Liquid crystal-based colloidal metamaterial useful in controlling scattering of light can be used in photonic devices

Scientists are constantly on the lookout for new materials for photonic devices like optical switches and sensors that are more operationally flexible for creating, manipulating, detecting light, or modulating and combining beams to suit the device. Researchers from Bangalore have developed such new material that can control the scattering of light efficiently.

A team from Centre for Nano and Soft Matter Sciences (CeNS), an autonomous institute of the Department of Science and Technology (DST) showed that a colloidal dielectric metamaterial they have put together is useful in controlling scattering of light implying that it can be used in photonic devices such as slow-light devices, optical switches, and optical sensors.

The research group led by Dr. Geetha Nair at CeNS demonstrated tunable Fano resonance in a colloidal dielectric metamaterial, in a research published in the journal *Advanced Optical Materials.*

Fano resonance is the unique feature of scattering efficiency of light completely vanishing when the Fano parameter reaches the value of unity. It leads to sharp switching from the total transmission to total reflection, clearly seen in the scattering curves. For any practical applications in photonic devices, tunability of the strength and wavelength at which the resonance occurs gives much needed operational flexibility. The phenomenon is described by what is known as Fano formula.

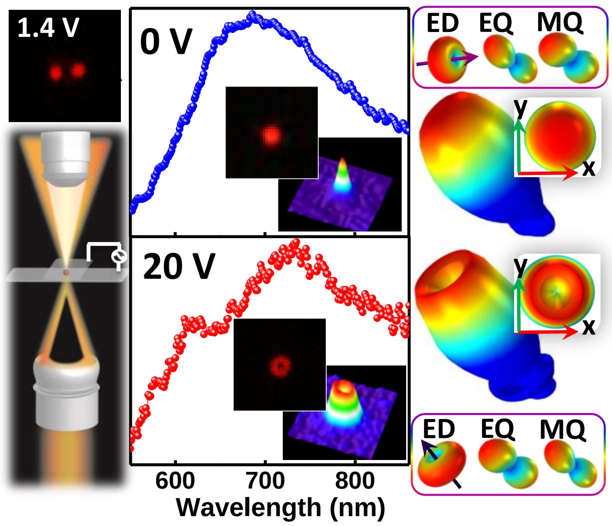
Fano resonance is observed in a wide range of systems such as auto-ionized atoms, Bose-Einstein condensates, quantum dots, photonic crystals, plasmonic nanostructures, and high refractive index microspheres. However, in all such systems, tuning of the strength and spectral position of Fano resonance is achieved by changing the geometric and material parameters of the system, which turns out to be quite cumbersome and expensive.

The phenomenon was achieved by the research team by utilizing the double refraction property of liquid crystal, which acts as the host media for high refractive index selenium sub-micron dielectric resonators. The system exhibits a novel mechanism for the creation of magnetic or electric resonance based on displacement currents, also called dipolar and quadrupolar Mie resonances in the optical regime. This mechanism is tunable due to the change in the optical property of a material having a refractive index that depends on the polarization and propagation direction of light or birefringence of the liquid crystal(LC) medium brought about by the application of an external ac electric field.

The scattering spectra of the system in the optical regime was studied using a technique called darkfield hyperspectral imaging (HSI) in collaboration with Prof. T. Pradeep’s group at Indian Institute of Technology, Madras. The light scattered from a single particle was collected using a darkfield objective, and the spectra was mapped from the collected images using HSI technique. The scattering spectra obtained in the pristine and electric field driven states exhibit novel features such as the split- (owing to the birefringence of the host LC), and doughnut-shaped scattering patterns due to the coupling between the broad electric dipole (ED) and narrow electric quadrupole (EQ) resonance modes.

With an increase in the magnitude of the electric field, the value of the Fano parameter, extracted from multi-pole Fano resonance analysis of the scattering spectra, decreases, and shifts towards a value of 1 corresponding to an ideal Fano shape. The finite element method simulations showed excellent agreement with the experimental results.

Mr. Amit Bhardwaj, the Ph.D. student who worked on this project, said, unlike the systems reported earlier in literature, the current system provides an elegant, efficient and facile route to realize tunable Fano resonance that will help practical applications.



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