Multipolar, time-dynamical model for the loss compensation and lasing of a plasmonic spaser

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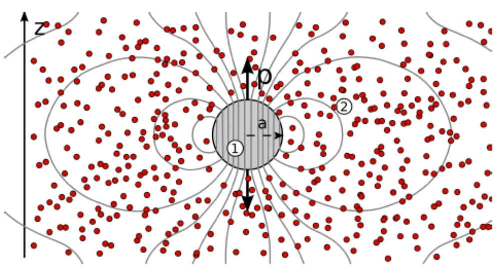

Nanoparticle immersed in an active medium (host medium filled with emitters).

The plasmonic response of a metal nanoparticle in the presence of surrounding gain elements is studied, using a space and time-dependent model, which integrates a quantum formalism to describe the gain and a classical treatment for the metal. Our model fully takes into account the influence of the system geometry (nanosphere) and offers for the first time, a complete set of coupled non-linear equations describing the temporal evolution of the multipolar modes of the particle.

We calculate the lasing threshold value for all multipoles of the spaser, and demonstrate that the dipolar one is lowest. The onset of the lasing instability (linear regime) is then studied both with and without external field forcing.

We also study the behaviour of the system below the lasing threshold, with the external field, demonstrating the existence of an amplification regime where the nanoparticle's plasmon is strongly enhanced as the threshold is approached.

Finally, a qualitative discussion is provided on the approach to the steady-state of the spaser; in particular, it is shown that, for the considered geometry, the spasing must be multi-modal and multipolar modes are always activated.