Optimization of exciton polarization for efficient chiral emission from a QD into a waveguide

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We consider a quantum dot (QD) coupled to the light field of a cylindrical single-mode nanofiber with core–cladding index contrast of 1.09 and a core radius of 250 nm. In such a system, the appearance of longitudinal field components leads to chiral circular polarization of the field in the plane containing the wave guide axis. As a consequence, the direction of emission of a nearby QD is correlated with the polarization of the excitonic transition[1]. We show that the degree of directionality can be optimized by an appropriate selection of the polarization of the emission, which can be tuned for a QD in a certain range.

The main motivation of considered system is to take the control of light-matter interaction at the level of single quanta. It is a central goal in quantum optics and is the basis for disruptive applications in quantum communication and quantum-information processing.

In this presentation, we show the results of the directionality of emission for the fundamental HE_{11} mode. The calculations are performed for circularly ($\sigma_\pm$), linearly (π) and ellipticaly polarized light emitted by a single QD. We assume that this polarization is not modified by the presence of the optical fiber. First, we calculate the polarization overlap ξ_i between the HE_{11} mode and all the polarization of QD transition (see fig. 1a). Next, we compute the directionality D averaged over the QD position (fig. 1b) that is defined as normalized difference of intensities for emission to the left and to the right. We show that the directionality can be nearly perfect for an appropriately selected elliptical polarization of the QD emission.

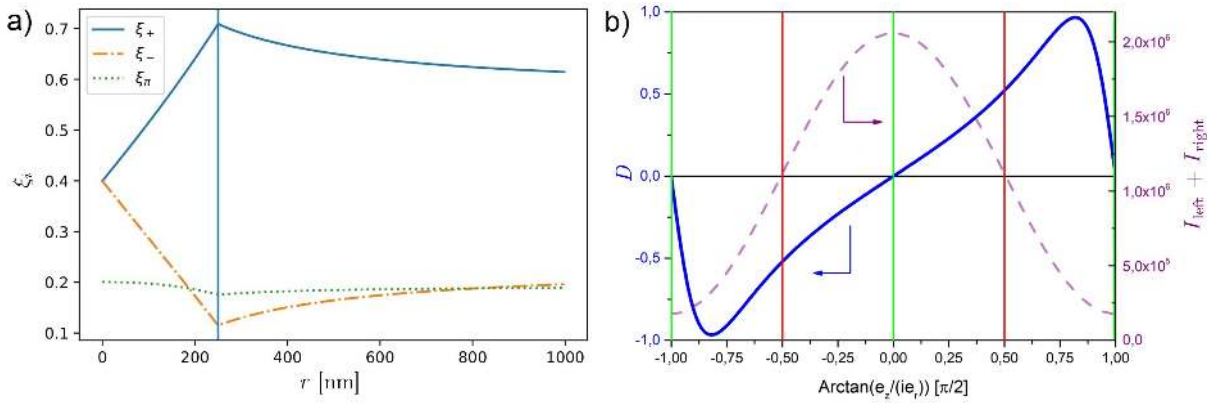

Figure 1: a) Polarization overlaps as a function of the QD position (distance from the waveguide axis), defined as $\xi_i = |\mathbf{e}_j^* \cdot \mathbf{u}|^2$, where $\mathbf{e}_j$ denotes the polarization of emitted light by QD and $\mathbf{u}$ is a local unit mode polarization vector. b) Directionality of emitted light (thick line) as a function of the ellipticity of polarization of the QD emission. Dashed line shows the total emission intensity. Vertical lines mark the limiting cases of linear and circular polarization.

[1] R. Mitsch, C. Sayrin, B. Albrecht, P. Schneeweiss and A. Rauschenbeutel, *Nat. Commun.* **5**, 5713 (2014).