The electric field of an electron in a electron-hole plasma with degenerate electrons

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We consider the conditions for formation of a superconductivity state either in a semiconductor or in an electron-hole plasma with the degenerate electrons due to the attractive forces between the electrons as a result of the exchange effects through the electron-hole sound wave by analogy to the phonon waves in a solid state. One of the major unsolved problems of the superconductivity theory is determination of the static potential of a point electron. We have determined the view of an interaction potential between two electrons in a degenerate electron-hole plasma (1) with non-degenerate holes. The potential appears to be attractive at distances large than the Debye radius and decreases as $1/r^3$, See Fig.1. We discuss the conditions at which the bound electron state - Cooper Pair in a such field can be formed. The interaction potential of two electrons $\alpha$ and $\beta$ in a electron-hole plasma can be described by the following equation [1]:

$$U(r) = \int e^{i\vec{k}\cdot\vec{r}} U(\vec{k}) d\vec{k}, \quad U(k) = \frac{e^\alpha e^\beta}{2\pi^2} \frac{1}{k^2 e'(kV_\alpha, k)}$$

where [2]

$$k^2 e'(kV_\alpha, k) = k^2 + \frac{3\omega^2}{V_{F-}^2} - \frac{\omega^2}{V_\alpha^2} + \alpha \beta, \quad \beta = \frac{3\pi V_\alpha \omega L^-}{V_{F-}}$$

here $V_\alpha$ is the speed of a test electron with the charge $e_\alpha$ producing the potential $\phi_\alpha$ at a point $r = 0$ where the charge $e_\beta$ is located; $V_{F-}$ - the speed of a weakly damped electron-hole sound wave, $\omega_{L+}, \omega_{L-}$ - the hole and electron Langmuir frequencies.

References


Figure 1: The potential (1) where the integration till the $k \leq \frac{1}{r_{De}}$ was performed, here $R = \frac{r}{r_{De}}$