Accounting for the local field when determining the dielectric loss spectra in metals under conditions of 1D, 2D and 3D confinement

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The effect of dipole-dipole interactions of free electrons on the spectral characteristics of simple metals and their nanoparticles is analysed using Drude theory and the model of the Lorentz local field under conditions of one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D) confinements. It is established that accounting for the dispersion of a local field under conditions of 1D confinement based on the optical constants of the bulk metal allows the determination of its spectral micro-characteristics in the frequency region of the longitudinal collective motions of the free electrons. This corresponds to the spectra of the dielectric losses of bulk plasma oscillations. A similar procedure for three-dimensional (3D) confinement produces the spectrum of dielectric losses at the frequency of localized plasma oscillations. Whilst accounting for the dispersion of a local field under conditions of 2D-confinment results in the spectrum corresponding to the surface plasma oscillation. Using a number of simple metal examples viz., Li, Na, K and also Al, Be and Mg, it is shown that the frequencies of volume and localized plasma oscillations obtained from a model of dispersion of the local field in the long-wave limit are in good agreement with the actual frequencies of the plasma oscillations of the corresponding metals and the absorption maxima of their nanoparticles with a radius of 2-20 nm. It is shown that the frequencies of the main mode of longitudinal plasma oscillations and the absorption frequency of localized plasmons are well described using the dynamic theory of crystal lattice vibrations.

The case of 3D confinement, expressed as a function $\varepsilon_2^{mic}(\nu_{3D})$, corresponds to the spectra of the dielectric loss of small spherical particles with a diameter, *d*, much smaller than the wavelength of the probing radiation ($d<<\lambda$) and demonstrates excellent agreement with the results of Mie theory and experimental data on absorption of metal nanoparticles.