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Active plasmonics and nano-scale laser light sources

RUPERT OULTON, University of California, Berkeley

Active plasmonics is a fascinating emerging research area presenting the opportunity to match the length scale of light with those of molecular, solid state and atomic electron wave-functions for the first time. The natural mismatch of visible and infrared light-matter interactions is about three orders of magnitude leaving the majority inherently weak and slow. However, by squeezing light and matter into the same nano-scale volume the interaction not only becomes stronger and faster, weaker effects that were once difficult to detect are dramatically enhanced and more accessible to application. I will discuss how both optical confinement and the available degrees of freedom in plasmonic and meta-material systems give them the unique ability to drastically enhance naturally weak physical effects such as spontaneous emission, stimulated emission and optical non-linearity. I will then use plasmonic amplification as an example of how this physics can be applied. Our recent progress on the realization of laser action of sub-wavelength surface plasmons neatly illustrates how active plasmonics can help us efficiently excite highly localized optical fields, sustain them indefinitely and restore the coherence that is typically destroyed by plasmonic losses. I will summarize by discussing potential applications of plasmonic lasers, loss compensation in plasmonics and lasing of localized surface plasmons.