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Spectral Dependence of the Amplification Factor in Surface Enhanced Raman Scattering

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Abstract Surface Enhanced Raman Scattering (SERS) is characterized by a strong signal amplification (up to 10^{8-10}) when both the excitation and the Raman photons frequencies match the localized plasmon resonances (LSPR) of the nanoparticles (NPs). In order to understand if the effective LSPR profile refers to the bare NPs or to the resonance of NPs "dressed" with the probe molecules, we perform multiwavelength (514 nm, 633 nm and 785 nm) SERS experiments using both evaporate gold NPs and gold Nanoantennas produced by electron beam lithography (EBL) as SERS-active substrate on which we deposited Methylene Blue molecules (MB) that yields a resonance energy red-shift and a broadening of LSPR profile.

The SERS spectra at the investigated excitation wavelengths display a different intensity ratio of the characteristic MB band (peaks at 450 cm^{-1} and 1620 cm^{-1}) with respect to the Raman counterpart. We observed that:

- *Au NPs*: the LSPR in presence of MB molecules is 50 nm red shifted. The enhancement of the Raman modes at the different excitation wavelengths follows a trend similar to the LSPR profile of the "dressed" NPs, although the maximum enhancement is found at 785 nm excitation, in spite of a LSPR peak at 600 nm.
- *Au Nanoantennas*: The LSPR in presence of MB is not shifted. The enhancement of the Raman modes follows the LSPR profile, with maximum enhancement at 633 nm excitation and enhancement of the 1620 cm^{-1} peak a 20% smaller than that of the 440 cm^{-1} one.

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