Tailoring Optical Properties and Beyond: Recent Advances in van der Waals Semiconductors and Collaborative Research at FORTH

I. Paradisanos [1#], **D. Katrisioti** [1,2], **E. Katsipoulaki** [1,3], **K. Mourzidis** [1,4], **X. Marie** [4], **M. M. Glazov** [5], **G. Kopidakis** [1,2], **I. Remediakis** [1,2], **G. Kioseoglou** [1,2], **E. Stratakis** [1,3], **J. Parthenios** [6], **K. Papaggelis** [6], **J. M. Poumirol** [7] and **V. Paillard** [7]

[1] Institute of Electronic Structure and Laser, Foundation of Research and Technology Hellas, 71110, Heraklion-Crete, Greece

[2]Department of Materials Science and Engineering, University of Crete, Heraklion 70013, Greece

[3]Department of Physics, University of Crete, Heraklion 70013, Greece

[4]INSA-CNRS-UPS, LPCNO, 135 Avenue Rangueil, 31077 Toulouse, France

[5]Ioffe Institute, 194021 St.Petersburg, Russia

[6]Institute of Chemical Engineering Sciences, Foundation for Research and Technology-Hellas, Stadiou str Platani, Patras 26504, Greece

[7]CEMES-CNRS, Université de Toulouse, Toulouse, France

email: iparad@iesl.forth.gr

ABSTRACT

In recent years, van der Waals semiconductors (vdWS) have attracted significant attention due to their unique optical, electronic, and quantum properties, which open up new possibilities for advanced optoelectronic, spintronic, nanophotonic, and quantum devices. Building on this growing interest, my research at FORTH, following my return from abroad and supported by an HFRI grant, has focused on enhancing and controlling the optical properties of vdWS through near-field interactions with dielectric nanoantennas.[1] These interactions have led to significant improvements in emission intensity, exciton (i.e. Coulomb-bound electron-hole pairs) polarization control, and Raman scattering efficiency in these materials, presenting exciting opportunities for future optoelectronic and nanophotonic devices.

In addition to these results, I have initiated new collaborative efforts within FORTH and internationally. One of these projects investigates exciton transport in exotic, lateral heterostructures, with sample fabrication at FORTH/ICE-HT & IESL and diffusion experiments conducted in collaboration with INSA, CNRS, and the University of Antwerp.[2] Another emerging research direction explores moiré physics in vertical heterostructures, aiming to understand the conditions under which vertically-stacked heterostructures exhibit rigid moiré superlattices or lattice reconstruction. This work, in collaboration with theory groups at FORTH, holds promise for uncovering and engineering novel quantum states. Finally, an innovative exploration of superradiance and superfluorescence in vdWS, bridging quantum optics with condensed matter physics will soon be initiated.

This talk will present our key findings and outline promising collaborative activities, demonstrating the innovative work being carried out at FORTH in the field of novel quantum materials.

REFERENCES

[1] A. Estrada-Real, I. Paradisanos, P. R. Wiecha et al. 2023. *Commun Phys,* **6**,102.
[2] H. Lamsaadi, D. Beret, I. Paradisanos et al. 2023. *Nat Commun,* **14**, 5881.