Fractional decay of quantum dots in photonic crystals

Philip Kristensen (1), A. Femius Koenderink (2), Peter Lodahl (1), Bjarne Tromborg (1) and Jesper Mørk (1)

(1): DTU Fotonik, Department of photonics engineering, Lyngby, DK
(2): FOM Institute for Atomic and Molecular Physics, Amsterdam, NL

Spontaneous emission dynamics represents a spectacular display of the quantum nature of light-matter interaction as it results directly from the coupling of a quantum emitter to the electromagnetic vacuum. Using novel materials (such as photonic crystals, see Fig. 1) it is possible to locally change the distribution of the vacuum modes and thus to change the spontaneous emission. In most cases the decay remains exponential, but with an altered rate. This effect is known as the Purcell effect. In certain special cases, however the decay may take on fundamentally different forms. In particular, a regime of so-called fractional decay has been pointed out. In this regime, the emitter coherently interacts with modes of low group velocity in such a way that it never fully decays, but rather remains in a superposition of the excited state and the ground state (see Fig. 2). Whereas the Purcell effect has been shown experimentally for quantum dots (QDs) in e.g. photonic crystals there is to date no demonstration of fractional decay.

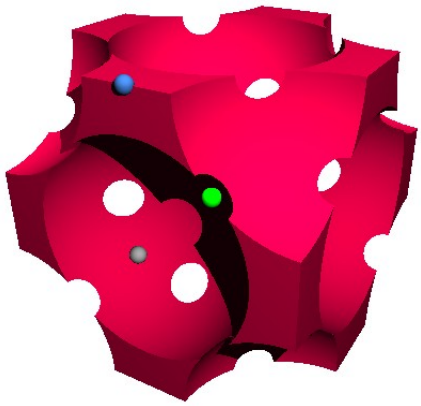

Fig 1. *Unit cell of an inverse opal photonic crystal. By carefully positioning quantum dots within the crystal it is possible to control the spontaneous decay dynamics* ,

In this work we define a practical measure of the degree of fractional decay and use it to investigate if the effect will be observable for QDs in real photonic crystals in the presence of absorptive losses.

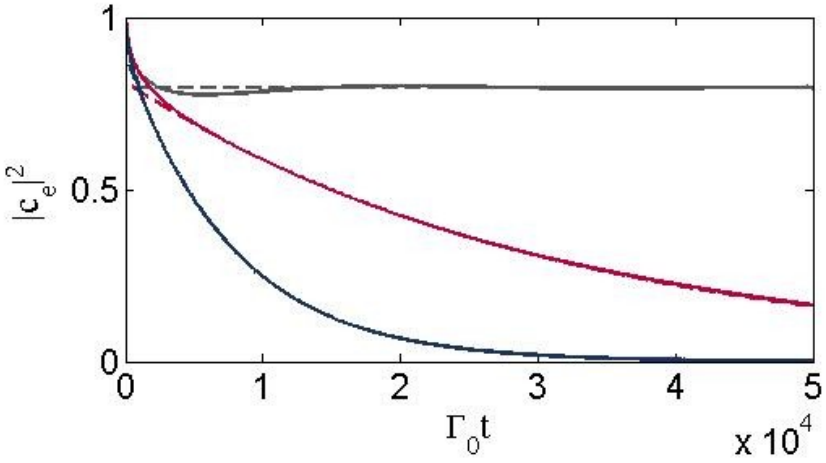

Fig2. *Decay curves from a quantum dot in the photonic crystal for different material absorption. Grey curve shows the fractional decay in the case of zero loss. Material absorption (red and blue curves) changes the decay from a fractional type into a single exponential decay.* Γ_0 *is the decay rate in vacuum.*