FINAL REPORT "Multiscale spoof plasmons"

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During my visit to the group directed by Prof. Stefan Maier, we explored the possibility of having spoof plasmons (confined electromagnetic modes at the interface between a corrugated perfect electrical conductor and a dielectric) at different spectral regions. The idea was to design a surface that could resonate at the same frequencies than those of selected molecules, possibly addressing simultaneously electronic and vibrational molecular absorption bands.

Several geometries have been discussed. The most promising geometry found is that composed by annular holes, which by themselves present intense electromagnetic resonances at Fabry-Perot resonances of the TEM fundamental mode (which depend on metal thickness) and at the cutoff frequencies of the TE11 waveguide mode. These cutoff frequencies can be tuned by changing the internal and external ratios, the metal thickness and, importantly, by filling the holes with an appropriate dielectric. Additionally, lattice resonances can be induced by the spoof plasmon concept of periodic corrugation. Actually, periodicity is not strictly necessary; instead the lattice resonances appear at peaks in the structure factor of the configuration of holes. This is helpful, as spoof plasmons in fully periodic structures are, for wavelengths larger than twice the array period, bona fide bound modes which, therefore, con not be excited by incident radiation. In contrast, spoof plasmons in quasi periodic or fractal structures are leaky waves that both radiate and can be excited by incident radiation. The final idea is thus to combine the hole and Fabry-Perot resonances with the lattice resonances in quasi periodic and/or fractal structures. The possible drawback is that as the corresponding surface plasmons present radiation losses, the achievable electric field enhancement is not too large. The possible limitations raised by this point can only be found by precise numerical simulations, which are currently under way.

Additionally, during the visit we also started a collaboration on graphene nano photonics and non-local effects in spoof plasmons. These are two very interesting problems, where the collaboration between the Imperial College and University of Zaragoza groups should be very fruitful, given the complementarity in the expertise of the two groups. These incipient collaborations are outside the planned scope of the visit, but are another axis of this very fertile scientific mission supported by the present grant.