Towards quantum electronics and optoelectronics with individual point defects in 2D semiconductors

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Atomic-scale quantum systems based on individual point defects and colour centres have become key elements in emerging quantum technologies, with applications in quantum sensing, computation, simulation, and communication. Different from conventional 3D semiconductors, electron (or hole) spins in atomically-thin (2D) semiconductors with hexagonal lattices, are coupled to an additional valley degree of freedom [1] in the presence of inversion asymmetry and strong spin-orbit coupling. In-gap states due to atomic point defects can inherit these properties [1], making them promising atomic-scale quantum systems that may allow coherent control of spin-valley states electrically and optically [2, 3]. Using low-temperature (4.5K) resonant tunnelling scanning probe spectroscopy in the Coulomb blockade regime [2], we show that sulphur (S) vacancies in monolayers of MoS_2 exhibit a rich in-gap electronic structure governed by an interplay of local crystal symmetry breaking and spin-orbit coupling. Combining the unrivalled spatial resolution of the scanning tunnelling microscope (STM) with conventional optics, we capture electrically stimulated luminescence – with single-photon character [3] – at length scales two orders of magnitude below the diffraction limit of conventional optics.

References

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