Contribution ID: **74** Type: **Oral**

The Effect of Space Dispersion on Polarization Field at Channeling in Nanotube

Wednesday, October 8, 2014 10:30 AM (15 minutes)

The paper is devoted to analysis of influence of spatial dispersion on a point charge imagination near a surface of a dielectric or a metal. The charge imagination sufficiently well describes the polarization field which occurs near a surface in the presence of the external point charge. Usually, in classical electrodynamics (see, e.g. [1]), this problem is solved without taking into account the spatial dispersion. As a rule, in this theory the maximal bond energy between the external charge and the image tends to infinity when the charge tends to the surface. We try to investigate which significant corrections should be made if the medium obey the spatial dispersion. Consider first the calculation of the interaction of a point charge with an uniform semi-infinite dielectric medium with a flat surface, based on the concept of the surface elementary excitations of electric type (field of surface plasmons). In this case, we go beyond the classical electrodynamics. At small distances of the order of de Broglie wave length of electrons on the Fermi surface of a solid the image charge isn't point (in opposite to the external charge). It is displaced in the volume with the characteristic size of de Broglie wave length. In particular, within the model dielectric permeability approach with the cut-off in the momentum space the potential energy of interaction between the external charge and the image obeys the regular behavior. In the neighborhood of the minimum the potential has a more complex behavior than it can be anticipated. In particular, the first derivative in the normal direction don't equal to zero at the boundary. Consider now a case of a dielectric/metal tube. In this case we assume the external point charge is moving with the constant velocity in the inner part of a tube parallel to the tube's axis. At the presence of spatial dispersion, when the Fourier components of the dielectric function depends on the all components of the wave vector, the expressions should be changed. Here we will present a some general consideration. But within an used simplest dispersion model with the cut-off we could transform the cut-off in the wave vector space into an equivalent cut-off in the angular momentum space. Therefore to any critical wave vector correspond the appropriate critical angular momentum. This angular momentum depends on the distance from the tube's axis. The momenta which exceed the critical value, should be excluded from calculations of the polarization potential as in the inner as well as in the outer part of the tube. In result the image charge should be the more smooth the less the radius of a tube.

References

1. J. Jackson, Classical Electrodynamics, J. Wiley & Sons, New York, London, Sydney, 1962.

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Session Classification: S4: Charged Beams Shaping