Bulk Isotropic Magnetism in Visible Light in a Self-Assembled Metamaterial

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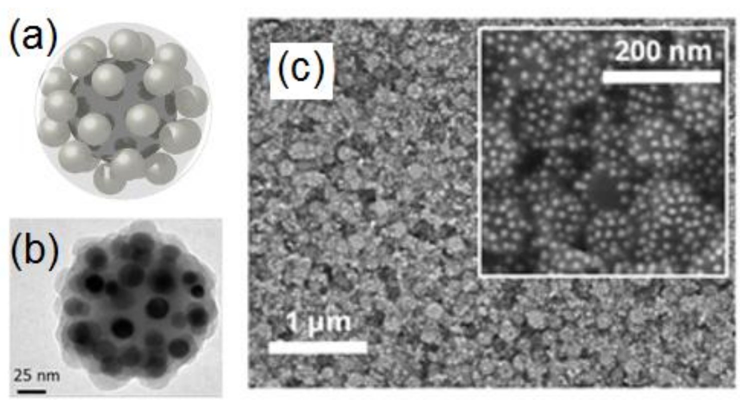
The magnetic susceptibility χ_m of natural materials is known to be negligible at visible light frequencies. Consequently, the usual laws of optics assume that the relative permeability $\mu = 1+\chi_m$ of all transparent materials takes the vacuum value $\mu = 1$. The possibility of overcoming this natural limitation through the generation of resonant optical diamagnetism was first demonstrated for microwaves in artificial composites (metamaterials), hence opening an extraordinary field with new opportunities to control the flow of light in optical devices. In visible light however, state-of-the-art magnetic metamaterials are strongly anisotropic and exhibit a large spatial dispersion of the magnetic response, a non local effect which strongly restricts the meaning of a bulk magnetic permeability. We report here on the experimental realization of a three-dimensional isotropic metamaterial that exhibits a strong artificial diamagnetism in visible light. The effective diamagnetic susceptibility is three orders of magnitude higher than natural materials and satisfies the principle of locality across a wide range of visible wavelengths. A large-scale fabrication of such magnetic metamaterials of arbitrary size and shape is made possible by our bottom-up approach, based on self-assembly of resonant plasmonic nano-clusters.



(a) Model of plasmonic magnetic nanocluster made of metal nano-particles surrounding a dielectric core.

(b) real magnetic nanocluster . (plasmonic raspberry).

(c) SEM image of the self-assembled metamaterial.