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Spectral Theory Approach to the Analysis of Diffraction Radiation Generated on a Metal-Backed Graphene Layer with Periodic Interface

Graphene stays in the spotlight for its exceptional properties and versatile applications, one of which is the development of flexible metamaterials. Its ability to integrate seamlessly with other components and adapt to nonplanar structures makes graphene a key material in advancing innovative flexible meta devices and functional metasurfaces [1]. This motivates us to focus on the interaction of the electromagnetic field with a graphene layer that has a periodic interface, with the ultimate goal of controlling the resonance properties of the structure electromagnetically. A periodic boundary at the graphene layer's external interface plays a crucial role in shaping the scattered field, which consists of an infinite set of spatial harmonics and exhibits complex resonance properties that could be exploited [2, 3].

The interaction of the electromagnetic field with a graphene layer is modeled (in the approximation of a given current) as a two-dimensional problem of diffraction of a plane monochromatic electromagnetic wave on the structure of interest. Employing the analytical regularization method (based on the modified C-method) and tools from the scattering matrix technique [3, 4], the original boundary value problem is transformed into an infinite system of linear algebraic equations with respect to the amplitudes of the spatial harmonics of the diffraction field. This method performs the analytical continuation of the solution of the diffraction problem into the domain of complex parameter values. Such an approach enables the unambiguous association of the resonant behavior of diffraction radiation with the excitation of natural oscillations of the periodic structure, which functions as an open resonator in this scenario. It has been established that the main mechanism underlying this behavior is the so-called synchronism of the phase velocities of the eigenwaves propagating along the structure and the phase velocities of the spatial harmonics of the diffraction field [2].

In this work, we detail the application of the aforementioned approach to the graphene structures of interest, present and discuss a set of detected resonances and the means to control them electromagnetically.

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