Brightening of localized exciton with strong phonon coupling in Ferromagnetic $CrBr_3$

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Emerging two-dimensional (2D) magnetic semiconductors such as chromium tribromide ($CrBr_3$) offer a promising platform for spintronic technologies. As an intrinsic ferromagnetic semiconductor at the atomic scale, $CrBr_3$ demonstrates that long-range magnetic order can be naturally sustained in atomically thin layers, providing new opportunities to investigate magnetic behaviour in reduced dimensions. Current research still lacks systematic and quantitative investigations of excitonic dynamics, which are crucial for establishing a detailed understanding of their optical properties and associated magnetic phase transitions[1], [2]. In this work, we investigate the optical response of the van der Waals ferromagnet $CrBr_3$ and identify a series of narrow emission lines in the near infrared that stand in clear contrast to the broader excitonic features commonly observed in the visible region. Using non-invasive optical probing, we demonstrate that these sharp peaks arise from exciton localization at unintentionally introduced defect states, with their behaviour further influenced by lattice vibrations through exciton–phonon coupling. These defects act as resonant phonon cavities, exhibiting a characteristic vibrational mode at 183 cm^{-1} that strongly enhances coupling with confined excitons. This pronounced interaction gives rise to exciton splitting mediated by lattice vibrations, observable even at room temperature. Our results underscore the important role of defect engineering in tailoring light–matter interactions and provide a promising route toward high-performance optical emitters and integrated photonic devices based on 2D magnetic materials with precisely controlled defects.

References

[1] B. Huang *et al.*, Nature, 7657 (2017) 270–273
[2] F. Yao *et al.*, Nat. Commun., 1 (2023) 4969

Figures

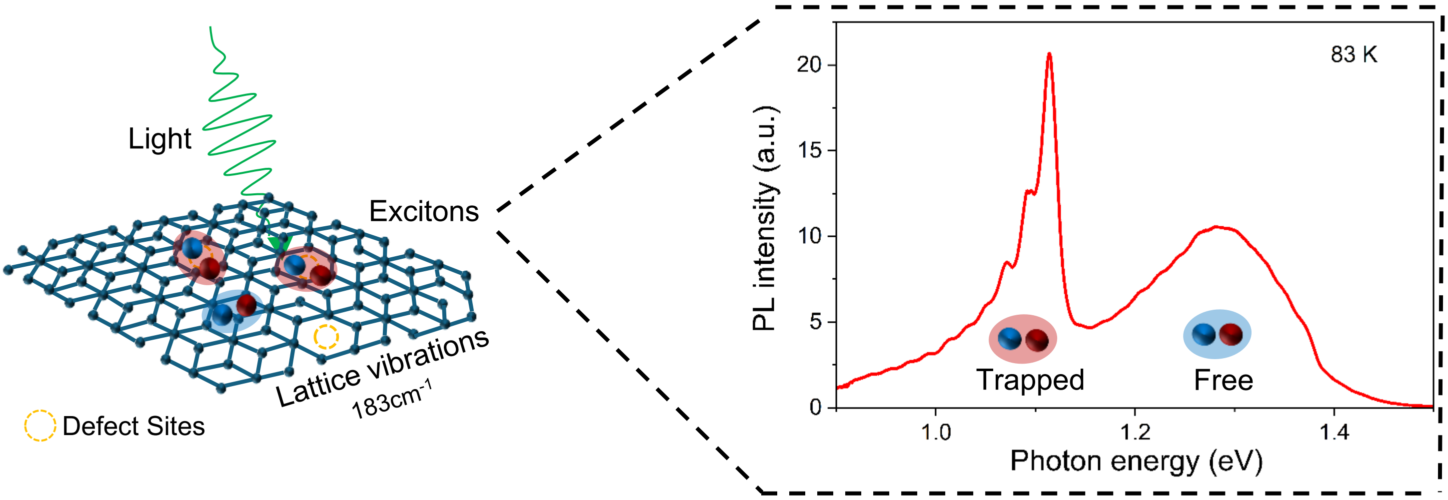

Figure 1: Schematic of $CrBr_3$ under optical excitation, leading to a broad emission from free excitons and a sharp narrow emission with phonon sidebands from excitons trapped at defects with lattice vibrations at 83K