DESCRIPTION FOR THE GENERAL PUBLIC

Free electrons in noble metal nanostructures can be easily driven into oscillations with incident light of appropriate frequency. Resulting charge density waves (localized surface plasmons) are responsible for enhanced electromagnetic field close to the metal surface, in comparison to the incident beam.

When a molecule is placed close to such nanostructures, it can absorb more light, but also more efficiently emit it back. In fact, the main reason of this is that both light absorption and emission happen with certain probabilities, which are modified by the nanostructure. However, this is not all that can happen. These other processes, that my project is focused on, require a closer look into the molecule electrons.

Electrons, including the ones that constitute molecules, have a spin. In classical physics, spin is associated with rotation. Electron can have one of the two opposite values of spin. Electrons in molecules are (except for some special cases) paired. Electrons that form a pair have opposite spins. When all electrons in a molecule are paired, this is called a singlet state. In some circumstances, a pair of electrons can separate. When this happens, one electron can change its mind about its spin – and pick the other one. When two electrons in a molecule are not paired and have the same spin, this is called a triplet state.

Electrons in molecules, either in singlet or triplet state, can be distributed in a number of ways. Each distribution has its own energy. Molecules in normal conditions are in their lowest energy state which (except for some special cases) is a singlet state. Putting molecule in a level of higher energy, either singlet or triplet, requires providing molecule an additional energy, for example through absorption of light.

Straightforward transition of a molecule from the lowest singlet state to any triplet state is usually almost impossible. However, there is a workaround for this. After light absorption, a molecule is for a very short time in a higher singlet state, from which transition to triplet state is more probable.

Why one would need molecules in a triplet state? The reason might be: when molecules in a triplet state interact with an oxygen molecule (that is normally in triplet state – a special case), reactive oxygen species are created. They are very harmful to living cells. This is why they are used in, e.g., photodynamic therapy of cancer, in which they are formed upon light illumination. This is just one of the many uses of triplet states.

With the use of metal nanostructures, the molecules close to the metal surface are more likely to absorb light and go to higher singlet state (we call it: enhanced absorption), and hence switch to a triplet state. In that way, metal nanostructures increase formation of triplet states in molecules.

The other side of a coin is that with a metal nanostructure, a molecule in a singlet state has lower probability to turn to a triplet state. Before the singlet-triplet transition occurs, a molecule can transfer the excess of energy to the nanostructure and return to the lowest singlet state. This situation is called: shortening of singlet state lifetime. The same thing can happen to a triplet state – a molecule then can also give its energy to the nanostructure before it reacts with oxygen or other molecules.

The aim of my study is to check how gold nanoparticles of different sizes, positioned at various distances from a molecule, influence formation efficiency and lifetimes of triplet states. My measurements will be based on optical methods.