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PROSEMINAR UHH-66-518 BIO/NANO-ELECTRONICS – BLICK GROUP

CHyN, Rm.-301, 09. Dezember 2025, 13.15h
[hybrid: Zoom 664 8257 0935, 07336627]

Strain-modulated exciton recombination probability in low-dimensional semiconductors

Daniel Hensel,
Leibnitz-Institut für Kristallzüchtung (IKZ), Berlin

Time-dependent acoustic strain provides a powerful tool to functionalize material properties and, when combined with the unique characteristics of semiconductor nanostructures, enables advanced optomechanical control. I first present the structural response of InP nanocrystals on silicon nanotips under femtosecond laser excitation. Time-resolved optical pump–probe reflectivity is used to identify the acoustic eigenmodes of the nanocrystals. At low excitation fluences, we observe two radial breathing modes at 8 GHz and 10.3 GHz. When the fluence exceeds 3 mJ/cm², nonlinear frequency mixing of these fundamental modes emerges, indicating strain-induced nonlinear elasticity. The resulting fluence-dependent spectral response can be modeled by a higher-order extension of Hooke's law. Complementary time-resolved X-ray diffraction measurements confirm the presence of a down-converted low-frequency mode that is also seen in the all-optical experiments. Since strain modulates the band structure of semiconductors via deformation potential coupling the recombination probability of excitons is also modulated. In the second part of the talk, I will discuss an approach to modulate the photoluminescence emission of low-dimensional semiconductors using laser-generated acoustic strain. Ultimately, dynamically switchable bandgap materials could be employed as a source of single photons.