Coupling in metamaterials

Lutz Langguth and Harald Giessen

4th Physics Institute and Research Center Scope, University of Stuttgart, Stuttgart, Germany

Recently, three-dimensional plasmonic structures have caused a lot of attention in the optical community. Metamaterials that consist of basic plasmonic buildings blocks which are arranged in a three-dimensional fashion [1] can give rise to complex structures such as chiral stereometamaterials [2] or plasmonic analogs of electromagnetically induced transparency [3]. Specific for all these structures is the fact that not only their individual constituents determine their eigenmodes, but also their relative arrangement in space.

One key problem in this new field is the calculation of the interaction strength between neighboring interacting elements. Simple dipole pictures give a first glance of what is happening, however, they are not really sufficient to understand the intricate details in dependence of distance and spatial orientation. Additionally, we are dealing with electric as well as magnetic building blocks, which complicate the whole problem. In particular, structures such as stereometamaterials that consist of twisted stacked split-ring resonators show complex spectra which hint at strong higher-order multipole contributions.

In this work, we discuss our ansatz in order to take the first steps towards the solution of this complex problem. We approximate our plasmonic structures by appropriate dipole distributions which are weighted by current and charge densities and calculate the sum of the individual dipole-dipole interactions, taking also phase retardation into account. The results for the coupling strengths are very encouraging and compare well with FDTD simulations as well as with experimental data.

[1] N. Liu et al., Nature Materials **7**, 31 (2008).
[2] N. Liu et al., Nature Photonics **3**, 157 (2009).
[3] N. Liu et al., Nature Materials **8**, 758 (2009).