Plasma phase transition (*by the fiftieth anniversary of the prediction*).

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The plasma phase transition was predicted in 1968 by analogy with the van der Waals equation [1]. Besides, for isotherms of pressure dependences on density, strong overlapping in the density of the equilibrium branch of one phase with a metastable branch of another phase are predicted [2], in contrast to the van der Waals equation. The third prediction [3] is a triple point on the melting curve [4]. Estimates [1-3] are obtained within the framework of the chemical model, where the ionization equilibrium equation is used with the corrections for the nonideality of the system of free charges. Over the next decades, this approach was developed: on the one hand, new components were included in the chemical model, in addition to electrons and ions, considering interactions between all components, on the other hand, the nature of accounting for these interactions was clarified. See brief reviews in [5,6].
The first experimental results, which could be interpreted as an experimental detection of the plasma phase transition, appeared only in the last decade (see references in [6]). The measurements are carried out with warm dense hydrogen in both shock waves and diamond anvil cells. At the same time, the theory began to use methods based on the theory of density functional. The properties of warm dense hydrogen are investigated by ab initio methods of molecular dynamics and quantum modeling using the density functional theory and quantum Monte Carlo theory. A first-order phase transition is observed. The coexistence curve is close to the measured one. There are different approaches for the description of the nature of the transition. The first assumption is related to the metallization of hydrogen under the influence of the work of Wigner and Huntington in 1935. The alternative one is the pressure dissociation of $H_2 \rightarrow 2H$. The plasma phase transition is also mentioned.
In [6], the idea is introduced that during the fluid-fluid phase transition in the warm dense hydrogen, the H_2 molecules are ionized to form the molecular ions H_2^+ and H_3^+. Thus, a plasma phase transition occurs with partial ionization of H_2 molecules and the formation of H_2^+ ions. H_3^+ ions are formed because of the reaction of H_2^+ ions with H_2 molecules. The nature of the transition combines ionization with structural changes. Strong ionization during the fluid-fluid phase transition in warm dense hydrogen makes this transition close to the prediction of the plasma phase transition [1]. Strong overlapping of metastable states corresponds to prediction [2]. The triple point is expected to be on the melting curve as in [3].
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