Characterization of Dark Plasmonic Modes in Silver Nano-Bowties

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Localized surface plasmons (LSPs) are collective oscillations of free electrons on metallic nanoparticles. By confining light into nanoscale volumes, LSPs generate strong electromagnetic near fields that facilitate strong interactions with quantum emitters. Harnessing these interactions is essential for emerging quantum technologies, frontier light-matter research, and nanophotonic systems. Increasing plasmon lifetime enhances the system's ability to reach the strong coupling regime, making long-lived plasmons a key factor in achieving robust light-matter interactions. A single nanoparticle can support different plasmonic modes, most notably bright and dark. While bright modes also radiate into the far field, dark modes remain confined near the source. As a result, dark modes have remained largely unexplored, as they are challenging to probe. I set out to discover whether dark plasmonic modes in metallic nano-antennas can support longer lifetimes than the widely studied bright modes. I fabricated silver nano-bowtie antennas using high-resolution electron beam lithography and, with a staff scientist's assistance, probed their plasmonic modes via electron energy-loss spectroscopy in a transmission electron microscope. The dark modes exhibited higher resonance energies and significantly longer lifetimes – approximately twice those of the bright modes. This pioneering experimental comparison of dark and bright plasmonic modes within a single nanostructure is among the first of its kind. The findings open a new frontier, establishing dark plasmons as promising, long-lived building blocks for future quantum computation, ultrasensitive sensors, light-matter interaction studies, and a broad spectrum of advanced photonic technologies, unlocking cutting-edge applications.

Awards Won:

Fourth Award of $600