Magnetic Octupole Response of Dielectric Quadrumers

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100-word Program Abstract.

Modern optics actively studies metasurfaces and metamaterials, which require advanced meta-atoms supporting a specially tuned optical response. High-order multipole excitations feature specific radiation patterns and distributions of near fields. Here we show that resonant magnetic octupole response (MOCT) can be obtained with nanostructured dielectric quadrumer of silicon cubes. This resonance can be tuned by changing distance between the nanocubes. We demonstrate that MOCT resonance provides magnetic hot-spots in the gaps between cubes, creating a strong magnetic gradient in free space. In addition, it leads to the anomalous energy absorption in near-infrared. Similar structures could be very perspective for MRI and other applications.

250-word Technical Abstract.

Modern optics actively studies metasurfaces and metamaterials, which require advanced meta-atoms supporting a specially tuned optical response. High-order multipole excitations feature specific radiation patterns and distributions of near fields. Here we show that a resonant magnetic octupole (MOCT) response can be obtained by dividing a solid rectangular silicon block to a quadrumer structure with the introduction of narrow gaps between four nanocubes. We control and tune the spectral position of the MOCT resonance by varying the distance between the nanocubes. We demonstrate that several magnetic hot-spots related to the MOCT resonance can be located in the gaps creating a strong magnetic field gradient in free space. We observe that the resonant excitation of the MOCT moment leads to a significant enhancement of light absorption in the system at the spectral region, where light absorption in bulk silicon is weak.

Involving high-order multipoles in the optical response of metasurfaces can expand their functional properties. It is very important to note that the excitation of high-order multipole moments exploiting nanostructuring of small particles is a powerful approach to avoid diffraction restriction in designing advanced metasurfaces and metamaterials. Moreover, after being scaled to the microwave region the considered structure could be very perspective for magnetic resonance imaging applications, where a strong concentration of magnetic fields is necessary to increase the contrast and quality of the pictures.

Reference:

P. D. Terekhov et. al, Magnetic Octupole Response of Dielectric Quadrumers, Laser and Photonics Reviews (2020), accepted