Modeling of the recombination in the expanding ultracold plasmas by the method of "scalable frames"

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The rate of recombination is, evidently, of crucial importance for the existence of ultracold plasmas [1]. Unfortunately, *ab initio* molecular-dynamic simulation of this process is a challenging task because of huge difference in the spatial and temporal scales for free and confined motion of the charged particles, which should be treated simultaneously with high accuracy if it is necessary to reproduce a capture of the electron by one of the ions. Moreover, the situation is further complicated if the entire plasma experiences a considerable evolution, *e.g.*, sharply expands into vacuum.
An efficient approach to solve this problem is using the Ewald-like system (where the entire plasma volume is composed of the identical cells) and employing the "scalable" reference frame, where each cell expands with the average rate of plasma expansion. This method was originally developed for the description of temperature evolution in the expanding ultracold plasmas [2] and subsequently found to be an efficient tool also for modeling the recombination [3].
It is the aim of our report both to outline the basic idea of the "scalable frames" and to present the most recent results of its application to the problem of recombination.

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[2] Dumin Y V 2011 *Plas. Phys. Rep.* **37** 858
[3] Dumin Y V, Svirskaya L M and Savinykh E S 2026 *AIP Advances* **16** 055110