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Advantages of Photon Counting Detectors for Terahertz Astronomy

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A brief review of terahertz detector technologies is made including heterodyne and direct detectors, which are followed by discussions on future technologies using fast photon counting detectors and their usages in astronomical observations.
Radiation detection in terahertz frequencies has variety because of the nature of radiation; both radio wave and photon detectors are employed. Moreover, photons are not independent and terahertz waves are expressed as streams of bunched photons.

There are several advantages of using photon counting detectors in terahertz frequencies:

1. Sensitivities are limited only by fluctuation of input radiation.
2. High dynamic range is obtained by fast photon counting detectors.
3. Photon statistics can be a measure of source physics.
4. Photon bunches can be a measure of delay time.

Terahertz observations from space environment requires high sensitivity detectors owing to low background observing condition, where background photon rate is typically less than 1 M photons/sec. Fast photon counting detectors will relax requirements on detector sensitivities and true background limited observations will be achieved.

In terahertz astronomical observations, high dynamic range measurements is required to identify diffuse emission around bright sources, such is the case for observing circum-stellar materials, debris disks and exo-planets around stars.

Photon statistics of thermal sources are governed by Bose-Einstein statistics and degree of photon bunching changes as a function of frequency and source thermodynamic temperature and vice-versa.

Photon bunches can tell us delay time between two telescopes for intensity interferometry (Matsuo 2012, 2014). The technology was recently demonstrated using Nobeyema Radio Heliograph (Ezawa et al. 2015).

Superconducting tunnel junction detectors can be sensitive photon counting detectors in terahertz frequencies; refer to Ezawa et al. LTD-16 abstract.

References

H. Matsuo, "Requirements on Photon Counting Detectors for Terahertz Interferometry", JLTP 167, pp. 840-845 (2012)
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H. Ezawa et al., "SIS Detectors for Terahertz Photon Counting System", LTD-16 abstract