How Close can SNSPDs Get to TES in Photon Number Resolution?

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Recent advances have enabled a standalone superconducting nanowire single-photon detector (SNSPD) to resolve photon numbers through electrical signal shape analysis — a capability long considered exclusive to transition edge sensors (TES). With several groups now reporting discrimination of up to 10 photons at high fidelity, a key open question is: can SNSPDs ultimately rival TES in photon number resolution (PNR)?

We are addressing this question from a fundamental perspective. We present multiphoton measurements on two devices: (i) a commercial SNSPD [1], where the detection threshold energy lies well below the single-photon energy, and (ii) a novel high-temperature MgB_2 nanowire detector [2], where it lies well above, enabling multiphoton absorption to probe the energy threshold directly. We show that multiphoton events provide an additional degree of freedom for assessing the physics of nanowire detectors. To describe these two limiting cases, we introduce a model that connects PNR fidelity to the intrinsic timing jitter of SNSPDs. This jitter partially originates from local thermal fluctuations in the superconductor [3], which simultaneously broaden the detection energy threshold — an effect particularly pronounced in the high-temperature MgB_2 detector. Our analysis identifies the operating conditions under which SNSPDs may approach TES-level PNR along with the associated trade-offs.

References

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[3] A. D. Semenov et al., Phys. Rev. B 102, 184508 (2020)