Real-Space Mapping of Fano Interference in Plasmonic Metamolecules

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Abstract

Fano resonances in plasmonic antennas have recently attracted great interest as they allow an unprecedented control of the antenna spectral response, opening the possibility for ultra-sensitive sensing applications [1]. The physical origin of the Fano resonances is the interference between two electromagnetic eigenmodes of the nanostructure, often referred to as “bright” and “dark”, that posses strongly differing radiative lifetimes. When both resonances are excited by the incident electromagnetic field, they contribute to the reflected field according to their dipole strength and lifetimes and, depending on the wavelength, exhibit either constructive or destructive interference in the far field. Up to now, the interpretation of such Fano interferences has been based on far-field spectroscopy and numerical calculations [2]. However, this characterization is both insufficient and ambiguous because different charge distributions can cause the same far-field scattering pattern.

Here, we use interferometric scattering-type scanning near-field optical microscopy (s-SNOM) to experimentally verify for the first time the theoretically predicted near-field patterns of highly symmetric heptamer and asymmetric pi structures resonant at mid-infrared frequencies [3]. The results show a dramatic redistribution of the electric field intensity and phase across the structures as the Fano resonance is traversed (Figure 1), in excellent agreement with numerical calculations. The insight gained from near-field images will further our understanding of plasmonic Fano resonances and may open novel applications based on the spectral manipulation of plasmonic near fields.

References

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Figures

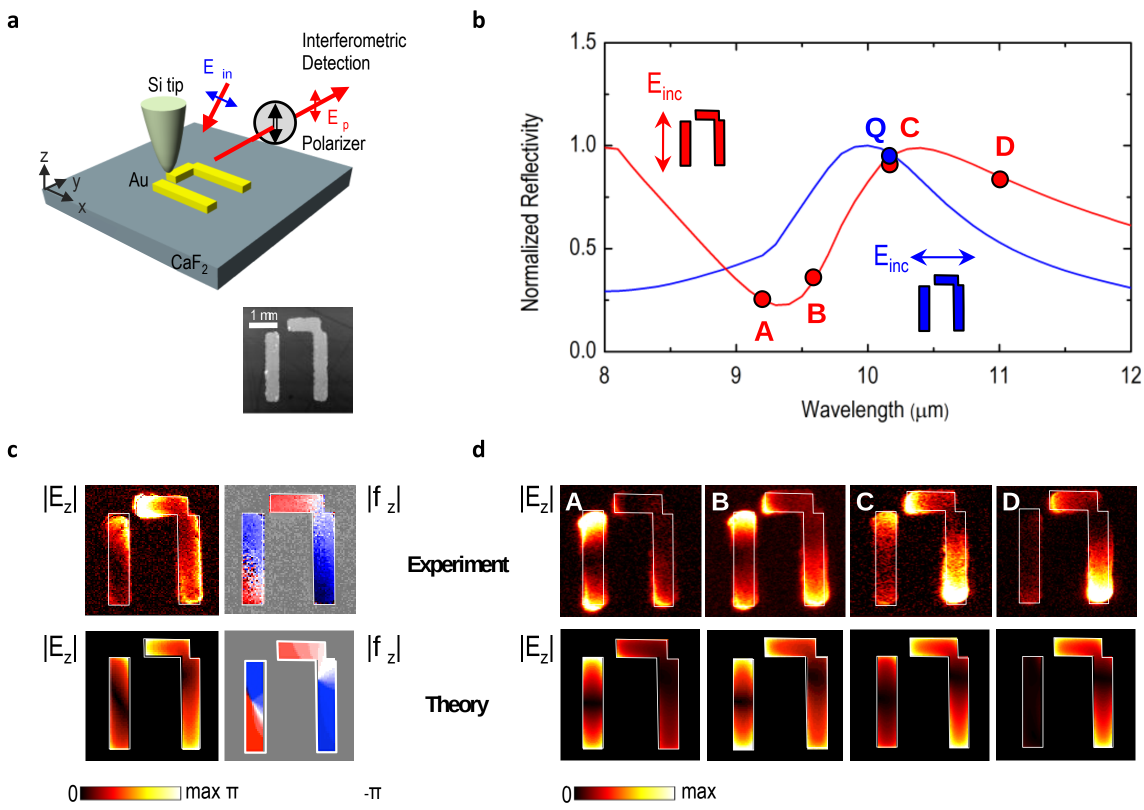

Figure 1: Real-space mapping of Fano interference in asymmetric PI-structures. (a) Experimental setup for near-field imaging in reflection mode. The PI-structure is illuminated from the side, with s-polarized light. Near-field imaging is performed by recording the tip-scattered radiation with an interferometer, yielding amplitude and phase images simultaneously to topography (grey image below). (b) Numerically calculated reflection spectrum for horizontal (blue) and vertical (red) polarization as indicated by the schematics. The letters mark the spectral positions where near-field imaging was performed. (c) Experimental (upper row) and calculated (lower row) amplitude $|E_z|$ and phase ϕ_z images for horizontal polarization, recorded at 10.2 μm wavelength. (d) Experimental (upper row) and calculated (lower row) amplitude $|E_z|$ images for vertical polarization, recorded at the spectral positions A-D marked in (b).