A Quantum Mechanical Approach to the Study of Collective Modes in a Free Plasma Subjected to a Radiation Field.

Bruno V. Ribeiro, Daniel D. A. Santos
Instituto de Física, Universidade de Brasília - DF - Brasil

Marco A. Amato
Centro Internacional de Física da Matéria Condensada, Universidade de Brasília - DF - Brasil

In this study we report the effects of an electromagnetic radiation field on the physical properties of free plasmas. In order to carry out the calculations we proceed within the semi-classical approximation, *i.e.*, the electromagnetic field is treated classically and the electrons from a quantum mechanical viewpoint. A weak local potential is also assumed.
In this framework we obtained a implicit expression for the dielectric function. The collective modes of the plasma come about the zeros of the dielectric function and the results are obtained numerically. We obtain expressions for both the longitudinal and transverse oscillations in the plasma. To calculate the matrix element we have to sum over all numbers of photons that may participate in the process and this poses as a difficult computational problem. However, we were able to perform such a sum over the number of photons involved in the process (m). Fixating a value for the radiation field frequency ω and amplitude (E), we obtain the dispersion relation for the longitudinal modes.
Although the sum is truncated, without loss of generality, it is more properly accounted for than those of previous studies. We note that the collective longitudinal modes are damped away more smoothly and in a smaller frequency range than those previously reported. We also see that, as we increase the radiation frequency, these modes are damped in a slower rate. Plotting the plasmon frequency as a function of E (for a randomly generated value of the wave number 'q'), we obtain an exponential-like decay of the frequencies. This decay is, again, slower for larger values of the radiation frequency.
To analyze the contribution of the photons in the damping and modulation processes, we plot the graphics of the dispersion relation and of the frequency versus E. To complete the analysis, we compute an expression for the high-frequency electrical conductivity of the plasma subjected to the radiation.