Molecular Optomechanics: amplification of vibrations in SERS

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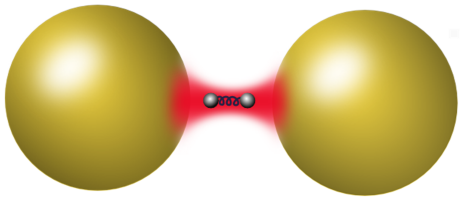

Over the past decades a range of theories have been developed to describe the scattering of the amplified Raman signal. However, considering only the electromagnetic factor, conventional models fail to account for all experimental observations. In a recent work [1], sub-nanometer, molecular-scale resolution was obtained in TERS – far below the common spatial extent of plasmons. Kippenberg's group proposed recently a new theory of plasmon-enhanced Raman scattering by mapping the problem to cavity optomechanics [2]. The herein presented enhancement mechanism, due to dynamical backaction amplification of molecular vibrations, may explain previous observations and shed new light on the physics of SERS and TERS.

The objective of this project is to reveal the role of dynamical backaction in SERS experiments by exploiting the new model to control both the measurements and the fabrication distinctly. In order to enable the detection of the inferred dynamical backaction amplification, methods allowing the controlled juxtaposition of two nanoparticles will be investigated. Fischer's group developed a fabrication method of large arrays of nanoparticles with full control over their size, spacing and material composition [3]. The method will allow to retain the particle size and shape (and hence the size of the cavity) whilst tuning the plasmon resonance. This collaboration aims to develop further the sensitivity and resolution of nano-scale Raman spectroscopy and imaging. More radically, evidences of this enhancement mechanism will pave the way for a completely new research field coupling molecules to cavity optomechanics.

[1] R. Zhang *et al., Nature* **498**, 82 (2013)
[2] P. Roelli, C. Galland, N. Piro, T. J. Kippenberg, *arXiv preprint*, (2014)
[3] A.G. Mark, J.G. Gibbs, T.-C. Lee, P. Fischer, *Nature materials* **12**, 802 (2013)