flow speed. This creates a condition for formation of a stationary shock, which sharply slows down and heats the compressed gas.

[1] V. Yu. Levashov, V. S. Tereshkin, V. V. Zhakhovsky, "Cluster formation at nonequilibrium evaporation of argon into its gas phase in the presence of an incondensable component", accepted for publication in *Fluid Dynamics* (Mekhanika Zhidkosti i Gaza, 2026).