On thermodynamics of the Coulomb plasma systems - from quantum theory to classical description

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The general structure of the perturbation theory series for the observable thermodynamic functions of the purely Coulomb quantum system of electrons and point ions is considered. In the classical limit, when the Planck's constant $\hbar \to 0$, some terms of the perturbation theory series diverge (see, e.g., [1]). The sum of the whole row cannot be found. The physical reason for such divergence is obliged to the impossibility of maintaining the stability of a purely classical system of different charges attracted to each other. At the same time, it is known that in a certain range of parameters, the models of the pure Coulomb systems of charges do not contain the Planck's constant and describe experimentally observable variables with a good accuracy. It is shown that the transition to a purely classical description, which implies the limit $\hbar \to 0$, is impossible (compare, e.g., with [2]). However, the terms of the series containing $\hbar$ are small for certain plasma parameters and can be discarded. This approch precisely explains the use of classical models and approximations to describe plasma in certain parameter ranges. We suppose that the similar situation exists for the kinetic properties of the pure Coulomb system of different charges. On this basis, a hypothesis (theorem) is formulated about the absence of the formal classical limit (when for quantum observable functions the limit $\hbar \to 0$ is applied) for all measurable thermodynamic and kinetic properties of the Coulomb plasma systems, in which point particles interact according to the Coulomb law and, therefore, there are no any fitting parameters.

[1] Hoffmann H and Ebeling W 1968 *Physica* **39** 593
[2] Trigger S 2010 *Physics Letters* **91** 66003