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Tip-enhanced Raman Scattering - a Tool for Nanoscale Analysis

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Optical spectroscopies are powerful tools in particular for the investigation of surfaces and interfaces. Particularly Raman spectroscopy allows a molecule specific label-free investigation with considerable spatial resolution, essentially limited by the Abbe diffraction limit. The main disadvantage of Raman spectroscopy is the notoriously weak efficiency of the process. Since three decades so called surface enhanced Raman spectroscopy (SERS) utilizes the intrinsic properties of small metal particles or roughness features to enhance the Raman signal by several orders of magnitudes. Hence, sensitivities down to the single molecule level have been reported. A major challenge for this method, however, is the application to analytical problems, either of multicomponent systems or of in homogeneous surfaces. In both cases a mixing or specific aplication of the enhancing substrate and the specimen is required. Interestingly if SERS is confined to only a single particle such problems can be avoided. This can be done for instance by immobilizing a single particle on the end of a scanning probe microscopy tip. This way, in addition to the benefits of Raman and SERS in general, the enhancement effect is always the same, the lateral resolution is directly related to the size of the particle, which is generally in the ten nanometer regime. This method is called tip-enhanced Raman scattering (TERS) and allows the label free investigation of surfaces with nanometer resolution.
As practical examples of TERS investigations ranginging from cell surface investigations down to the spectroscopy of single proteins will demonstrate the potential and also the current limitation of the technique.