EXTRAORDINARY OPTICAL REFLECTION FROM SUB-WAVELENGTH CYLINDER ARRAYS

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The study of light scattering from periodic structures has been a topic of interest during the last century. Already in 1902, Wood [1] reported remarkable effects (known as Wood's anomalies) in the reflectance of one-dimensional (1D) metallic gratings. Two different types of anomalies were definitely identified by Fano [2]. One is associated to the discontinuous change of intensity along the spectrum at sharply defined frequencies and was already discussed by Rayleigh [3]. For a given angle of incidence, this occurs for those wavelengths at which a diffracted order becomes tangent to the plane of the grating. The other is related to a resonance effect. They occur when the incoming wave couples with quasi-stationary waves confined in the grating. The nature of the confined waves depend on the details of the periodic structure [4]: surface plasmon polaritons in shallow metallic gratings, standing waves in deep grating grooves or guided modes in dielectric coated metallic gratings.

Since the emergence of the concept of photonic crystals [5] and, more recently, the observation of enhanced transmission through a metallic film perforated by a 2D array of sub-wavelength holes [6], there has been a renewed interest in analyzing and understanding the underlying physics of both reflection and transmission ``anomalies'' in both 2D hole [7] and 1D slit [8] arrays. Although the enhanced transmission is commonly associated to the excitation of surface plasmons, there remains some controversy surrounding the transmission mechanism [9]. Here we discuss the physics behind the (Babinet) complementary problem: the extraordinary reflection from an array of sub-wavelength cylinder scatterers [10]. The optical properties and their dependence on wavelength, geometrical parameters and dielectric constant are analytically derived for both s- and p-polarized waves. In absence of Mie resonances and surface (plasmon) modes, and for positive cylinder polarizabilities, the reflectance present sharp peaks close to the onset of new diffraction modes. At the lowest resonance frequency, and in absence of absorption, it is possible to have a perfect reflected wave even for vanishingly small scatterers (Fig. 1).

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Figures:

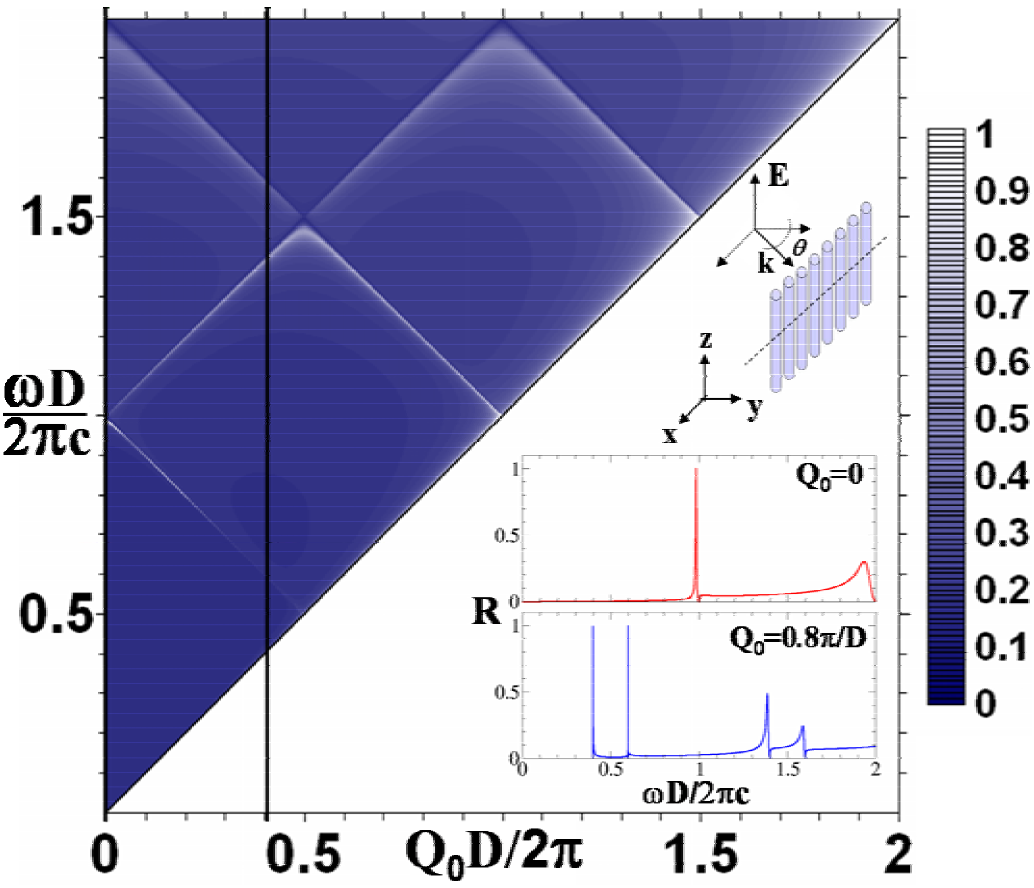

FIG. 1: (s polarization) Calculated reflectance **R** in a frequency ω versus in-plane number $\mathbf{Q_0=(\omega/c)\sin\theta}$. The reflectance along the vertical lines is shown in the inset.