36 months PhD Position

Toward polaritonic (electro) catalytic materials: exploring the production of H_2 from H_2O strongly coupled with light

Background It is well known that the structure of the materials can be engineered to interact with light. What is less known is that, in some cases, this interaction can be so strong that physical and chemical properties of the system can be modified and this even in absence of light.[1] One emerging strategy to obtain strong coupling consists in designing optical devices called resonators that interact with molecular vibrations in the infrared range.[2] This effect, called vibrational strong-coupling, was proven to lead to surprising modification of the chemical reactivity of homogenous liquid systems in absence of external light.[3] Extending this emerging principle to heterogeneous systems has the potential to make a conceptual breakthrough in heterogeneous (electro)catalysis.

Objective In this PhD project, we aim at providing a decisive step for this quest by investigating the catalytic and electrocatalytic H_2 production into optical resonators in which H_2O molecules are strongly coupled with light and this, without applying any external light. The main goal will consist in fabricating these devices to unveil the effect of light-matter strong coupling on the catalytic and electrocatalytic H_2 production. To do so, three partners with complementary expertise (material chemistry, quantum physics, simulation and catalysis) will team-up to support the PhD candidate. The project will involve 4 parts:

- Synthesis of the (electrocatalytic) catalytic materials
- Design by electromagnetic simulations and clean-room fabrication of the resonators
- Optical characterization by in situ IR ellipsometry and FTIR microscopy
- Testing of the catalytic and electrocatalytic H_2 generation.

Profile: The project is mainly of experimental nature at the interface between materials chemistry and physics. Thus, different profiles are suitable for this position: an engineer with a broad background in both physics and chemistry; a material chemist with a background in materials synthesis and/or catalysis, or a material physicist with a background in solid-state physics, optics, quantum physics or simulation. Considering the collaborative and multidisciplinary nature of the project, the ideal candidate should be open to learn new concepts, possess strong team-working abilities and excellent communication and writing skills.

Location/supervision:
The candidate will work downtown Paris in two main locations and will be supported by several researchers with complementary expertise:

1) Laboratoire Chimie de la Matière Condensée de Paris at Sorbonne Université (Pr. M. Faustini)
2) Laboratoire de Physique de L'ENS (Pr. C. Sirtori, Pr. A. Vasanelli)

In addition, a strong collaboration with the Univ. Paris Cité (Pr. J. Peron) is also planned.
The PhD candidate will be enrolled at the doctoral school "Physics and Chemistry of Materials" at Sorbonne Université. The project will be co-directed by Pr. Marco Faustini and Pr. Carlo Sirtori.

How to apply? The applicant will attach a CV, a short motivation letter, grades and the contact of 2 academic references.

Contacts: if you are interested → marco.faustini@sorbonne-universite.fr and carlo.sirtori@ens.fr

References

1) *Garcia-Vidal, F. J. et al. Manipulating matter by strong coupling to vacuum fields. Science 373, (2021)*
2) *Shalabney, A. et al. Coherent coupling of molecular resonators with a microcavity mode. Nature Communications 6, 5981, (2015).*
3) *Fukushima, T. et al. Inherent Promotion of Ionic Conductivity via Collective Vibrational Strong Coupling of Water with the Vacuum Electromagnetic Field. Journal of the American Chemical Society 144, 12177-12183, (2022).*