PhD proposal on microscopic origin of quantum light emission in 2D crystals

Laboratories: CRHEA, Valbonne - CEA-IRIG Grenoble, France. The precise allocation of time between CRHEA and CEA for co-supervision purposes will be determined based on scientific goals as well as the requirements and preferences of the candidate.

The **2D+ group at CRHEA and LEMMA team at CEA** are looking for well-qualified, highly motivated and dynamic PhD candidate who wish to enhance his/her scientific career in a friendly and stimulating environment within the field of electron microscopy and quantum nano-photonics. The objective of this project is to gain insights into the nanometer scale structure of single photon emitters in semiconducting 2D crystals such as hBN and WSe_2. This will be achieved through the utilization of advanced characterization techniques capable of detecting single photons in a cryogenic environment, along with a state-of-the-art transmission electron microscope (TEM) that offers a remarkable resolution of 70 picometers. Although 2D crystals have exhibited quantum light emission, the underlying mechanism behind this phenomenon remains elusive due to the limitations of optical techniques in achieving micron-scale resolution. This PhD project aims to unravel the origin of quantum light emission in 2D crystals by correlating atomic resolution images with maps of single photon emission. One of the primary goals is to fabricate 2D crystal samples on TEM grids and investigate the relationship between their microscopic structures (such as strain and electric-field distribution) and properties of single photon emission (such as position, spectral purity, and antibunching). The study will explore the use of diverse 2D crystals (such as TMDs, twisted van der Waals heterostructures, and epitaxial 2D crystals). Additionally, the project will investigate the potential of using electron-beam to introduce defects in a deterministic manner, which could provide a means to engineer quantum nano-photonics devices based on 2D materials. Concretely, this PhD work will directly impact emerging quantum technologies in nano-photonics (e.g. integrated single photon sources) as well as condensed matter community (e.g. electric field distribution in 2D crystals, exciton trapping).

References:

- **Quantum Nanophotonics in Two-Dimensional Materials**. A. Reserbat-Plantey *et al.* ACS Photonics. 2021
- **Two dimensions and one photon.** V. Perebeinos. Nature Nano. 2015
- **Single photons at room temperature**. J. Wrachtrup. Nature Nano. 2016
- **Impact of a van der Waals interface on intrinsic and extrinsic defects in an $MoSe_2$ monolayer**. C. Alvarez, M.T. Dau, A. Marty, C. Vergnaud, H. Le Poche, P. Pochet, M. Jamet, H. Okuno,. Nanotechnology. 2018

Requirements:

- Master's degree (or equivalent or higher) in physics, photonics, condensed-matter or any related discipline
- Interest in the development of new optics experiments and nanofabrication techniques
- Experience in Python and CAD software are advantageous, but not requisite.
- Good organizational skills and team spirit.

Responsibilities:

- Scientific contribution to the project, literature review, experiment planning, data analysis.

- Experimental development of 2D quantum devices fabrication (exfoliation, dry transfer on TEM grids).
- Measurement in TEM (4D-STEM, electric-field characterization, structural characterization e.g. moiré, strain, defects)
- Single photon counting measurements using micro-spectroscopy optical setup operating at 3K
- Close collaboration with the project partner.
- Presentation of research findings on international conferences as well as publication of findings in English.

→ In case of interest, candidates may contact Dr. Hanako Okuno (hanako.okuno@cea.fr) Dr. Antoine Reserbat-Plantey (antoine.reserbat-plantey@cnrs.fr) for further details.