Dusty plasma as a Left-handed Medium

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In 1968, Veselago [1] studied theoretically the electrodynamics properties of a medium having both negative dielectric permittivity $\varepsilon(\omega)$ and magnetic permeability $\mu(\omega)$ simultaneously and concluded such media must have surprising propagation characteristics in comparison with the conventional ones. These media were called the "left-handed materials" (LHM). In particular, they posses the reversal effects of the Doppler shift and the Cherenkov radiation. Such a medium was manufactured in form of a long line of the three-dimensional array of intersecting thin straight wires. The propagating modes of this line have the dispersion relation analogous to the usual plasma [2]. The anomalous optical properties of the LHM were discussed in [3].

In this communication we report the results of our study of the dispersion properties of the dusty plasma with ferromagnetic grains in the strong magnetic field H_0 when following inequality holds true $d_M H_0/T_0 >> 1$ (d_M is the magnetic dipole moment of a grain, T_0 is the grain system temperature). We also suppose that $H_0 >> 4\pi N_g d_M$ (N_g is the grain density number) that allows us ignore the influence of the magnetic field created by the magnetised grains. This system has the additional typical frequency $\omega_0 = (d_M H_0/J)^{1/2}$ associated with the small vibrations of the magnetic moments of grains around the direction of the magnetic field (J is the inertia moment of a grain).

The linearly polarised electromagnetic wave propagating along y-axis in our medium transversally to the constant magnetic field (z-axis). We have shown that this media have simultaneously negative ε and μ in the following range of frequencies: $\omega_0 < \omega < \Omega_e$, $\Omega_e = (4\pi N_e e^2/m_e)^{1/2}$ is the electron plasma frequency.

The left-hand side of this inequality depends on the magnetic parameters of grain and external constant magnetic field and its right hand side depends only on the electron density number. This allows us to make a statement that above-described system may be considered as a good candidate of the LHM with controlled parameters.

References

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