Anisotropic Light Scattering by Magnetite Nanoparticles in a Presence of External Magnetic Field

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Nanoparticles possessing magnetic moment exhibit a number of interesting optical properties. These are magnetic dichroism, magnetically induced birefringence, Faraday rotation and ellipticity, to name a few. Zero backscattering and weak localization of light in a suspension of magnetic nanoparticles subjected to the external magnetic field was also observed. Those unusual optical effects are attributed to the delay of light propagation that result from the formation of standing waves within the scatterer due to the resonances in backscattered efficiency and forward-backward anisotropy factor. Based on Mie theory calculations it was found that the intensity of light scattered by magnetic nanoparticles depends on incident wave configuration with respect to the direction of the external magnetic field [1]. Photonic Hall effect was predicted and experimentally confirmed for a scattering medium subjected to the transverse magnetic field. Despite a great deal of works on the optical effects in the magnetic nanoparticle assemblies some aspects of those phenomena remain unexplored. In particular, few studies consider variations in scattered light intensity of a magnetic nanoparticle suspension when the latter is subjected to the transient magnetic field.

In present work we report experimental results on fast variations in the optical transmission of superparamagnetic magnetite Fe_3O_4 nanoparticle aqueous suspension depending on mutual orientation of the incident electromagnetic wave and the magnetic field direction. The nanoparticles were 10–15 nm in diameter with a volume fraction of 0.0012. He-Ne laser with a 632.8 nm wavelength was used as a light source. It was found that optical transmittance of the suspension varies in the range of 10–15% when the DC operated magnet was switched on. The characteristic time of those variations is less than 1 ms which makes magnetite nanoparticle assembly an appealing platform for high-speed magneto-controlled optical devices. Our studies reveal that fast optical response is due to orientation of the magnetic moments associated with each nanoparticle along the applied magnetic field. Our findings are important for understanding of the interaction of light with magnetic nanoparticles as well as for practical applications.