Optical Forces in Plasmonic and Dielectric Metamaterials

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Abstract - We demonstrate that nanoscale deformation of reconfigurable metamaterials with light leads to giant optical nonlinearities in plasmonic and dielectric metamaterials. While effective optical nonlinearities already many orders of magnitude greater than in natural media are experimentally observed in plasmonic nanomechanical structures, modelling suggests that the underlying optical forces can be even larger within dielectric metamaterials, promising phenomena such as optomechanical bistability and strongly directionally asymmetric transmission.

Reconfigurable metamaterials, which consist of elastic nanostructures that may be rearranged on the nanoscale by electrical, magnetic and thermal actuation mechanisms have developed into a versatile platform for controlling metamaterial properties in real time with large contrast. Recently, it has emerged that such structures can be reconfigured by light, resulting in giant optical nonlinearities.

We report on experimental measurements of extreme optical nonlinearities, for example a nonlinear absorption coefficient exceeding that of GaAs by seven orders of magnitude, in elastically deformable plasmonic nanostructures, resulting from optical forces and opto-thermal mechanisms. It has been seen recently that all-dielectric architectures can deliver metamaterial functionalities free from the high resistive losses inherent to noble metal frameworks and we show here that they can support optical forces that may be an order of magnitude larger than in comparable plasmonic structures, enabling reconfigurable dielectric metamaterials to provide highly directionally asymmetric nonlinearities, resulting in unidirectional transmission and bistability.

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