Antenna-Controlled Antibunching in the Photoluminescence of Single Carbon Nanotubes

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Since its first report in 2008 [1], photon antibunching in the photoluminescence (PL) from semiconducting single-walled carbon nanotubes (SWCNTs) attracted considerable attention because of potential applications of SWCNTs as single-photon-sources. Known for single point-like quantum systems, the observed antibunching from a 1D nanomaterial also raised fundamental questions regarding the underlying mechanism. In general, antibunching is thought to require the efficient localization of the excited state energy at local minima in the exciton energy landscape or at chemical dopant sites and was reported for different nanotube materials and configurations upon optical as well as electrical excitation [2-5].

We performed photon-correlation experiments in a Hanbury-Brown-Twiss setup. A sharp laser-illuminated metal tip operated in a scanning probe scheme acted as optical antenna providing near-field PL enhancement with a spatial range around 20 nm [6,7]. In the near-field of the tip, the second order correlation at zero delay $g^{(2)}(0)$ was found to be substantially reduced (Fig. 1). Stronger PL antibunching resulting from the antenna-induced localization of the light-matter interaction has the potential to reach the single-photon-regime ($g^{(2)}(0) < 0.5$) for nanotubes on glass. We discuss possible mechanisms of antenna-controlled antibunching including localized exciton-exciton annihilation [5] and applications to other low-dimensional materials.

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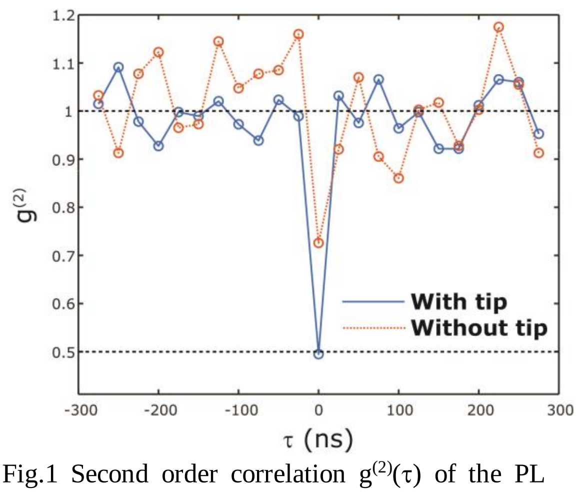

Fig.1 Second order correlation $g^{(2)}(\tau)$ of the PL emission from a single (6,5) SWCNT with and without optical tip antenna.