Microwave resonances in aqueous monomer and dimers

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***Abstract*— The highly-localized and intense electromagnetic hotspots afforded by plasmonic resonances in nano-scaled metallic objects have led to many exciting biomedical applications. The equivalence between nanoplasmonic hotspots, and those due to morphology-dependent resonances in high-index dielectrics is a promising avenue of nanophotonic research. In the microwave frequency regime water is such a material (n~9), and thus cm-sized aqueous dielectric objects can become resonant to few-GHz light from microwaves, WiFi, and other communication-band sources. We are using experimental, analytical, and computational approaches for studying hotspots in aqueous dimers. Experimentally, we use a household microwave oven, grape-sized hydrogel beads, and thermal imaging to demonstrate a transition from dipole-like resonance in isolated spheres to intense hotspots at the nexus of dimers. We computationally identify a host of fundamental resonances in spherical monomers that hybridize to yield either/both internal and point-of-contact dimer modes. We demonstrate that an intuitive vector-field addition approach intuitively identifies which resonances are most likely to combine to form an axial hotspot in the dimer. The usefulness of this approach is confirmed with 3D FEM simulations.**

Keywords—Mie Scattering; Morphology Dependent Resonances (MDR); Microwave Photonics; Dimers; Vector Fields;

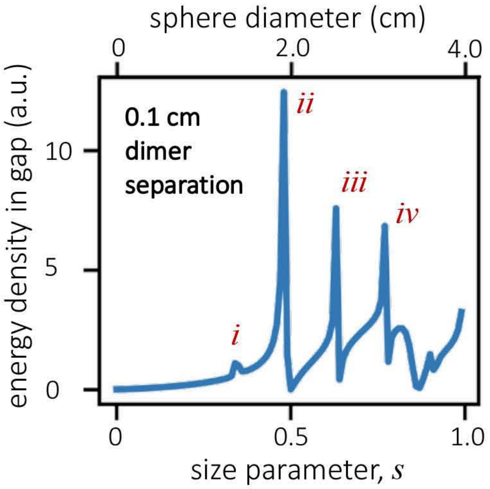

Figure 1. *A (computer simulated) spectrum of resonances in the gap separating two spheres with the index of refraction of water but reduced absorption. The excitation geometry is "transverse polarization" wherein the magnetic field is along the dimer axis. Modes labelled i and ii are fundamental morphology-dependent resonances in the monomers. Mode ii hybridizes in the dimer via strong constructive interference of radial field components, whereas mode i suffers destructive interference of radial field components. Modes iii and iv are extremely weak modes in the monomers but grow rapidly into dominant dimer hotspots as the monomers are brought together.*

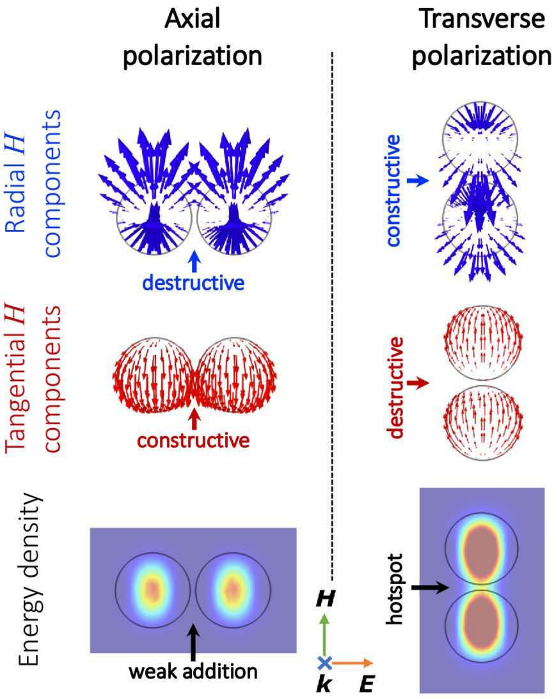

Figure 2. *A vector-addition approach to explaining the hybridization of the fundamental magnetic dipole mode found in monomers with $s=0.35$ (diameter of 1.95 cm). [Left panels] With electric field polarized along the dimer axis, the radial components of the magnetic field in each sphere experience destructive interference in the gap, while the weaker tangential components combine to additively. This mode corresponds to resonance **i** in Figure 1. [Right panels] With the magnetic field polarized along the dimer axis, the radial components of the monomer modes add constructively in the dimer to yield a moderate electromagnetic hotspot in the gap.*

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