Optical probing of strain-tuned quasiparticle control in monolayer MoS_2 at 10 K

J. Fernández-Martínez[1], N. Kyvelos[2], H. P. Van Der Meulen[1,3]
G. López-Polín[1,3], D. Hernández-Pinilla[1], P. Ares[3,4], C. Tserkezis[2],
M. O. Ramírez[1,3], L. E. Bausá[1,3,#]

[1]Dept. Física de Materiales, Universidad Autónoma de Madrid, Spain
[2]University of Southern Denmark, POLIMA-Center Odense, Denmark;
[3]Condensed Matter Physics Center (IFIMAC), Madrid, Spain;
[4]Dept. Física de la Materia Condensada, Universidad Autónoma de Madrid, Spain;

Transition metal dichalcogenides (TMDs) are a class of atomically thin materials exhibiting a variety of emergent phenomena with promising impact in optoelectronics, electronics, and spintronics. At the monolayer level, TMDs exhibit a direct-bandgap and strongly tunable optical properties, enabling their excitonic landscape to be tailored through different physical and chemical approaches.

In this work, we explore the optical response of monolayer MoS_2 transferred onto linear chains of silver nanoparticles (Ag NPs), which are self-organized on a periodically poled $LiNbO_3$ ferroelectric substrate. These nanoparticle chains generate localized strain fields at the nanoscale, giving rise to controlled nano-wrinkles in the MoS_2 monolayer. Spatially resolved photoluminescence measurements reveal that the resulting strain gradients effectively modulate the band structure and induce exciton-to-trion conversion within regions of approximately 50 nm. At cryogenic temperatures, enhanced quasiparticle localization further boosts this effect, leading to an increase in trion emission exceeding 50% compared to unstrained areas (see Fig. 1) [1].

Overall, these results demonstrate that long nanometer-scale Ag nanoparticle chains provide a versatile platform for one-dimensional strain-induced quasiparticle confinement, opening opportunities for trion-based circuits and next-generation quantum technologies.

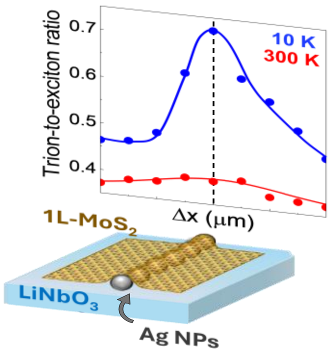

Fig. 1 Top: Spatial evolution of the trion-to-exciton ratio in monolayer MoS2 (1L- MoS2) at 10 K in the vicinity of the Ag NP chain. Bottom: Scheme of the 1L-MoS2/Ag NP chain/LiNbO3 sample.

[1] J. Fernández-Martínez, et al., (2026) Journal of Luminescence 292, 121727.

corresponding author: luisa.bausa@uam.es