INTERNSHIP PROPOSAL

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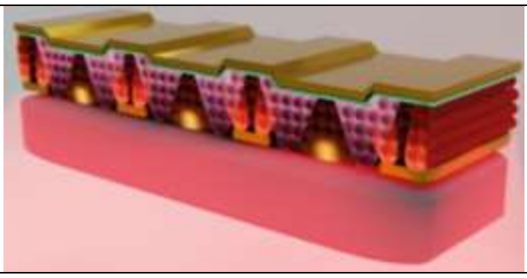
Thesis possibility after internship: YES (actually preferred)
Funding: YES If YES, which type of funding: ERC (already secured)

Active photonic devices using colloidal quantum dots

Summary Traditional infrared camera designs rely on integrating an absorbing layer with a CMOS (complementary metal-oxide-semiconductor) circuit, which offers high efficiency but presents several limitations, including high fabrication costs, challenges in reducing pixel size, and limited spectral tunability. To address these issues, strategies based on colloidal nanomaterials [1-2] are being developed, allowing direct functionalization of the CMOS surface. However, for optimal efficiency, especially in maximizing light absorption, nanocrystal films benefit from being coupled with photonic structures.
The basic concept involves embedding the nanocrystal layer within a cavity and tuning the cavity resonance to match the nanocrystal band gap. This approach enhances the magnitude of light absorption while offering new flexibility to shape the spectral response. The next step in advancing this technology is to move toward active coupling [3], where the spectrum can be dynamically tuned using an external input, such as a voltage bias. This requires the design of innovative cavities that amplify the inhomogeneity of the incident electric field.
In this project, the applicant will first receive training on designing fundamental nanocrystal-based infrared detectors and, in parallel, start developing the appropriate photonic cavities. A major goal is to create strategies that can be transferred to camera systems. This introduces additional challenges, such as working with non-transparent substrates and dealing with finite pixel sizes. The project will involve aspects of chemistry (supported by an engineer), optics, fabrication, and optoelectronics.
While expertise in all these fields is not required, a willingness to explore and learn these interdisciplinary topics is essential. This work aims to combine advances in materials science with cutting-edge photonics and device engineering to revolutionize infrared detection technology.



Schematic of a multi resonant structure used as infrared detector

References
[1] The Rise of HgTe Colloidal Quantum Dots for Infrared Optoelectronics, KA Sergeeva, et al, Advanced Functional Materials, 2405307 (2024)
[2] Photoconductive focal plane array based on HgTe quantum dots for fast and cost-effective short-wave infrared imaging, C. Gréboval, et al, Nanoscale 14, 9359 (2022)
[3] Bias Reconfigurable Photoresponse of an Infrared Nanocrystal Film Integrated into a Coupled Fabry-Perot Resonator, TH Dang et al, ACS photonics 10, 1601 (2023)

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: YES Theoretical Physics: NO