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COUPLING COEFFICIENTS OF DIFFERENT SPHERICAL DIELECTRIC MICRORESONATORS

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КОЕФІЦІЄНТИ ЗВ'ЯЗКУ РІЗНИХ ДІЕЛЕКТРИЧНИХ МІКРОРЕЗОНАТОРІВ СФЕРИЧНОЇ ФОРМИ

Розраховано узагальнені коефіцієнти зв'язку між відмінними за розмірами та діелектричної проникністю діелектричними мікрорезонаторами сферичної форми. Досліджені залежності зв'язку від параметрів резонаторів.

The construction of filters based on the use of different types of microresonators in some cases significantly improves their scattering characteristics. To design such filters it's necessary to be able to calculate the coupling coefficients of different microresonators [1]. The present study examines the mutual coupling coefficients of different Spherical microresonators in the Open space (fig. 1). We obtained general analytical expressions for the coupling coefficients for the excitation of no degenerate oscillations of a magnetic or electric type in resonators, characterized by a given symmetry with respect to the plane AA' (fig. 1, b).

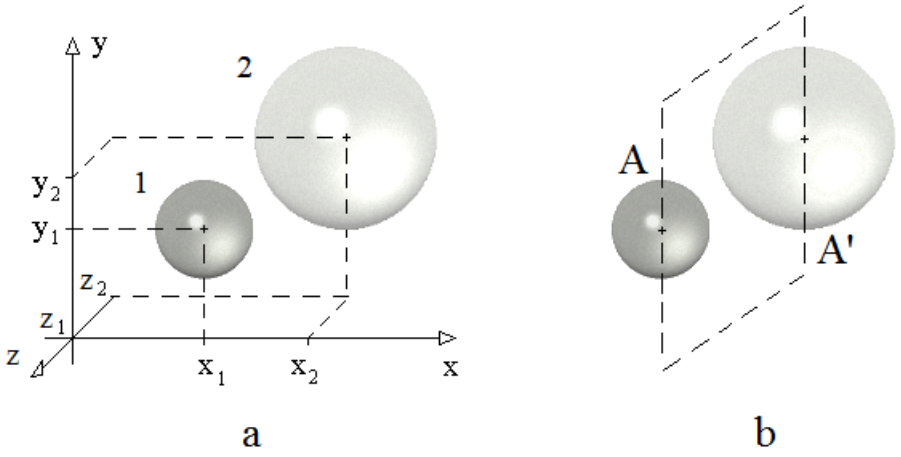

Fig. 1. Different Spherical microresonators in the Open Space (a).
Plane of symmetry AA' for two different microresonators (b).

Using the expressions found, we investigated the dependence of the coupling coefficients of various spherical microresonators on the structure parameters. The obtained analytic expressions of the coupling coefficients become known in the case of identical microresonators [2].

In Fig. 2 shows the dependence of the module of the coupling coefficient multipliers on the dielectric constant of the second microresonator in the case of two magnetic type oscillations (a); in the case of two oscillations of the electric type (b) and for oscillations of magnetic type in the first microresonator and electric type of

oscillations in the second (c). The calculations carried out show different values of the coupling coefficients for microresonators of different sizes.

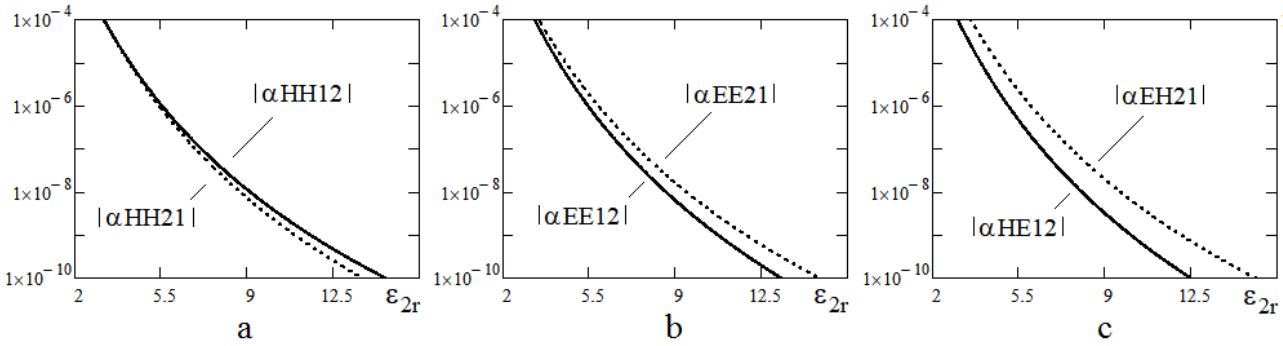

Fig. 2. Dependence of modulus of the Spherical microresonator coupling coefficient multipliers on the relative dielectric permittivity ε_{2r} ($\varepsilon_{1r} = 2,2$; $n_1 = 16$; $n_2 = 21$) for the H_{n_1ml}, H_{n_2ml} (a); E_{n_1ml}, E_{n_2ml} (b); H_{n_1ml}, E_{n_2ml} (c) oscillations.

In Fig. 3, 4 show the dependence of the coupling coefficients on the coordinates of the centers of microresonators for oscillations of magnetic types (Fig. 3) and for oscillations of magnetic and electric types (Fig. 4). The real part of the coupling coefficients is represented by solid curves (left axis of ordinates), and imaginary dashed curves (right axis of ordinates). The dependence of κ_{12} is shown in Fig. 3-4, a, b, and the dependence of κ_{21} is shown in Fig. 3-4, c, d.

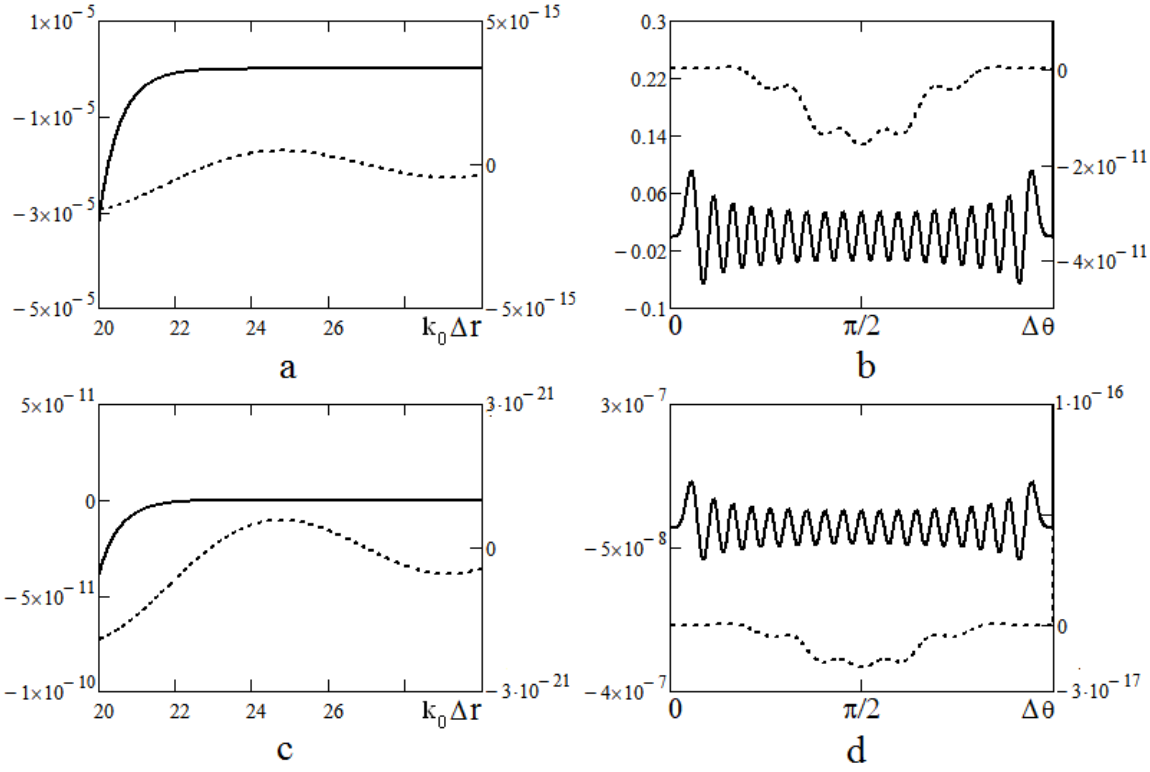

Fig. 3. Coupling coefficients as functions of the microresonator relative coordinates for the $H_{n_1m_1l}$, $H_{n_2m_2l}$ oscillations ($\varepsilon_{1r} = 4$; $\varepsilon_{2r} = 16$; $n_1 = 22$; $n_2 = 20$; $m_1 = 4$; $m_2 = 2$).

Here the $\Delta r = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$ is the relative distance between the centers of the microresonators (Fig. 1, a); k_0 - is the wave number; $\cos\Delta\theta = (z_1 - z_2)/\Delta r$.

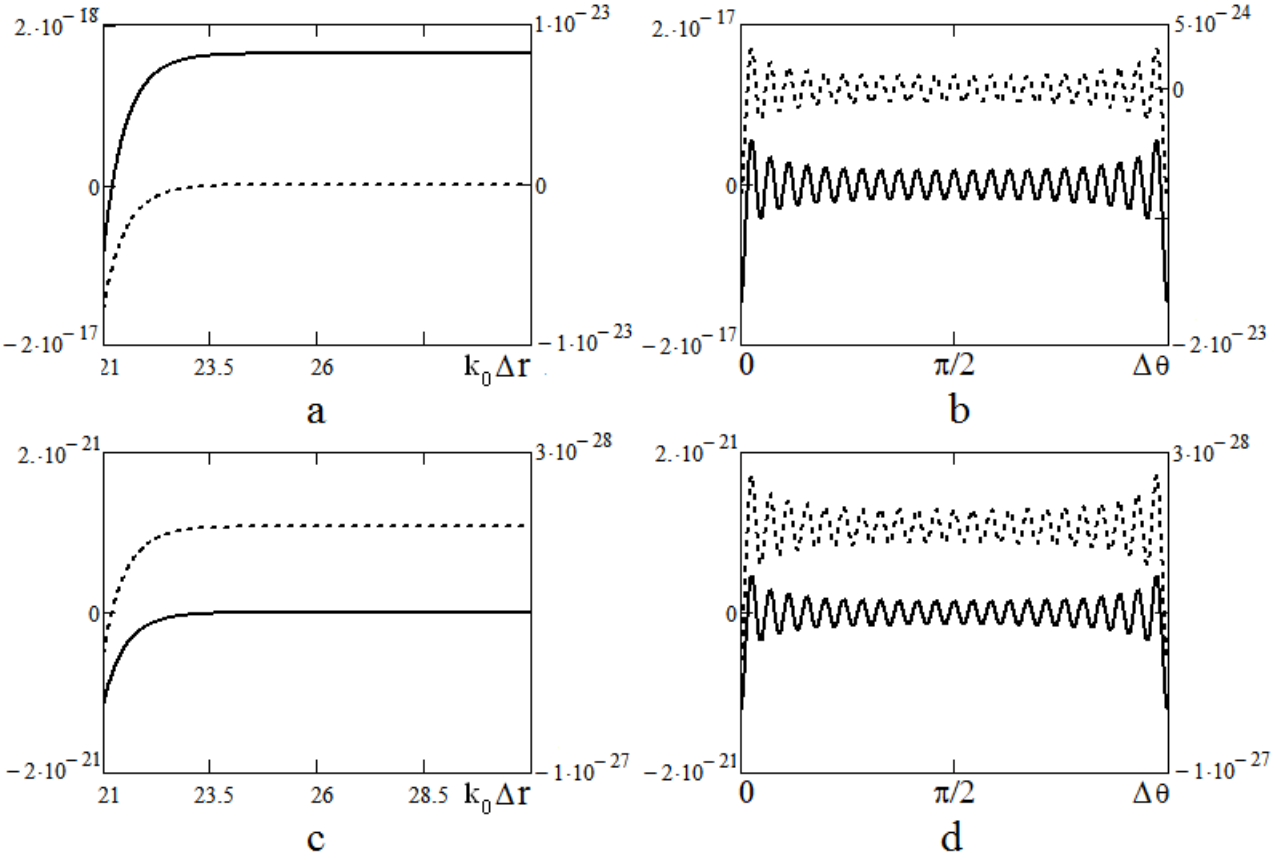

Fig. 4. Coupling coefficients as functions of the microresonator relative coordinates for the $H_{n_1m_1l}$, $E_{n_2m_2l}$ oscillations ($\varepsilon_{1r} = 4$; $\varepsilon_{2r} = 16$; $n_1 = 22$; $n_2 = 24$; $m_1 = 1$; $m_2 = 1$).

The obtained analytical expressions allow us to calculate the coefficients of mutual coupling of different spherical microresonators for any no degenerate modes.

As can be seen, the coupling coefficients for oscillations of higher types are characterized by a complex dependence on the coordinates of the microresonators and poorly predicted at the level of oscillation modes of resonators.

The use of various microcavities greatly extends the design possibilities of optical filters.

References

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2. A.A. Trubin, Coupling coefficients of the Spherical Dielectric Microresonators with Whispering gallery modes, Bulletin of NTUU "KPI" ser. Radiotechnique, Radioaparatus Building., 2015. N.62, pp. 49-61.