URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Resonance frequency and radiative Q-factor of plasmonic and dielectric modes of small objects

C. Forestiere* (1), G. Miano (1), and G. Rubinacci (1)
(1) Department of Electrical Engineering and Information Technology
Università degli Studi di Napoli Federico II, Via Claudio 21, 80125 Naples Italy

A nonmagnetic object, smaller than the free-space operating wavelength, may exhibit two types of electromagnetic scattering resonances, namely plasmon and dielectric resonances. When its permittivity is negative, a small object may undergo a plasmon resonance. It is well established that when the size of the object is much smaller than the incident wavelength in vacuum, plasmon resonances can be predicted by the electroquasistatic approximation of the Maxwell-equations, and they are associated to the values of permittivity for which source-free electrostatic fields exist.

A small dielectric object with positive permittivity may also resonate when the free-space wavelength is large in comparison with the object dimensions if the permittivity is sufficiently high. We show that these resonances are described by the magnetoquasistatic approximation of the Maxwell's equations in which the normal component of the displacement current density field vanishes on the surface of the particle. These resonances are associated with the values of permittivity and frequency for which source-free quasistatic magnetic fields exist, which are connected to the eigenvalues of a magnetostatic integral operator. We present the general physical properties of magnetoquasistatic resonances in dielectrics with arbitrary shape.

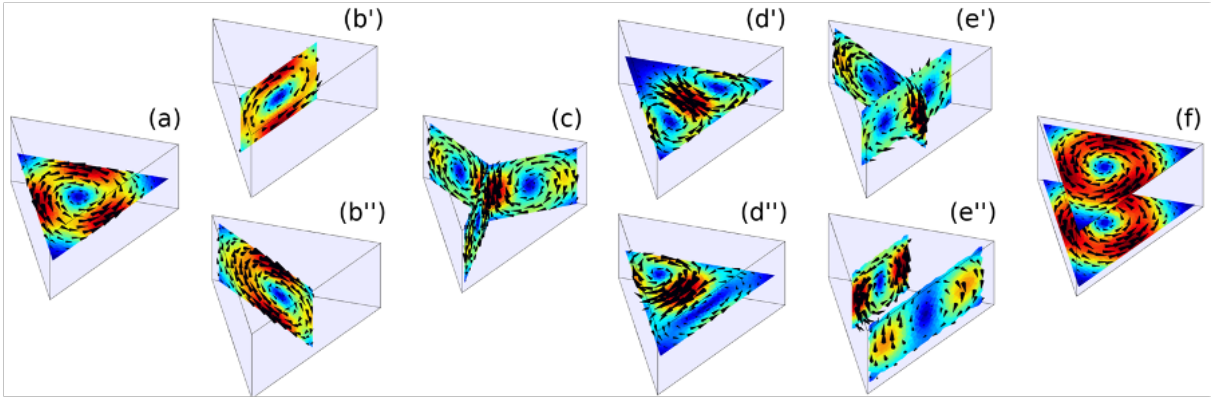

Figure 1. Magnetoquasistatic current modes of a triangular prism with L = 2H associated to the first six nondegenerate magnetoquasistatic eigenvalues.

Unfortunately, the electroquasistatic and magnetoquasistatic descriptions fail to correctly account for the frequency shift and the radiative broadening of the plasmon and dielectric resonances when the size of the object becomes comparable to the wavelength of operation. Thus, we introduce radiation corrections to the electroquasistatic and magnetoquasistatic resonances and modes of arbitrarily shaped objects, which only depend on the quasistatic current modes. These radiation corrections enable to derive closed-form expressions of the frequency shift and the radiative Q-factor of both plasmonic and dielectric modes of small objects, where the dependencies on the material and the size of the object are factorized. In particular, it is shown that the radiative Q-factor explicitly depends on the multipolar components of the quasistatic mode and its corrections.

References

[1] C. Forestiere et al., "Magnetoquasistatic resonances of small dielectric objects" *Physical Review Research* **2**, 013158, February 2020

[2] C. Forestiere et al. "Resonance frequency and radiative Q-factor of plasmonic and dielectric modes of small objects", *Physical Review Research* **2**, 043176, November 2020