The evolution of ultracold Coulomb plasma

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In supercooled ( nonideal ) classical Coulomb system recombination due complex many-particle interaction , which is a result of its sharp slowdown . This phenomenon of slowing down the rate of recombination , as well as many other processes have been investigated by molecular dynamics in a series of papers in 1986 - 1996 years (see [1 - 2] ) . Discovered a new state of the Coulomb system in which plasma is recombined according to the known law of 9/2 at low temperatures. This state of the classical Coulomb system has been called a metastable supercooled plasma. While not exist in nature physical object consisting of charged-particle, which would satisfy the condition of strong-coupling . Therefore, despite the active discussion found plasma state and remains at the level of the computing artifact.

But in 1999, with selective laser ionization of xenon atoms supercooled state was obtained metastable supercooled Coulomb plasma, for 10 years prior to that observed in the numerical experiment . Then followed a series of papers, both experimentalists and theorists to study the properties of a new physical object , called an ultracold plasma (ultra cold plasma - UCP). Were rediscovered and reconfirmed many of the results obtained in 10-20 years earlier.

In this paper, based on the molecular dynamics calculations , studied the evolution of ultracold plasma at the initial stage , when a cloud formed after photoionization immobile atoms and electrons occupies a fixed volume.

Formation of metastable state passes through a phase of slow recombination fill their bouded ion- electron states. Ultracold neutral system charged particles (plasma cloud in trap), formed by the selective ionization of cold atoms, in the relaxation process passes through two stages. On the first, with little change in the density of the plasma is the formation of a metastable state. In which there is a balance between the free electrons and Rydberg atoms. Investigation of parameters and kinetic characteristics of this plasma is of fundamental problem because of the high degree of plasma coupling. In the second stage of evolution is an expansion of the plasma in the surrounding area, further hypothermia and possibly plasma phase transition to the crystalline phase. Most of the experimental work is devoted to the relaxation of the plasma is in its expansion in surround gas. We consider the relaxation of the plasma in the first phase, which is under experimental conditions correspond to the times of less than 1 microsecond. At this stage, without changing the plasma density due to the expansion. The main physical process is the established of quasi-stationary state of plasma.

We consider the time evolution of the strongly coupled Coulomb system, in which the total energy at the initial time is zero. By the molecular dynamic method is obtained the solution for a system of 2000 particles in the range of 8000 inverse plasma frequencies. It is shown that under conditions typical for experiments with ultracold plasma, the coupling parameter of such plasma can not reach high values nonideality due to the recombination heating.

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References

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