

Photon-Correlation Spectroscopy of Quantum Cutting Perovskite Nanocrystals

Keywords : photon statistics, quantum cutting, ytterbium, perovskite nanocrystals, photon correlations, photophysics

Context. Quantum cutting (QC) converts one absorbed high-energy photon into two lower-energy emissive excitations. Yb³⁺-doped halide-perovskite nanocrystals are particularly promising because the semiconductor host provides strong UV-visible absorption, while Yb³⁺ emits near 980 nm, within the absorption range of silicon. Absolute photoluminescence quantum yields (PLQYs) above 100% have been reported for Yb:CsPb(Cl,Br)₃ nanocrystals^{1,2}. However, these results remain difficult to reproduce, and the microscopic processes responsible for photon multiplication are still debated.

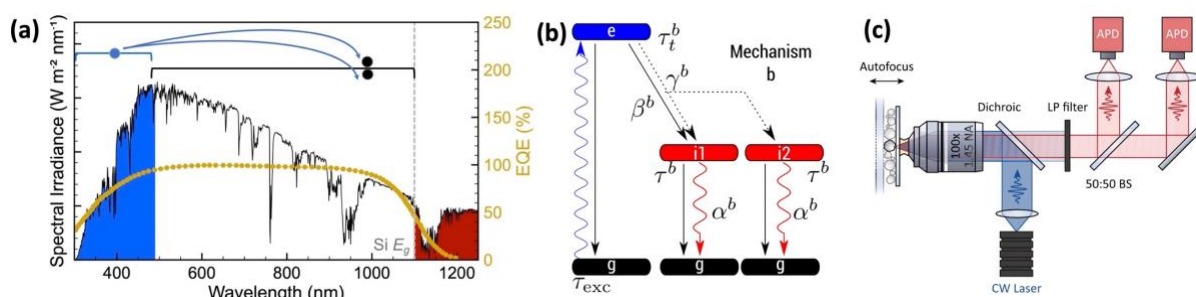


Fig. 1 (a) Concept and (b) mechanism of the quantum cutting process with reference to the solar spectrum and the external quantum efficiency (EQE) of a Si solar cell; (b) taken from ref. 4. (c) The photon correlation experiments reported in the literature⁵.

State of the art. PLQY measures the average number of emitted photons per absorbed photon but does not establish whether two photons originate from the same absorption event, particularly when non-radiative losses keep the PLQY below 100%. QC should instead produce temporally correlated photon pairs from Yb emission: after one host excitation, the two Yb³⁺ ions emit within a time window governed by their excited-state lifetime. This produces photon bunching, a peak in the second-order correlation function $g^{(2)}(\tau)$, whereas conventional one-to-one downshifting ideally produces Poissonian photon statistics^{3,4,5}. Correlation measurements therefore provide an orthogonal observable to PLQY.

Project. The student will establish and validate a near-infrared photon-correlation experiment, including optical alignment, calibration, time-tagged acquisition and $g^{(2)}(\tau)$ analysis. Hyperspectral PLQY imaging will provide spatially and spectrally resolved absolute PLQY maps, enabling validation of the measurement chain, quantification of sample heterogeneity and, together with $g^{(2)}(\tau)$, estimation of the correlated two-photon yield. The methodology will then be applied to benchmark Yb-doped perovskite nanocrystals prepared by LPEM. Joint interpretation of photon correlations, absolute PLQY and time-resolved photoluminescence will assess whether the observed Yb emission arises from photon multiplication or conventional one-to-one sensitisation.

Expected outcome and training. The project will deliver a validated experimental and analytical workflow for distinguishing correlated two-photon emission from ordinary downshifting and experimental artefacts. It will provide new physical insight into whether, and under which structural and excitation conditions, Yb-doped perovskite nanocrystals genuinely perform QC. The student will receive training in optical alignment, hyperspectral PLQY imaging, single-photon detection, time-correlated measurements, data analysis, photophysics and quantitative modelling.

Applicant profile Master 2 student in physics, applied physics, optics, photonics, or physical chemistry, with a strong interest in optical experiments and data analysis. Experience with Python or MATLAB would be advantageous.

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Doctoral continuation Yes (via doctoral school PhD scholarship applications)

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⁵ V. R. M. Benning *et al.*, *ACS Energy Lett.* **2025**, 10, 4620–4626. [DOI](#)