Direct Amplitude-Phase Near-Field Observation of Higher-Order Anapole States

Anapole states associated with the resonant suppression of electric-dipole scattering exhibit minimized extinction and maximized storage of electromagnetic energy inside a particle. Using numerical simulations, optical extinction spectroscopy, and amplitude-phase near-field mapping of silicon dielectric disks, we demonstrate high-order anapole states in the near-infrared wavelength range (900-1700 nm). We develop the procedure for unambiguously identifying anapole states by monitoring the normal component of the electric near-field and experimentally detect the first two anapole states as verified by far-field extinction spectroscopy and confirmed with the numerical simulations. We demonstrate that higher-order anapole states possess stronger energy concentration and narrower resonances, a remarkable feature that is advantageous for their applications in metasurfaces and nanophotonics components, such as nonlinear higher-harmonic generators and nanoscale lasers.