Electron–plasmon approach in the electron–liquid theory

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The coexistence of individual and collective electron excitations in metallic systems is the physical basis for the formulation of the renormalized perturbation theory in terms of electrons and plasmons. Such perturbation theory was proposed to calculate energetical, structural and dielectric characteristics of the electron–liquid model for a wide range of Wigner-Brakner's parameter r_s.

At low temperatures the effective Hamiltonian consists of the Hamiltonian with a renormalized electron spectrum and short–range interactions, the Hamiltonian of anharmonic plasmons and the operator of weak non–local electron–plasmon interactions. Unlike conventional perturbation theory, zero–order approximation Hamiltonian is the Hamiltonian of free electrons and non–interacting plasmons. As a result, a renormalization of the Coulomb interactions, fast convergence of the perturbation theory and the absence of divergent diagrams were obtained. As a test it was shown that the correlation energy in the RPA approximation for electrons and plasmons (summing of non–divergent diagrams), match the Gell-Mann–Brueckner's result.

In this approach correlation energy, structure factor, binary distribution function and the local field correction function of the electron–liquid model were calculated for $1 \leq r_s \leq 40$. It has been found that the calculated correlation energy agrees with the results of Monte Carlo simulations better than all other semi–analytical approaches. The obtained behaviour of the binary distribution function proved the accuracy and effectiveness of the proposed approach. Partial contributions of electrons and plasmons were investigated in different ranges of the parameter r_s.

Electron - plasmon approach, considered in this work, was generalized in case of the electron–ion model of metal.