Structural properties of strongly coupled ions in quantum plasmas

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Despite recent advances in modeling and computer simulations, a fully self-consistent treatment of highly nonequilibrium electron-ion plasmas has not been possible so far due to the requirement of the simultaneous account of electronic quantum effects together with the strong ionic correlations. The main problem here is the vastly different time scales of electrons and ions resulting from their different masses. A possible solution of this dilemma is a multi-scale approach based on a screened ion potential with a linear response treatment of the electrons [1]. Recently, going beyond the random phase approximation [2], we have performed an analysis of the screened ion potential in the case of non-ideal quantum electrons by making use of local field corrections which are determined on the basis of the Singwi–Tosi–Land–Sjölander approximation (STLS) [3] and Quantum Monte Carlo data [4]. From the analysis of the structural properties of strongly coupled ions on the basis of different screened ion potentials [5, 6], the region of densities and temperatures where the STLS description of screening by partially (or totally) degenerate electrons can be used for the calculation of the structural properties of ions were determined. It was found that correlations (non-ideality) of the electrons result in a larger isothermal compressibility of the ions due to the stronger screening of the ion charge. Additionally, calculations using different screened potentials clearly show that strongly coupled ions can be very sensitive to the shape of the pair interaction potential and, therefore, to the approximation used for the description of screening by electrons.

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