

Low Frequency Tensor of Dielectric Permittivity of Dusty Plasma with Account of Dipole Moments of Granules

V.Grimal'skii¹, S.Koshevaya², A. Kotsarenko³, V.Mal'nev³, Eu. Martysh³

1. National Institute of Astrophysics, Optics and Electronics (INAOE), Puebla, Mexico

2. Autonomous University of Morelos, CIICAp., Av.Universidad, 62210, Cuernavaca, Morelos, Mexico

3. UNICIT, UNAM, Campus Juriquilla, Queretaro, Mexico

4. Physics Department, Taras Shevchenko Kyiv National University, Kyiv, Ukraine

According to many reports on physical properties of dusty plasmas, the granules may carry a comparatively large negative electric charge q that could reach up to 10^3 charges of electrons. In many cases the granules cannot be treated as spherical particles. They could be modeled rather as elongated ellipsoids or even needles. The corresponding electric dipole moments of the granules are of the order of $d \cong qL$ (L is a length of an elongated particle) [1]. For $L \sim 1 \mu$ we obtain that a dipole of the granule could reach $d \sim 10^4 D$. These dipoles rotate with a thermal frequency $\omega_T = \sqrt{T/J}$ (T is a temperature of granules that is equal to the temperature of ions or a buffer gas, J is a moment of inertia of the granule $J \cong ML^2$, M is a mass of the granule). Taking the granule mass $M \sim 10^{-11} - 10^{-12}$ g we obtain that $\omega_T \sim 10^2 - 10^3$ Hz. It is worth noting that there is a report even about $\omega_T \sim 10^4$ Hz [2].

In this communication we present the results of calculation of the low frequency part of the tensor of dielectric permittivity of the dusty plasma consisting of charged granules with dipole moments. We have calculated the tensor of polarizability of a system of rigid rotators in an alternating electric field by using the methods of quantum mechanics. The tensor of dielectric permittivity associated with the rotational motion of the granule-rotators could be obtained in the classical limit because a difference between the rotation levels $E = \eta^2 l(l+1)/2J$ is always very small in comparison with a temperature T .

The tensor of dielectric permittivity under consideration contains an imaginary part that results in appearance of a special type of the Landau damping that does not depend on a wave vector and takes the form $\gamma \sim \exp(-\omega^2 / \omega_T^2)$. This type of the Landau damping was firstly discussed in [3] where the tensor of dielectric permittivity of the electron – ion plasma with polar molecules as a neutral component has been obtained.

The above mentioned Landau damping results in a considerable absorption of the low frequency electromagnetic radiation near the frequency ω_T . It may also suppress the allowed vibrations of the dusty plasma that are close to ω_T . From the other hand, this mechanism of damping may be inverted and utilized for amplifying of the low frequency vibrations in the dusty plasma. It could be realized with the help of an external source of energy that creates a nonequilibrium population of the rotation levels or when a temperature of rotation of the granules becomes higher than a temperature of their translation motion.

1.D.D. Tskhakaya, P.K. Shukla, N.L. Tsintsadze, Electrodynamics and dispersion properties of a magnetized plasma containing elongated and rotating dust grains, *Zhur. Exper. Teor. Fiz.*, **120**, 340 (2001).

2.P.K. Shukla, A.A. Mamun, *Introduction to Dusty Plasma Physics*, IoP Publishing, London, 2002.

3.Solomon.Mulugeta and V. Malnev, Thermodynamic properties and waves in a dipole plasma, *J. Plasma Phys.*, **39**, 475 (1988).