Quantum Limits of Spoofing an Electromagnetic Signal

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To infer an object's position from a distance, we capture the reflection of electromagnetic waves from it in our eyes (the receiver). The emission of carefully crafted electromagnetic waves can fool us into believing that there's something when there isn't. That is how the TV does it. Radar works similarly, capturing the reflection of electromagnetic signals from an object. A third party (the spoofer) can also carefully craft electromagnetic waves to false the object's position, shape, speed, etc. The difference between these situations is that, in radar, the receiver is also the emitter of the electromagnetic waves, thus giving the possibility of encoding information (for instance, into the pulse shape and spectral content) to distinguish a truly reflected signal from the one generated by a spoofer. Recently, Blakely et al. [1] proposed a quantum version of the spoofing problem where the signal pulses contain a pair of non-orthogonal quantum states. The quantum mechanical version of the spoofing problem is twofold. On one side, it limits the spoofer's ability to infer the signal's quantum state as it has to measure the signal, and the outcome is probabilistic. Conversely, the receiver must also measure with a probabilistic outcome. Then, the receiver can detect the spoofing with a certain probability that can potentially surpass the classical one. In [1], the authors demonstrated quantum advantages when limiting themselves to a few photons. Those advantages quickly vanish as the number of photons increases. Here we show that the maximum quantum advantage remains for large number of photons. We also derive the quantum states needed to attain that advantage. We demonstrate that single photon sources are not required for a proof-of-principle experiment. Indeed, our results open the door for an experimental implementation with the current experimental capabilities of a standard quantum optics lab and can facilitate further development of quantum radar technology.

[1] J.N. Blakely and S.D. Pethel, Physical Review Research 4, 023178 (2022)
[2] T.P. Espinoza, S.C. Carrasco, J. Rogan, J.A. Valdivia, and V.S. Malinovsky, in preparation