PLASMA PHASE TRANSITION IN COMPLEX SYSTEMS

Saitov I.M.

[1]*JIHT RAS, Moscow, Russia,* [2]*HSE, Moscow, Russia,* [3]*MIPT, Dolgoprudny, Russia*

saitovilnur@gmail.com

In the literature, the plasma phase transition (PPT) [1–3] is considered mainly as a possible mechanism of the phase transition in a nonideal hydrogen plasma and warm dense hydrogen [4–6], which may give the impression that the PPT is associated exclusively with hydrogen. However, this is not the case, although the PPT in the plasma of other substances was in the shadow compared to hydrogen. A brief review of the current state of the PPT in plasma of other substances is presented in this work. Helium, helium-hydrogen mixture, aluminum, cesium, cerium, silicon, ionic and exciton plasma are considered.

The possibility of PPT in helium was first demonstrated theoretically in [7] within the framework of a chemical plasma model. In contrast to hydrogen, in helium, two PPTs are predicted, associated with the gradual ionization of helium atoms. The possibility of PPT is also considered in a mixture of helium and hydrogen in [8]. In this case, two PPTs arise, associated with the ionization of hydrogen atoms at low pressures and the ionization of helium atoms at high pressures.

In [9], a density jump was found in an aluminum plasma on the 17400 K isotherm at a pressure of 8 GPa, the magnitude of which is 0.35 g/cm^3. The low-density state corresponds to a plasma with an average charge of 1.2, consisting of various aluminum ions with charges from 1 to 3 and containing no neutral atoms. In a state with a high density, the outer shell of aluminum ions is completely ionized, and the average charge of the ions is 3.

The PPT in cesium was predicted theoretically in [10] with a critical point at a temperature of 6400 K, a density of 5.3 g/cm^3, and a pressure of 6.1 GPa. The estimates made showed that this transition is observed in a degenerate nonideal plasma in the region where there is a sharp change in the average charge from 1.5 at a density of 3 g/cm^3 to 3.5 at a density of 6.5 g/cm^3.

The liquid-liquid phase transition in silicon, coupled with a sharp increase in the average atomic charge from 3 to 4, was predicted in [11]. A density jump was found on the 11600 K isotherm at density 1.5 g/cm^3. In this case, a sharp increase in electrical conductivity is also observed and structural changes occur associated with a decrease in the average distance between atoms due to an increase in the average charge. Thus, the mechanism of this phase transition can be related to the PPT.

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