Strained-induced exciton hybridisation in transition metal dichalcogenide monolayers unveiled by high magnetic field photoluminescence

Antonio Polimeni

Dipartimento di Fisica, Sapienza Università di Roma, Italy

Within the variegated family of two-dimensional crystals, semiconducting transition-metal dichalcogenides (TMDs) show alluring optoelectronic and spin properties in the monolayer (ML) limit, featuring a direct bandgap which results in an efficient visible/near-infrared light emission, and a strong spin-orbit coupling. Furthermore, these materials display exceptional flexibility and robustness and can be subjected to remarkable strains.

Here, we explore new strategies to tune the peculiar properties of 2D TMDs by engendering localised strains in TMD MLs exploiting on low-energy hydrogen-ion irradiation of bulk flakes. This process leads to the formation of ML-thick, highly pressurised micro-/nano-sized domes filled with molecular hydrogen [1].

The domes are durable and incredibly robust, and, due to their single-layer nature, TMD domes behave as efficient light emitters [2,3]. The high strain fields they host cause dramatic changes in the TMD opto-electronic properties, and photoluminescence (PL) steady-state and time-resolved studies enabled the characterisation of the strain-induced band-structure modifications and revealed intriguing phenomena, such as a strain-induced direct-to-indirect bandgap crossover [2]. Magneto-optical measurements allowed us to study the effect of strain on the magnetic moment of the excitons in TMD MLs, and to pinpoint hybridisation phenomena between direct and indirect excitons [4].

[1] E. Blundo, T. Yildirim, G. Pettinari, and A. Polimeni, Phys. Rev. Lett. **127**, 046101 (2021)
[2] E. Blundo, M. Felici, T. Yildirim, G. Pettinari, D. Tedeschi, A. Miriametro, B. Liu, W. Ma, Y. Lu, and A. Polimeni, Phys. Rev. Res. **2**, 012024 (2020).
[3] D. Tedeschi, E. Blundo, M. Felici, G. Pettinari, B. Liu, T. Yildrim, E. Petroni, C. Zhang, Y. Zhu, S. Sennato, Y. Lu, and A. Polimeni, Adv. Mater. **31**, 1970314 (2019).
[4] E. Blundo, P. E. Faria Junior, A. Surrente, G. Pettinari, M. A Prosnikov, K. Olkowska-Pucko, K. Zollner, T. Woźniak, A. Chaves, T. Kazimierczuk, M. Felici, A. Babiński, M. R. Molas, P. C. M. Christianen, J. Fabian, and A. Polimeni, Phys. Rev. Lett. **129**, 067402 (2022).