Theoretical and experimental analysis of the directionality of the electromagnetic scattering by magnetodielectric small spherical particles

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Abstract Magnetodielectric small spheres present unusual electromagnetic scattering features, theoretically predicted a few decades ago by Kerker et al. [1]. However, achieving such behavior has remained elusive, due to the non-magnetic character of natural optical materials or the difficulty in obtaining low-loss highly permeable magnetic materials in the gigahertz regime. Here we present unambiguous experimental evidence that a single low-loss dielectric subwavelength sphere of moderate refractive index ($n \approx 4$ like some semiconductors (Si, Ge) at near-infrared) and radius $a<\lambda$ radiates fields identical to those from equal amplitude crossed electric and magnetic dipoles, and indistinguishable from those of ideal magnetodielectric spheres. The measured far-field scattering radiation patterns (see Fig. 1(a)) and degree of linear polarization (3–9 GHz/33–100mm range) show that, by appropriately tuning the a/λ ratio, zero-backward ('Huygens' source) or almost zero-forward ('Huygens' reflector) radiated power can be obtained [2]. Also, the near-field scattering distributions and their correlation with those measured in far-field, are numerically calculated and analyzed (see Fig. 1(b)). These Kerker scattering conditions [1] only depend on a/λ. Our results open new technological challenges from nano and micro-photonics to science and engineering of antennas, metamaterials and electromagnetic devices.

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References

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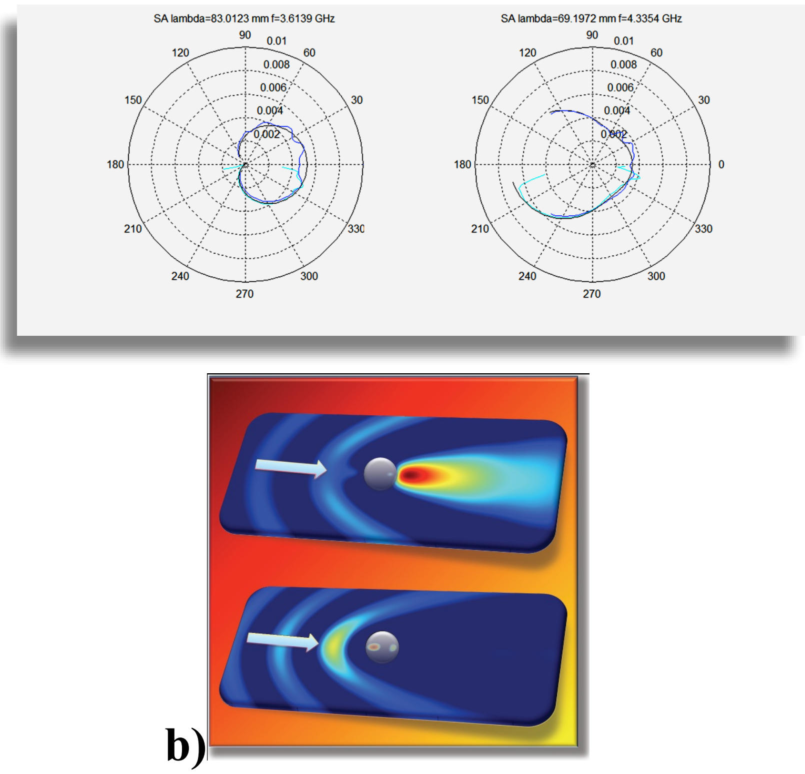
Figures



a)

b)

Figure 1- (a) Far-Field (experiment (blue line), theory (black line)) and (b) Near field intensity distributions of a subwavelength dielectric sphere (refractive index≈4+0i), illuminated by a linearly polarized monochromatic wave (white arrow), for the two Kerker frequencies: Zero-backward: 3.6GHz (left in (a), top in (b)) and near zero-forward: 4.3GHz (right in (a), bottom in (b)).