Plasmonic Fano resonances on single nanorods: Application to refractive index sensing

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Metal nanoparticles exhibit a rich optical phenomenology due to the excitation of localized surface plasmons (LSPs). A special type of LSP resonances are highly promising for potential applications due to the extremely narrow (asymmetric) line shapes and fine sensitivity to environment changes: Fano LSP resonances [1]. Fano LSP resonances require typically complex multi-particle configurations involving wide, dipolar modes with narrow, dark modes.

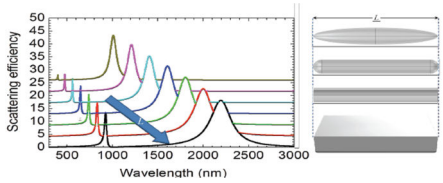

Figure 1: Calculated scattering efficiency spectra for a single Ag spheroid (top right) surrounded by glass (ε_d=2.25). Incident field is p-polarized and perpendicular to the rotation axis of the spheroid. Different curves correspond to increasing values of L (diameter D=30 nm). Right: Nanorod geometries for which evidence of Fano LSP is found in [2].

Contrary to such common assumption that coupling between nanoparticles is required to excite Fano LSP resonances, we show analytically and numerically in this work [2] that (single) elongated Ag nanoparticles such as nanospheroids, nanorods, and rectangular nanowires, suffice to exhibit asymmetric (Fano) resonances as a consequence of the interference between the broad, (dipole-like) half-wavelength mode, with dark, higher-order modes (see Fig. 1). We make use of explicit analytical expressions for light scattering by spheroids to conclude that not only spectral but also spatial overlap (i.e. non-orthogonality) between interacting modes underlies the emergence of such single-rod resonances [2].

Potential applications in (Fano) LSP sensing are discussed that exploit the simplicity of the required nanostructures, resulting in turn in large figures of merit [3]. In particular, two configurations are proposed based on elongated nanorods: colloidal nanorice and nanobelts on a substrate (see Fig. 2).

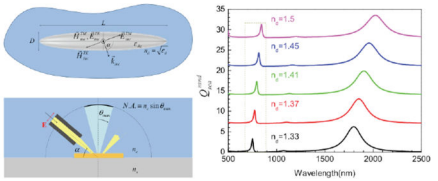

Figure 2: Left: Configurations proposed for refractive index sensing based on Fano LSP resonances: Colloidal Ag nanorice (top) and Au nanobelt on a substrate (bottom). Right: Scattering efficiencies for random orientation for a single nanospheroid (L=345 nm, D=30 nm) embedded in a medium with different index of refraction n_d [3].

Acknowledgements: Spanish "Ministerio de Economía y Competitividad" (CSD2008-00066 and FIS2009-11264), "Comunidad de Madrid" (S2009/TIC-1476), and CSIC (JAE-Pre grant).

References

[1] A. Miroshnichenko, S. Flach, and Y. Kivshar, Rev. Mod. Phys. 82 (2010) 2257.

[2] F. López-Tejeira, R. Paniagua-Domínguez, R. Rodríguez-Oliveros, and J. A. Sánchez-Gil, New. J. Phys. 14 (2012) 023035.

[3] F. López-Tejeira, R. Paniagua-Domínguez, and J. A. Sánchez-Gil, ACS Nano in press (2012).