The Alchemy of Vacuum
- Hybridizing Light and Matter -

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Strong coupling of light and matter can give rise to a multitude of exciting physical effects through the formation of delocalized hybrid light-matter states. When molecular materials with high transition dipole moments are placed in the confined fields of metallic microcavities or surface plasmons, Rabi splittings approaching 1 eV are observed due to the interaction with the vacuum electromagnetic field. This leads to fundamental changes in the properties of the coupled system even in the dark. While strong coupling has been extensively studied due to the potential it offers in physics such as room temperature Bose-Einstein condensates and thresholdless lasers, the implications for molecular and material science have remained mostly unexplored. After introducing the fundamental concepts, examples of modified properties under strong coupling, such as enhanced charge transport in organic semiconductors and non-radiative energy transfer, will be given to illustrate the broad potential of light-matter states.

Towards fundamental nanophotonic devices using surface plasmon polaritons

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The functionality of novel plasmonic devices relies on the enhancement of electromagnetic interactions. This may concern absorption, emission or scattering processes. We report on two examples.

One deals with the realization of a nanoscopic source of coherent plasmonic excitations, often referred to as SPASER. Based on extensive previous studies, we will introduce improved designs, that should work for realistic parameters, i.e. existing fabrication/ synthesis techniques and gain material.

The other device aims at the realization of a logic element using only a single organic molecule as non-linear element. A challenge in such a device is the efficient conversion of optical, plasmonic, and electrical excitation. We report on first experimental steps and quantitative simulations of realistic design architectures.