

On-demand single-photon source over the terahertz regime

Carlos Sánchez Muñoz

Caspar Groisseau, Miguel A. Martínez-García, Antonio Fernández Domínguez, Diego Martín Cano.

Institute of Fundamental Physics-CSIC, C/Serrano 113, 28049 Madrid, Spain

carlos.sanchez@iff.csic.es

We propose a deterministic single-photon source in the terahertz (THz) regime, triggered by a sequence of coherent optical pulses [1].

The scheme leverages the permanent dipole moment of a single-polar quantum emitter to induce THz transitions between optically dressed states, enhanced by a resonant coupling to a hybrid THz cavity [2]. We present a cavity design that delivers high efficiency, purity, and indistinguishability while also enabling easy tunability of the emission frequency across the THz range.

A key challenge in this new class of dressed-state sources is that, unlike standard solid-state single-photon sources, the dressed nature of the transitions can lead to undesired optical repumping during emission due to spontaneous photon emission in the visible range, which reduces the purity of the THz single-photon state. We show that this issue can be mitigated through optimized pulse areas and a sufficiently high Purcell rate, criteria that are met by our proposed cavity design.

Finally, we demonstrate the significant purity enhancement of postselected THz photons by means of optical heralding, illustrating the new opportunities unlocked by the unique integration of terahertz and visible technologies with dressed polar quantum emitters.

References

- [1] [1] C. Groisseau, M. Á. Martínez-García, D. Martín-Cano & C. Sánchez Muñoz, Deterministic single-photon source over the terahertz regime, arXiv:2509.26486 (2025).
- [2] C. Groisseau, A. I. Fernández-Domínguez, D. Martín-Cano & C. Sánchez Muñoz, Single-Photon Source Over the Terahertz Regime, PRX Quantum 5, 010312 (2024).

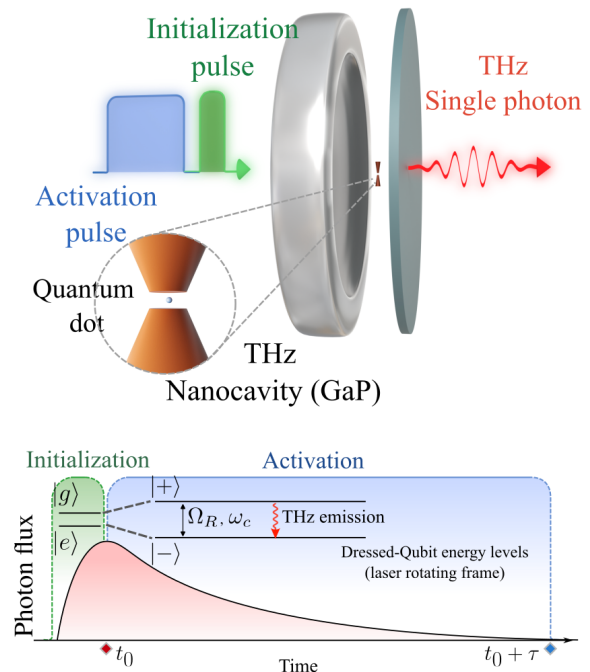


Figure 1: Overview of a proposed deterministic single-photon THz source based on a quantum emitter in a hybrid nanocavity formed by GaP nanocones inside a Fabry–Pérot resonator. The system is driven by optical pulse protocols to initialize and activate THz emission, with simulations illustrating emitter dynamics.