Title: Electrochemistry under vibrational coupling with plasmons

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Scientific description:

Recently, it was shown that chemical reaction rates can be modified by up to an order-of-magnitude by performing the reaction in a Fabry-Perot cavity tuned to the vibrational mode of one of the molecular species appearing along the reaction path. This remarkable observation, for which there is as yet no clear physical explanation, was made in the absence of any external photo-excitation. Inspired by this, we propose an internship and PhD project whose long-term goal is to study electrochemical reactions under vibrational strong coupling conditions. The intern will participate in, and contribute to, a series of experiments in which plasmonic metasurfaces will be fabricated using state-of-the-art lithography, then used as the working electrode in an electrochemical cell. Initial tests will target the study of text-book electrochemical reactions under external, mid-IR excitation, with the aim being to explore the effect of photon confinement at the electrode surface on reaction kinetics.

The candidate will have the opportunity to pursue several different routes during the internship, and in a subsequent PhD project. These routes could include (i) the design and modelling of the optical properties of plasmonic metasurfaces using finite difference, time-domain (FDTD) or rigorous coupled-wave analysis (RCWA), (ii) the fabrication of the designed metasurfaces using state-of-the-art lithography techniques, (iii) the optical characterization of the metasurface properties using tunable, cascade laser sources and Fourier-transform infrared spectrometers, and (iv) the study of the kinetics of a text-book electrochemical reaction occurring at the fabricated metasurfaces. Reactions may include (but will not be limited to) for example, the widely-studied ferrocyanure/ferricyanure redox couple, or reactions of important to the energy transition (e.g. CO_2 reduction or water electrolysis).

This work is inter-disciplinary and relies on experimental competencies from the fields of electrochemistry (sample preparation and electrochemical characterizations), analytical chemistry (infrared spectroscopy) and optics (plasmonics, vibrational coupling). Supervision will be undertaken by an interdisciplinary team of chemists and physicists. We invite interested candidates to contact one of us directly, to obtain further reading on the subject, and to arrange a discussion of the scientific details of the internship and subsequent thesis.