Magnetic control of electrically uncharged magneto-optical particles

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Abstract

Constant magnetic fields are known to interact with electrically charged particles inducing Lorentz forces that point in a direction perpendicular to the field. However, if the particle is electrically discharged, it is impossible to induce a force using a constant magnetic field. An exotic option is to mimic a magnetic charge on a neutral particle. This false magnetic monopole will interact with the magnetic field just as an electric charge would do with an electric field through the Coulomb interaction. Attempts to generate this magnetic charge have mainly relied on quasiparticles generated using condensed matter spin ice networks [1-3]. In this work we present another option based on neutral magneto-optical particles illuminated by a spinning monochromatic light field [4]. We will analyze the behavior of these particles under different fluctuating isotropic optical configurations [5,6], and we will calculate the value of the induced magnetic charge. We will prove that this is a purely non-reciprocal effect as the reciprocal equivalent (a chiral dipole) despite presenting a dichroic response, does not experience any force when illuminated by the spinning field. The magnetic charge induced by impinging radiation on the magneto-optical dipole is found to depend linearly on the helicity of the field. In addition, this artificial monopole experiences a dichroic permanent optical torque and does not interact with an external electric field.

References

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Figures

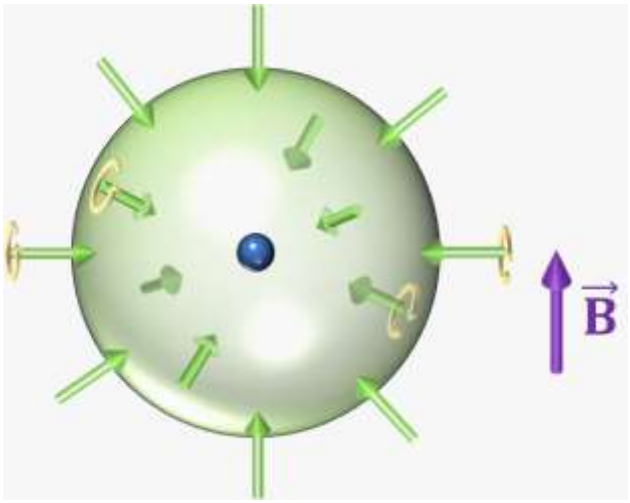

Figure 1. Schematic view of the isotropic random field. The green sphere represents a uniform distribution of incoming waves with the same helicity. The arrows are to illustrate that all beams have a counter-propagating pair with the same intensity. By applying an external magnetic field, the MO particle (depicted by the blue sphere), which supports dipolar resonances, experiences a Coulombic-like force, proportional to the magnetic field.