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Phase space path integral simulations of momentum distribution functions and thermodynamics of strongly coupled quantum plasmas

Filinov V S[2] and **Larkin S A**[1]

[1]Joint Institute for High Temperatures RAS, Russia

[2]Moscow Institute of Physics and Technology, Russia

Quantum effects may affect equilibrium momentum distribution functions making them non-maxwellian. For example, exchange effects lead to Fermi-Dirac or Bose-Einstein distributions in systems of non-interacting particles. On the other hand, interaction between particles restricts available for particle volume and could result in broadening of momentum distribution due to Heisenberg principle. This effect may strongly influence the reaction rates and may be important in studies of combustion, detonation and even nuclear fusion. Under extreme conditions systems of particles are usually strongly coupled and perturbative approaches are not applicable. Therefore, ab initio non-perturbative methods for calculation of momentum distribution functions are required. In our work we use path integral representation for Wigner function and propose two Monte Carlo methods for studies of momentum distribution functions of degenerate non-ideal Fermi systems. In the first method to obtain explicit expressions for Wigner functions we take into account pair exchange interaction of fermions and linear or harmonic local approximations of interparticle potential. The second method (single-momentum) is based on reduced Wigner function, integrated over all momenta except several few. Both methods have been tested on simple models: one particle in different external potential fields and ideal Fermi gas. Results are in good agreement with available analytical and numerical data. Then momentum distribution functions for a two component degenerate plasma media have been investigated. Quantum corrections to Fermi and Maxwell distributions in form of "power - low tails" have been found.

vladimir_filinov@mail.ru