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WATER VAPOR NANOBUBBLES UNDER NORMAL CONDITIONS

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The hydrodynamic stability of a water vapor nanobubble in water under normal conditions is investigated. The hydrodynamic equation describing the motion of the nanobubble boundary taking into account the nanobubble charge and the dependence of the surface tension coefficient on the radius, as well as the heat balance equation of the nanobubble are used for the study. Taking into account the nanobubble charge leads to a competition between capillary and electrostatic forces, which affects the hydrodynamic stability of the nanobubble. The main equations are written down and an analysis of the stability of small disturbances is carried out. The characteristic equation is obtained and the stability conditions of the nanobubble are determined. It is shown that the radius of a stationary nanobubble is equal to the Tolman radius, since at this radius its energy is minimal. The value of the surface charge density and the charge of a vapor nanobubble in water are determined.

To date, the question of the existence of water vapor nanobubbles in water under normal conditions (NC) remains unclear. From a theoretical point of view, the emergence and existence of nanoscale vapor bubbles is described by the theory of homogeneous nucleation, where the nucleation condition is determined by the dependence of the difference in the Gibbs free energies of water and vapor on the size of the nucleus [1 - 3].

In order to experimentally clarify the existence of water vapor nanobubbles in water, atomic force microscopy, rapid cryofixation, neutron reflectometry, and direct optical imaging were used. The results of the studies showed that nanoscale bubbles form in the form of bridges that adhere to a solid surface.

In the work to substantiate the hydrodynamic stability of a water vapor nanobubble at NC, hydrodynamic equations were used that describe the motion of the nanobubble boundary taking into account the nanobubble charge and the dependence of the surface tension coefficient on the radius.

The heat balance equation of a nanobubble was also used. The presence of a bubble charge introduces changes in the dynamics of nanobubble formation, because there is a competition between capillary and electrostatic forces.

A characteristic equation for small perturbations of the nanobubble parameters was obtained and its stability was analyzed on its basis. It was shown that the radius of a stationary nanobubble is equal to the Tolman radius, since at this radius its energy is minimal. The surface charge density and the overall charge of a vapor nanobubble in water were determined. It was shown that nanobubbles formed as a result of homogeneous nucleation are stable.

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