EIGENVALUE PROBLEM IN A LINEAR CHAIN OF COUPLED INFINITE-LONG PLASMA CYLINDERS

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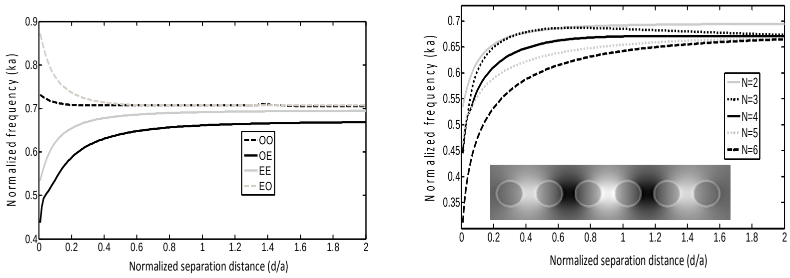
Strong interest in the electromagnetic wave propagation and scattering in the presence of plasma objects is due to the wide range of potential applications of such study. Tuning of resonant characteristics of resonators by free carrier plasma injections can be used in active switches or tunable filters [1]. Transient phenomena in plasma lead to the possibility of the frequency up-shifting and the generation of waves [2]. Using resonators composed of negative permittivity materials such as plasma can form the basis of effective small-size antenna elements [3].

The main goal of this paper is to analyze the plasmonic resonances in finite array of plasma coupled cylinders. The eigenvalue problem in a linear chain of N coupled identical infinite-long plasma columns is considered. Radius of each column is a, separation distance between them is d. The ambient medium is free space. We use the Drude model to describe plasma $\varepsilon_p(\omega) = 1 - \omega_p^2 \cdot (\omega(\omega + i\gamma))^{-1}$. Here ω_p represents the plasma frequency, γ is the material absorption. Sub-wavelength resonances are possible when $\varepsilon(\omega) < 0$ (or equivalently $\omega_p > \omega$), they are called plasmon resonances or surface plasmons. In this paper, we study surface plasmons finding eigenfrequencies of the structure. H-polarized fields are considered.

For the case of two coupled plasma cylinders the structure has two symmetry axes that causes four classes of excited plasmons with different symmetry: EE (even symmetry with respect to x and y axes), EO, OE, OO similarly. Figure 1(a) demonstrates real values of the eigenfrequencies of the EE, EO, OE, OO plasmons for two plasma columns ($s = 1$) (s is a number of angular field variations). With the decreasing of the separation distance between the plasma cylinders we see decreasing of the resonant frequency for EE and OE plasmons and increasing for the OO and EO plasmons. Figure 1(b) illustrates eigenfrequencies of EE plasmon ($s = 1$) for different number of coupled plasma columns. It is seen that eigenfrequencies decrease with increasing the number of plasma columns. Inset in Figure 1(b) shows the field distribution of EE plasmon in a chain of six plasma columns.



(a) (b)

Figure 1. Dependence of the normalized frequency on the normalized separation distance between the coupled plasma cylindrical columns for $s = 1$ for: (a) EE, OE, EO, OO plasmons for two columns; (b) EE plasmons for chain of N columns.

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