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Nonlinear Optical Response of Arrays of Metamolecules: New Observations and Ways of Enhancement

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Recent advances in nanofabrication made it possible to produce arrays of artificial structures (metamolecules) with good optical quality. This, in turn, enabled the observation of many unusual phenomena, such as invisibility cloaking, negative refraction, generation of beams with orbital angular momentum and other modifications to the polarization state of the incoming light. Of special importance is the nonlinear optical response of such arrays. Since there is a lot of flexibility in the choice of the materials and shapes of individual metamolecules, it is expected that the nonlinear optical properties of such arrays could be largely controlled and tailored.

In this talk, we will be discussing two methods of such tailoring. One of the methods involves the resonant enhancement of the overall nonlinear optical response enabled by the coupling between the metamolecules in the arrays.

Another method of tailoring the nonlinear optical properties of an array of metamolecules relies on local-field effects. It has been recently shown that such effects are capable of inducing an additional contribution to a higher-than-the-lowest-order nonlinear optical response present in a material medium. This contribution is of cascaded nature: it relies on the multistep contribution of a lower-order nonlinearity to a higher-order susceptibility. When induced by local-field effects, such a cascading is of local nature: it occurs at the scale of the neighboring metamolecules forming the array. This unique feature distinguishes this effect from a better known macroscopic cascading. Microscopic cascading is a relatively new effect that has not been studied in detail yet. We present our resent efforts at identifying the conditions under which this effect could become the dominant contribution to a higher-order nonlinear optical susceptibility.

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