Ultrafast optical coherent control of a single-photon emitter in hBN

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The optical coherent manipulation of single solid-state quantum systems is a key challenge in the development of quantum communication devices and quantum computation. Recently, the family of solid-state quantum emitters was joined by single-photon sources in atomically thin transition metal dichalcogenides and other 2D van der Waals materials [1]. Among these, colour centres in hexagonal boron nitride (hBN) are attracting considerable attention due to their remarkable properties, including bright single-photon emission at room temperature, a wide spectral range, narrow emission lines, and an excellent tunability.
We demonstrate coherent state manipulation of a single hBN colour centre with ultrafast laser pulses using a double-pulse sequence, as schematically shown in Fig. 1 [2]. The coherence properties of the two-level system are detected by measuring the photoluminescence intensity, which is proportional to its occupancy, as a function of the pulse delay. Our experiments and simulations reveal the effects of different sources of spectral jitter on the ultrafast coherence dynamics. We also demonstrate that coherent control can not only be exerted resonantly on the optical transition but also phonon-assisted, which provides profound insight into the internal phonon quantum dynamics. In the case of optical phonons, we find that the increased decoherence rates are due to dephasing processes of the phonon states, partly due to their anharmonic decay. The dephasing induced by acoustic phonon generation manifests itself in a rapid decrease in the coherent control signal when propagating phonon wave packets are emitted. Our demonstration of phonon-assisted coherent control of single hBN colour centres is an important step towards hybrid quantum technologies that combine electronic and phononic excitations.

References

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Figures

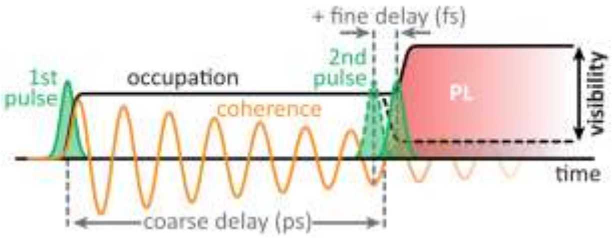

Figure 1: Double-pulse sequence of the ultrafast coherent control experiment. The initial phase of the quantum coherence is determined by the phase of the first laser pulse, while the timing of the second pulse affects the occupation of the quantum system, which is detected by measuring the photoluminescence intensity.