Single Photon Detection of 1.5THz Radiation with the Quantum Capacitance Detector

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Abstract— The Quantum Capacitance Detector (QCD) is a new high-sensitivity direct detector under development for low background applications such as far-infrared spectroscopy from a cold space telescope. The QCD has demonstrated an optically-measured noise equivalent power of $2x10^{-20}$ W $Hz^{-1/2}$ at 1.5THz, making it among the most sensitive far-IR detectors systems ever demonstrated, and meeting the requirements for spaceborne spectroscopy. Under these low-background conditions, the photon arrival rate is of the order of 100Hz making it possible to detect individual photons, provided the detector has enough speed. In this work we describe a new fast readout technique for the QCD that enabled single photon detection and counting at 1.5THz. Single photon detection and counting of single photons was demonstrated between 100Hz and 10 kHz. The QCD also demonstrates high absorption efficiency: both the photon arrival rate in counting mode, and the statistics of the shot noise in the non-counting mode indicate a total photon absorption and detection rate which is within a few percent of that expected for the experimental setup. Our measurements provide further confidence in the QCD as a detector approach for future ultrasensitive far-IR instrumentation.