Thermodynamic limit of photon detection sensitivity: Can we achieve it; can we change it?

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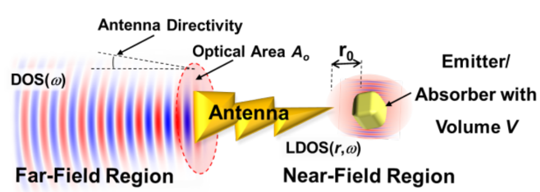
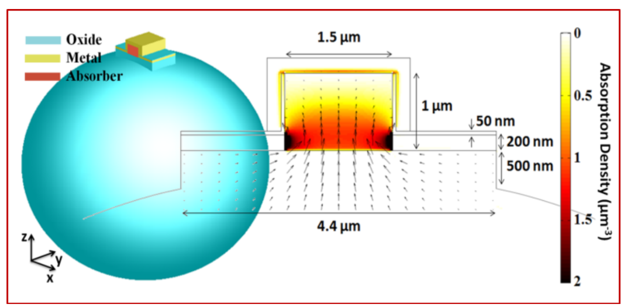
Photon detectors are now at the heart of many modern scientific, medical, industrial and security systems. These detectors, whether single-element or imaging arrays, are often the performance bottleneck in such systems. While cooled mid- and long-wavelength infrared (MWIR and LWIR, or wavelength of 3–12 μm) detectors have reached the thermodynamic limit of sensitivity, achieving such performance has remained elusive at shorter wavelengths.

I will discuss the historic view of quantum and thermodynamic limit of sensitivity, and then discuss two related but distinct topics: our new findings that indicate the thermodynamic limit of sensitivity in the short-wavelength infrared (SWIR, λ = 1–2 μm) is indeed achievable; and our new results show that the thermodynamic limit of sensitivity in the MWIR/LWIR could be increased beyond the commonly believed level.

I will present new devices based on electron injection might be able to approach the thermodynamic limit of SWIR at relatively high temperatures [1, 2]. Interestingly, the energy of photons is significantly larger than the thermal energy in this region, and hence non-cryogenic single-photon detectors with high detection efficiency and very low false detection rate seem feasible for the first time.

I will also present our evaluation of the effect of the hybrid optical antenna in the MWIR/LWIR range [3], and present results suggesting that one can manipulate the thermodynamic limit and produce substantially higher sensitivities.





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2. V. Fathipour, S. J. Jang, I. H. Nia, and H. Mohseni, *Appl. Phys. Lett.* **106**, 021116 (2015).
3. A. Bonakdar and H. Mohseni, *Nanoscale* **6**, 10961 (2014).