CALCULATION OF THERMAL RADIATION OF DROPS FORMED AT AN IRRADIATION OF METAL TARGETS BY HEAVY ION BEAMS

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ABSTRACT: The kinetics of metastable metallic states is part of the general problem of the correct description of first order phase transitions and therefore, is of great scientific interest. However, complete theory of metastable state which are in principle non-equilibrium states is absent. Nevertheless, classical researcher of thermodynamic stability of metastable states has been done still by Van der Waals and Maxwell models. The further success in the description of nonequilibrium states at phase transition has been received by means of methods of physical kinetics. In particular, Ya.I. Frenkel and Ya.B. Zeldovich obtained a kinetic equation of the distribution function of drops size. The effective solution of this equation is based on the temporal hierarchy at different nucleation stages. E.M. Lifshits and V.V. Slezov developed a theory for growth of big drops at the final stage of the phase transition due evaporation of smaller droplets. The direct modeling of the metastable states and kinetics of phase transition were done with the use of Monte-Carlo and molecular dynamics methods.

Theoretical approaches for the description of non-equilibrium phase states requires experimental verification of the kinetic models used in the theory. In general, experimental shock-wave data do not provide information on temperature, which is very important parameter for kinetic description of nucleation. So it is necessary to use other methods for generating these states. Intense heavy ion beams provide novel and very efficient tool that generates high energy density states by action on solid metallic targets. In such experiments, physical parameters of the sample including density, pressure and temperature are directly measured. Temperature measurements by means of pyrometry has been developed at IPCP (Chernogolovka) that has already been used in preliminary experiments.

The intensity of the beam that is currently available is sufficient to generate biphasic liquid-gas state in metallic targets. The thermal radiation made by liquid metal droplets which are in contact to their metastable (overcooled) steam, belongs to a visible and infra-red spectrum. Study of its characteristics requires information about the kinetics of the nucleation, defining quantity of viable droplets.

It is to be noted that due to incompleteness of the physical picture of the formation of the thermal radiation took place in hot biphasic liquid-gas media, a number of important practical problems have not yet been solved. For example, the abnormally high thermal radiation of Na vapors in the close infrared spectrum leads to inexplicable energy loss (20-30%) in Na high-pressure lamps. Anyway, it is obvious that one of the possible mechanisms responsible for the high emissivity at low-temperature and, as a consequence, non-ionized and optically transparent metallic vapors, is the formation of droplets. The reason of formation of these drops is overcooling of metals steams as a result of adiabatic expansions.

In this work we present numerical modeling of kinetics of droplets growth and thermal radiation from such droplets that are produced by irradiation of thin metallic foils by intense heavy ion beam. A numerical method has been developed to solve the problem of estimating the effective brightness temperature of a vapor-droplet medium. This method provides correct description of the droplets kinetics in overcooling vapor formed in result of heavy ion beams action on metallic foils. Calculation results of effective brightness temperature are represented for lead foils being under action of heavy ion beams having continuance 300ns and specific absorption energy 2kJ/g.