Comment on "Experimental Evidence of Zero Forward Scattering by Magnetic Spheres"

In a recent Letter [1], Mehta *et al.* presented an interesting study of the transmission of light through a ferrofluid containing a suspension of magnetite nanoparticles mixed with the microspheres of magnetite. They find that there is a critical magnetic field at which the transmitted light intensity vanishes [e.g., see panel (d) of Fig. 3, Ref. [1]] and remains zero over a "stop band" of the field. This feature is essential to much of their work that follows, and has been explained by them in terms of the vanishing of the forward scattering of light by the magnetic particles. As we will show below, this interpretation of theirs, however, is fundamentally flawed, and this point of error has also escaped notice of García-Cámara *et al.* in their recent Comment [2] on the Letter [1]. Besides, this erroneous identification of vanishing transmission with the vanishing of the forward scattering has persisted undetected in their other published work [3]. It is not merely a matter of terminology. Hence this Comment.

The authors of [1] make use of a result derived by Kerkar [4] that gives the condition for the vanishing of the forward scattering, as $\varepsilon = (4 - \mu)/(2\mu + 1)$, where ε is the relative electric permittivity and μ the relative magnetic permeability. The expression is valid in the small spherical scatterer limit, when the lowest-order term in the Mie scattering predominates. And, indeed, the ferrofluid sample does permit the tuning of its scattering properties by an externally applied magnetic field, so as presumably to satisfy the above condition. However, we point out here that the vanishing of the forward scattering does not imply the vanishing of transmission. Indeed, from the well-known optical theorem [5], we have the total scattering cross section $\sigma_{\text{tot}} = 2\pi\lambda \text{Im} f(0)$, where $f(0)$ is the scattering amplitude at an angle of 0° (i.e., the forward scattering) and λ the wavelength. (Note that the forward scattered light retains its polarization, and hence the scalar notation used above for simplicity.) Thus, the total scattering cross-section also vanishes when the forward scattering vanishes. However, contrary to the interpretation of Mehta *et al.*, vanishing of forward scattering does not imply absence of transmission; in fact it implies total transparency (absence of scattering) inasmuch as the direct, unscattered light then propagates right through the sample in the forward direction. We believe that what they observe experimentally, namely, a total absence of transmission, is essentially a strong resonant trapping of the light. A possible explanation of zero forward intensity is the storage of the light energy within the medium either by absorption, or *as light* in a localized mode.

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