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Artificial Magnetism through Mimicking Magnetic Localized Surface Plasmons

C. Rizza [1]*, E. Palange [2], A. Galante[3,4,5], M. Alecci[3,4,5]

[1] Department of Physical and Chemical Sciences, University of L'Aquila, Via Vetoio 1, I-67100 L'Aquila, Italy
[2] Department of Industrial and Information Engineering and Economics, University of L'Aquila, Via G. Gronchi 18, I-67100 L'Aquila, Italy
[3] Department of Life, Health and Environmental Sciences, University of L'Aquila, Via Vetoio 1, I-67100 L'Aquila, Italy
[4] Institute for Superconductors, Oxides and Other Innovative Materials and Devices, CNR-SPIN, Via Vetoio 1, I-67100 L'Aquila, Italy
[5] National Institute for Nuclear Physics (INFN), Gran Sasso National Laboratory, Via G. Acitelli 22, Assergi, I-67100 L'Aquila, Italy

Metamaterial (MM) science allowed the design of effective magnetic materials. In the optical frequency range, the magnetic response of most materials is very weak and their relative permeability is $\mu \simeq 1$, whereas dielectrics show different properties where the permittivity ϵ can be positive, negative, or even zero. MMs restored the symmetry between the magnetic and dielectric domains and artificial magnetism is a fundamental ingredient for realizing many fascinating electromagnetic devices. On the other hand, the accomplishment of such magnetic MMs requires rather complex geometries and the standard MM approaches fail at very deep subwavelength scales. They are based on effective medium theories describing the spatial dynamics of the macroscopic (average) fields at a scale much greater than the MM inclusions' size, making hard the design of photonic devices operating at these scales.

We discuss an alternative strategy for achieving artificial magnetism. We show that a homogeneous high-index dielectric sphere is equivalent to an effective negative permeability one with the same radius. More precisely, we prove that such a dielectric sphere near a Mie resonance can reproduce the electromagnetic field of a magnetic localized surface plasmon, generally supported by a negative permeability sphere [1]. Our approach holds at extremely near-field scales since it is not based on an effective medium theory and the considered structure does not exhibit spatial subwavelength inhomogeneities. Our results can be exploited to design subwavelength magnetic photonic devices in the spectral regions where high-index dielectric materials are available (up to GHz) [2].

[1] C. Rizza, et al, Phys. Rev. Appl. 14 (2020) 034040
[2] C. Rizza et al. J. Pys. D:Appl. Phys. 54 (2021) 165108

Corresponding Author e-mail: carlo.rizza@univaq.it
*lead presenter: e-mail: carlo.rizza@univaq.it