A generalized non-local optical response theory for plasmonic nanostructures

Metallic nanostructures exhibit a multitude of optical resonances associated with localized surface plasmon excitations. Recent observations of plasmonic phenomena at the sub-nanometre to atomic scale have stimulated the development of various sophisticated theoretical approaches for their description. Here instead we present a comparatively simple semiclassical generalized non-local optical response theory that unifies quantum pressure convection effects and induced charge diffusion kinetics, with a concomitant complex-valued generalized non-local optical response parameter. Our theory explains surprisingly well both the frequency shifts and size-dependent damping in individual metallic nanoparticles as well as the observed broadening of the crossover regime from bonding-dipole plasmons to charge-transfer plasmons in metal nanoparticle dimers, thus unravelling a classical broadening mechanism that even dominates the widely anticipated short circuiting by quantum tunnelling. We anticipate that our theory can be successfully applied in plasmonics to a wide class of conducting media, including doped semiconductors and low-dimensional materials such as graphene.