Freddy Rabouw: Coupling nanoparticles to plasmons on a silver surface

Plasmons are oscillations of the free electrons in a metal. Plasmons in noble-metal nanocrystals or on the flat surface of a bulk noble metal create strong local electromagnetic fields. These fields enhance the absorption and emission of nearby molecules. This can be used for improved sensing (e.g. surface-enhanced Raman spectroscopy) or for control over the brightness and directionality of fluorescence.

In this presentation I will first highlight possibilities to improve the detection of weak "forbidden" signals using plasmonic structures. Europium-doped nanoparticles show orange emission that is forbidden according to electric-dipole selection rules. Enhancing this emission requires strong local magnetic fields, in contrast to normal "allowed" emission that is affected by strong local electric fields. We achieve this with a high-quality structured silver surface, onto which the europium-doped nanoparticles are precisely placed using hydrodynamic printing.

Next, I will show how we coupled fluorescent nanoparticles to plasmons on a silver surface so strongly that not only absorption and emission are enhanced, but even the energy levels in the nanoparticles are modified. To achieve this so-called "strong light–matter coupling" we use CdSe nanoparticles that exhibit strong and narrow-band green emission deposited as a film. We measure energy level shifts in the plasmon-coupled nanoparticles of as large as 75 meV. Strong light–matter coupling is a relatively unexplored research area, but I will discuss possible implications of resulting energy level shifts to control photochemistry.