Disorder in metallic photonic crystals

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Recent advances in nanofabrication have demonstrated that the optical properties of metallic nanostructures can be tailored by periodic arrangement on top of a waveguide layer. In such systems, the particle plasmon can couple strongly to the waveguide mode, forming a so-called waveguide-particle-plasmon-polariton [1].

In this work, we investigate the influence of disorder on the linear optical properties of such nanosystems. We vary the positions of the nanostructures with respect to their original grid positions, controlling type and amount of the disorder precisely. Long-range and frozen-phonon disorder are characterized in detail by their two-point correlation function.

We find that the optical properties of the samples are strongly modified. Increasing disorder reduces the excitation efficiency of the waveguide mode, resulting in a reduced modulation depth of the resonance. Angle-resolved extinction measurements allow to determine the band structure of the samples. The different branches of the polariton show a decreasing band-splitting for increasing disorder due to a lowered spatial overlap of the wavefunctions of particle plasmon and waveguide mode. Different disorder models affect the linear optical properties in a characteristic way.

[1] A. Christ, S.G. Tikhodeev, N.A. Gippius, J. Kuhl, and H. Giessen, *Phys. Rev. Lett*. **91**, 183901 (2003)