INTERNSHIP PROPOSAL

(One page maximum)

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Internship location: ESPCI

Thesis possibility after internship: NO
Funding: YES If YES, which type of funding: ANR

NbN thin film synthesis and characterization

Niobium nitride (NbN) is a very interesting material both for its fundamental properties but also for applications in quantum technologies. It is a superconducting material with a relatively "high" critical temperature (up to 13 K) and the transition temperature can be tuned with the thickness of the film [1]. All this makes it a promising candidate for a wide variety of quantum technology applications without the need for a dilution refrigerator. Recently it has been used for magnetic imaging at "high" temperature [2], to make high quality resonators for circuit QED [3], high range cryogenic thermometers [4] and single photon detectors [5].

In the lab we have been developing a NbN magnetron deposition systems that will produce such superconducting films for different team in the group. Your task during this internship will be to make such high quality NbN films, to develop reliable deposition protocols and characterize the resulting films. The characterization will be electronic (transport), optical (reflectometry and ellipsometry) and also topographic (AFM). Depending on the progress made, you will be involved in the fabrication of quantum circuits made out of these films.

This internship will give you direct hands-on experience on a wide range of experimental techniques that are widely used in condensed matter and quantum technologies (ultra-high vacuum, cryogenic, DC transport, film deposition, ellipsometry, AFM).

References:

[1] Jing, Tian-Yu, *et al.* « Quantum phase transition in NbN superconducting thin films ». Physical Review B 107, nº 18 (2023): 184515. https://doi.org/10.1103/PhysRevB.107.184515
[2] Zhang, *et al*. « The On-Chip Scanning Probe with Dual Niobium Nitride Nanoscale Superconducting Quantum Interference Devices for Magnetic Imaging at the High Temperature ». Superconductor Science and Technology, 2023. https://doi.org/10.1088/1361-6668/ad0182.
[3] Frasca, S., *et al.* « NbN films with high kinetic inductance for high-quality compact superconducting resonators ». Physical Review Applied 20, no 4 (2023): 044021. https://doi.org/10.1103/PhysRevApplied.20.044021.
[4] Nguyen, *et al.* « Niobium Nitride Thin Films for Very Low Temperature Resistive Thermometry ». Journal of Low Temperature Physics 197, no 5 (2019): 348 56. https://doi.org/10.1007/s10909-019-02222-6.
[5] Hu, Peng, Hao Li, Lixing You, Heqing Wang, You Xiao, Jia Huang, Xiaoyan Yang, Weijun Zhang, Zhen Wang, et Xiaoming Xie. « Detecting Single Infrared Photons toward Optimal System Detection Efficiency ». Optics Express 28, no 24 (2020): 36884 91. https://doi.org/10.1364/OE.410025.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: NO Theoretical Physics: NO