WWU MÜNSTER

Aktuelle Fragen der Nanophysik

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Online Seminar

Influence of non-equilibrium phonon dynamics on photoluminescence spectra of color centers in hexagonal boron nitride


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Single photon emitters are of crucial importance for many quantum information applications. A few years ago color centers in hexagonal boron nitride (hBN) have been discovered to show stable single photon emission even at room temperature, making them promising candidates for such applications. To achieve maximal control of the color centers and to harness their full potential, the underlying atomic structure and possible interaction mechanisms have to be fully understood. The first aspect is still under debate and can only be resolved with a joint experimental and theoretical effort. Here I will focus on the second aspect, more specifically on the coupling of the color center to the phonons of the host lattice. Especially the coupling to longitudinal optical (LO) phonons with energies of up to 200 meV is remarkably strong, leading to dominant phonon sidebands (PSBs) in the optical spectra that are well separated from the zero phonon line (ZPL). This makes these phonon modes excellent candidates to investigate the underlying interplay with the color center in more detail and study the influence of non-equilibrium phonon dynamics.
To this aim I will present simulations of time-dependent photoluminescence (PL) spectra, calculated using the quantum regression theorem for open quantum systems. The focus is mainly on the influence of the finite lifetime of the LO phonons due to lattice anharmonicities, but also on the influence of quantum superpositions of different LO modes on the optical signals. Thus the non-equilibrium process of phonon thermalization becomes accessible for investigation in a temporally and spectrally resolved manner, which could also help to identify the underlying atomic structure of the color center, as will be explained in my talk. An example of how the decay of LO phonons influences the time-dependent PL after excitation at the +2 PSB is given in Fig. 1 for a toy model with a single phonon mode coupling to the color center.

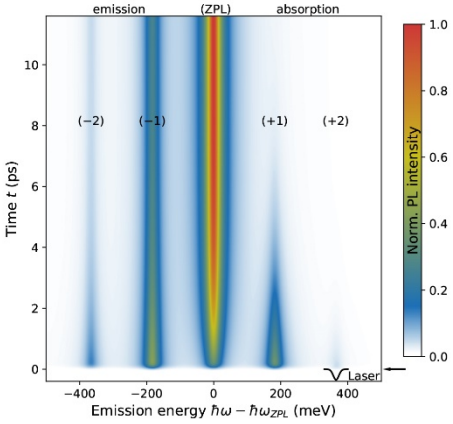

Fig. 1: Time-dependent PL spectrum for a toy model with a single phonon mode after optical excitation on the two-phonon absorption PSB [1].

[1] D. Groll et al, Mater. Quantum. Technol. 1, 015004 (2021)