New Resonant Elements for Isotropic Magnetic Metamaterials

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In 1999 Split Ring Resonator (SRR), as a unit cell of negative permeability media, was first introduced by Pendry [1]. Afterwards, Smith et al., [2] analyzed an array of wires and SRRs obtaining an artificial medium with simultaneously negative permittivity and permeability. This was the first realization of a left-handed medium which was theoretically studied by Veselago [3] several decades ago. However, this and subsequent realizations were highly anisotropic. A first attempt towards the design of isotropic magnetic metamaterials was made by Gay-Balmaz and Oliver Martin [4], who obtained a 2D isotropic SRR. The SRR is not the unique candidate for artificial quasi-isotropic medium, as was demonstrated by using Ω particles in [5]. More recently, an SRR based proposal for isotropic magnetic metamaterial design has been presented [6].

The main aim of this work is to design particles from which an isotropic media can be made. Really, no material composed by periodical arrangement of unit cells can be fully isotropic. However, in many cases the behavior of such system can be characterized by second order tensors (e.g., the electric, magnetic or magneto-electric polarizability tensors), without considering tensors of higher orders. The cubic structures of Figs. 1 and 2 show the group of symmetry of the cube, thus being candidates for fully isotropic magnetic metamaterials [6]. In addition, it can be shown that the sub-group generated by the four operations $(\mathbf{I}, -\mathbf{I}, \mathbf{C}_{4x}\mathbf{C}_{4y}, \mathbf{C}_{4y}\mathbf{C}_{4x})$ also provides isotropic tensors. An example of an isotropic resonator invariant by this group of symmetry (in fact a modification of a previous proposal [7]) is shown in Fig. 3. A modification of Fig. 2 which substitutes the four gaps broadside-coupled SRR (BCSRR) by a simpler two-gaps BC-SRR is also invariant by the aforementioned symmetry group. Finally, the elimination of the inversion (-**I**) operation may lead to bi-isotropic magnetic media.

Figure 1.

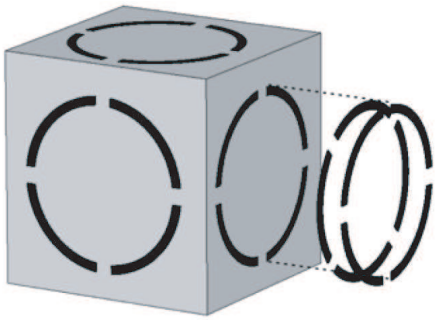

Figure 2.

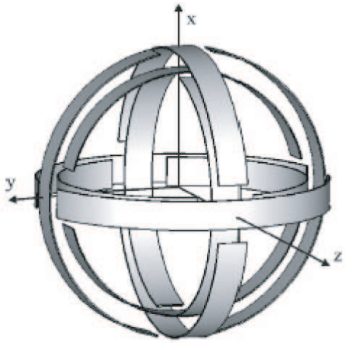

Figure 3.

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