§18. Quantum Effects on Magnetization Due to Ponderomotive Force in Cold Quantum Plasmas

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The quantum effects on the magnetization due to the ponderomotive force are investigated in cold quantum plasmas. It is shown that the ponderomotive force of the electromagnetic wave induces the magnetization and cyclotron motion in quantum plasmas. We also show that the magnetic field would not be induced without the quantum effects in plasmas. It is also found that the quantum effect enhances the cyclotron frequency due to the ponderomotive force related to the time variation of the field intensity. In addition, it is shown that the magnetization diminishes with an increase of the frequency of the electromagnetic field[1].

The scaled electron cyclotron frequency $\bar{\omega}_c = \omega_c / \omega_{pe}$, where ω_{pe} is the plasma frequency of the electron, in cold quantum plasma can be expressed in the following form:

$$\bar{\omega}_c = \frac{1}{\pi\alpha^2}\left(\frac{Ry}{\hbar\omega_{pe}}\right)\frac{\lambda}{L}\beta_0{}^2 M(\bar{\omega},\bar{k}),$$

where α is the fine structure constant, Ry is the Rydberg constant, λ is the wavelength of the electro magnetic wave, L is the scale length of electromagnetic field $|\vec{E}|^2$, $\beta_0 = v_0/c$, and v_0 is the electron quiver velocity. The magnetization function,

$$M(\bar{\omega},\bar{k}) = \frac{\bar{k}^6}{\bar{\omega}(\bar{\omega}^2 - \bar{k}^2)^2},$$

is obtained as drawn in Figures 1 and 2, where scaled wave number $\bar{k} = k\lambda_{qe}$ (where λ_{qe} is quantum wavelength of the electron) used. This magnetization in quantum plasmas is due to the ponderomotive force related to the time variation of the field intensity. This magnetization function has been strongly suppressed as $\bar{k} \to 0$, i.e., diminishing the quantum effect. The magnetization cannot be happened in the cold classical plasmas. The quantum effect causes the magnetization and cyclotron motion in quantum plasmas. Thus, the magnetization due to the ponderomotive interaction can be used as a plasma diagnostic tool in quantum plasmas.

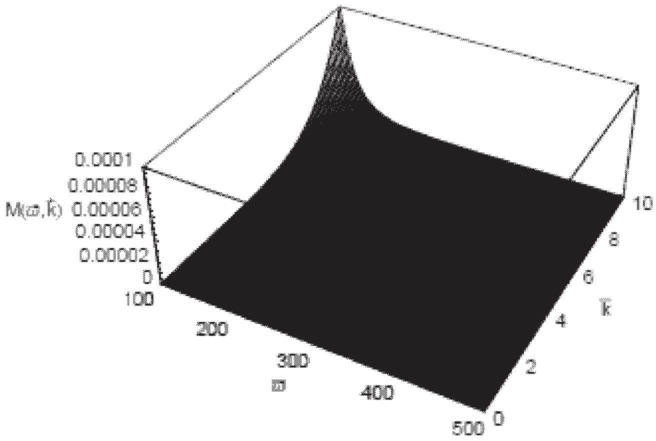

FIG. 1. The three-dimensional plot of the magnetization function $M(\bar{\omega},\bar{k})$ due to the ponderomotive force in cold quantum plasmas as a function of the scaled wave number $\bar{k}$ and scaled frequency $\bar{\omega}$.

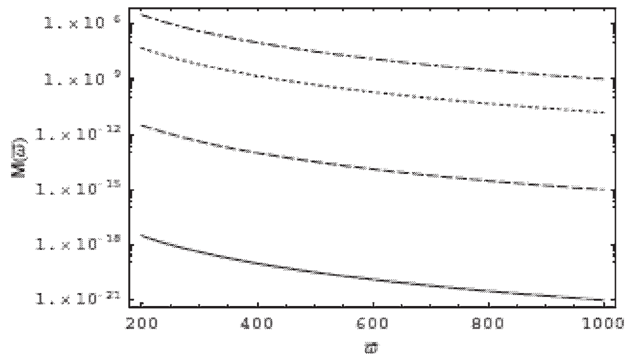

FIG. 2. The magnetization function $M(\bar{\omega})$ as a function of the scaled frequency $\bar{\omega}$. The solid line represents the case of $\bar{k}$ = 0.1. The dashed line represents the case of $\bar{k}$ = 1. The dotted line represents the case of $\bar{k}$ = 5. The dot-dashed line represents the case of $\bar{k}$ = 10.

1) Jung, Y.-D., Murakami, I.: Phys. Lett. A, **373** (2009) 969