Covert Quantum Target Sensing

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We study the Quantum Target Ranging task in the context of multi-hypothesis testing and its application to real-world LiDAR systems. We find the theoretical bounds and the advantages of quantum ranging in presence of background considering time-of-flight measurements, the operational mode of most LiDAR systems [1]. Moreover, we focus on the covert scenario, in which the sensing is performed while avoiding detection from an adversary. Interestingly, we discover that against a technologically evolved adversary, covertness is only possible with a quantum probe state constrained by a low mean number of photons, while classical transmitter fails to ensure covertness [2]. We realize an experimental demonstration of the protocol exploiting commercial sources of photon pairs at telecom wavelength and superconducting nanowire single photon detectors in a tree configuration. We demonstrate a large quantum advantage with respect to a conventional approach that uses short-pulsed laser at the same power.

Our results represent a new perspective on optical quantum sensing and provide strong motivation for the development of quantum LiDAR.

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References

[1] G Ortolano and I Ruo-Berchera, Phys. Rev. Res. **7**, L022059 (2025)

[2] G Ortolano, I Ruo-Berchera and L Banchi, Phys. Rev. Lett. **136**, 060801 (2026)