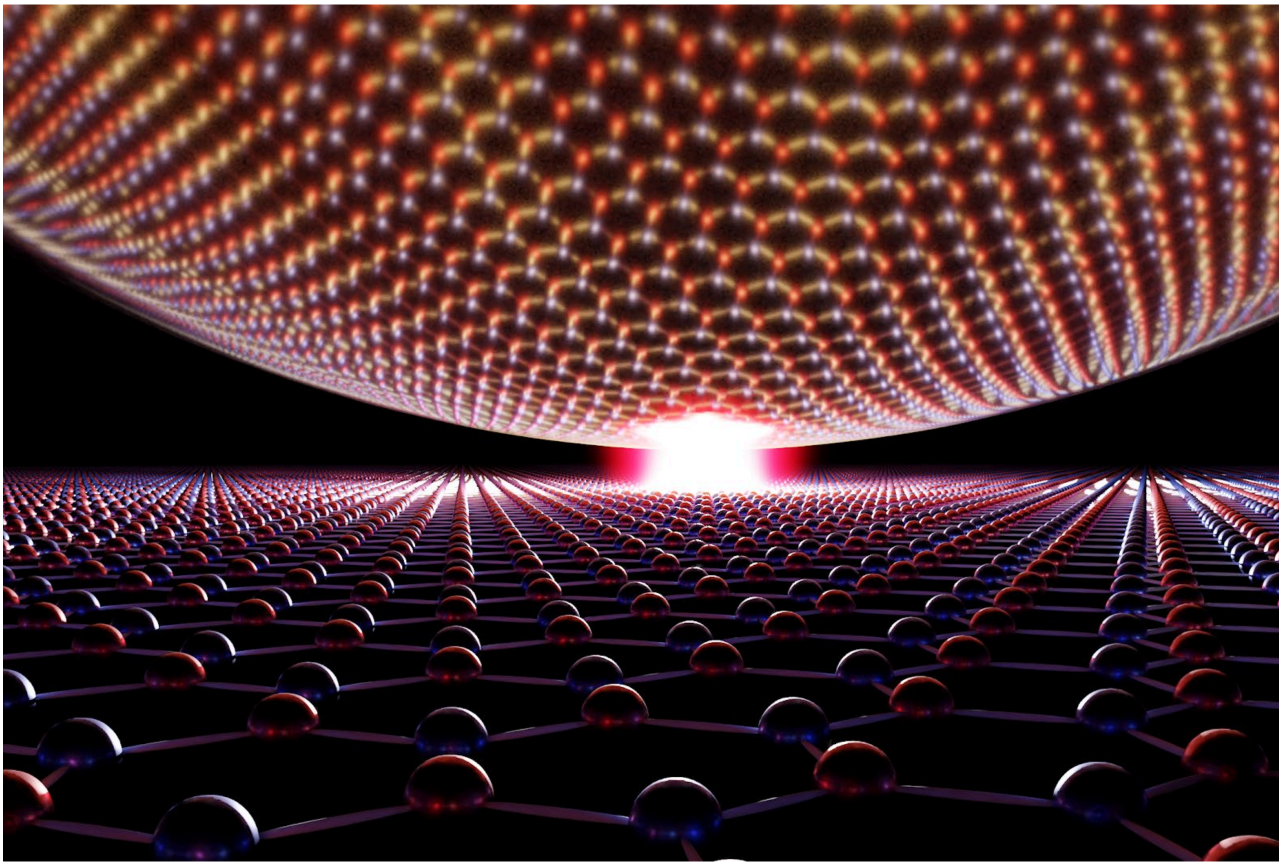
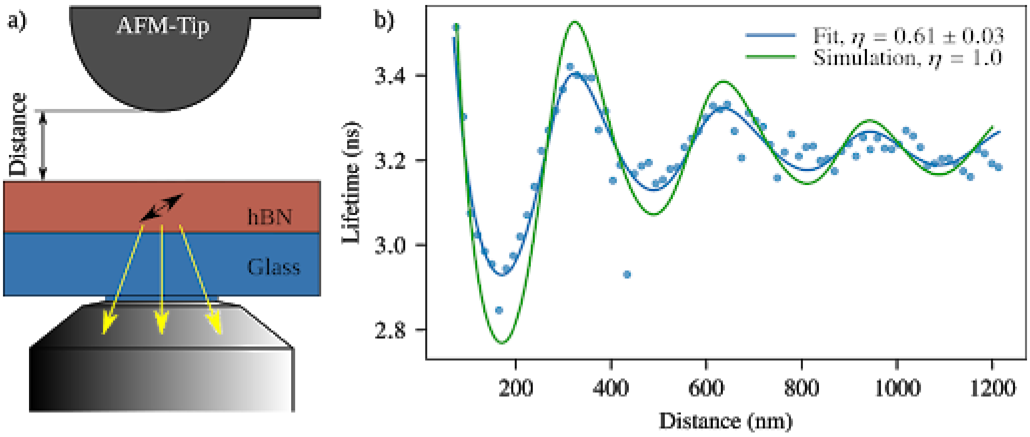
Direct measurement of quantum efficiency of single-photon emitters in hexagonal boron nitride



Two-dimensional materials like boron nitride (h-BN) have recently attracted the attention of the quantum optics and nano optics community. Individual single photon emitting (SPE) defects can be found even in single layers of h-BN. These emitters are bright and stable and have a narrow emission line, making them potentially suitable for use in quantum communication devices. As the field is still young, it is difficult to create SPEs with desired properties. One reason for this is the yet unknown atomic origin of the defect, which could help to identify processing steps that could lead to the desired outcome. In order to determine the atomic origin of an emitter, calculations are carried out under the assumption of different atomic configurations and compared with the observed spectra. Unfortunately, the h-BN SPEs spectra are distributed over a wide range, which makes the application of this method difficult. Another intrinsic property is the quantum efficiency (QE), i.e. the branching ratio between a radiative rate and the total (radiative and non-radiative) decay rate.



Schematics of the performed experiment and a distance dependent lifetime measurement. (a) The AFM is equipped with a gold-coated hemispherical tip aligned with an SPE in h-BN and held at a variable distance. The objective lens on the bottom of the glass excites the SPE (green pulsed laser) and collects its emission. With this setup, distance-dependent lifetime measurements can be performed, one such measurement is shown in (b) (points). To determine the QE, an adjustment was performed (blue solid line). The same fit function with a QE of 1.0 is represented by the green solid line as a reference.

Researchers of Nanooptik AG of Humboldt-University of Berlin in cooperation with the Technical University of Sydney could now directly measure the absolute QE of single defects in h-BN. The underlying principle is based on the proportionality between a controlled change in the local density of the states into which the emitter can emit and the lifetime of the excited state. The researchers implemented this experimentally by controlling the distance between the SPE and a mirror with nanometer accuracy while measuring the lifetime of the excited state. In this way, not only the high QE of up to 87(7) % was determined, but also a correlation between fluorescence wavelength and QE was found. This paves the way for a better understanding of the origin of the emitters.

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