Magnetic Fields Generated by Light in Dielectric Particles

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In 2010, it was published in [1] that a plane wave incident on a dielectric nanosphere with a high refractive index excites a large magnetic moment in it. This phenomenon was confirmed experimentally [2] and became the basis for creating resonant dielectric nanostructures with a high refractive index [3]. Resonant scattering of electromagnetic waves is a widely studied phenomenon with a vast range of applications that span completely different fields, from astronomy or meteorology to spectroscopy and optical circuitry. Despite being subject of intensive research for many decades, new fundamental aspects are still being uncovered, in connection with emerging areas, such as metamaterials and metasurfaces or quantum and topological optics, to mention some. We show that weakly dissipating dielectric spheres made of materials such as glass, quartz, etc. can support high order Fano resonances associated with internal Mie modes [4]. These resonances, happening for specific values of the size parameter, yield field-intensity enhancement factors on the order of 10^4–10^7, which can be directly obtained from analytical calculations. Associated to these "super-resonances", we analyze the emergence of magnetic nanojets with giant magnetic fields, which might be attractive for many photonic applications. We show experimentally [5] that GHz radiation illuminating a high refractive index ceramic sphere creates instant magnetic near-fields comparable to those in neutron stars, opening up a new paradigm for creation of giant magnetic fields on the millimeter's scale. Recently we demonstrated the ability to create big magnetic fields in photonic lenses with whispering gallery waves at Janus particles [6].

References

[1] A B Evlyukhin, C Reinhardt, A Seidel, B Luk'yanchuk and B N Chichkov, Phys. Rev. B **82**, 045404 (2010)

[2] A I Kuznetsov, A E Miroshnichenko, Y H Fu, J B Zhang and B Luk'yanchuk, Sci. Rep. **2**, 492 (2012)

[3] A I Kuznetsov, A E Miroshnichenko, M L Brongersma, Y S Kivshar and B Luk'yanchuk, Science **354**, aag2472 (2016)

[4] Z B Wang, B Luk'yanchuk, L Yue, B Yan, J Monks, R Dhama, O V Minin, I V Minin, S M Huang and A A Fedyanin, Sci. Rep. **9**, 20293 (2019)

[5] B Luk'yanchuk, L M Vasilyak, V Ya Pecherkin, S P Vetchinin, V E Fortov, Z B Wang, R Paniagua-Domínguez and A A Fedyanin, Sci. Rep. **11**, 23453 (2021).

[6] I V Minin, O V Minin, Y Cao, B Yan, Z Wang and B Luk'yanchuk, Opto-Electron. Sci. **1**, 210008 (2022)