High sensitivity microwave receiver for quantum radar applications

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Quantum illumination is a quantum target detection protocol in which entangled photon pairs, usually called signal and idler, are used to improve the performance of systems for detecting low-reflectivity objects that are immersed in strong thermal noise.

The signal photons, generated at microwave frequencies, are used to interrogate a region of space where a target is suspected to be, while the idler photons, generated at optical frequencies, are kept at the source. Finally, a joint quantum measurement between the reflected and idler photons is performed to obtain information provided by the correlations caused by the entanglement condition.

In this paper we propose a receiver subsystem for a quantum radar in which this protocol is implemented at microwave frequencies and at room temperature.

In order to perform the joint quantum measurement with the stored idler, the return signal received at the radar needs to be up-converted into optical frequencies. To achieve this, the received signal is sent to an integrated lithium niobate whispering-gallery mode resonator (WGMR). The WGMR is excited by two signals: an optical carrier generated by a laser and the return signal received at the radar. By phase matching both signals inside the resonator, the up-conversion of the RF signal to the optical domain is achieved. As a result, two optical sidebands are located around the laser pump v_p by sum-frequency v_s and difference-frequency v_d generation. These optical sidebands represent the signal that we are interested in. One key advantage of this detection architecture is its negligible thermal noise in the optical frequency range due to the significantly higher energy of the optical photons, making them immune to relatively weak thermal noise of the receiver even at room temperature, eliminating the need of using cryostats.

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