Terahertz Intensity Interferometry for Very High Angular Resolution Observations

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High angular resolution imaging in far-infrared and terahertz frequenciesare foreseen either using large single dish telescopes orinterferometers. In this presentation I will focus on a realization ofrelatively long baseline interferometer in terahertz frequencies thatenable milli-arcsecond angular resolution.

Intensity interferometry was first demonstrated by Hanbury-Brown and Twiss.However, low correlation efficiency and missing phase informationrestricted their application to aperture synthesis imaging.In terahertz frequencies, a large number of bunched photons enables delaytime measurements, and high efficiency aperture synthesis imaging can berealized.We have already demonstrated the delay time measurement by an intensityinterferometer experiment in microwave frequency (Ezawa et al. ISSTT2015 proceedings).

In this presentation, an application of the intensity interferometry to space terahertz interferometry will be discussed in detail.Under a low background condition with cryogenic space telescopes, photoncounting detectors become advantageous for high dynamic range intensitymeasurements, so the interferometer technology can be named as a photon counting terahertz interferometry (PCTI).A photon rate of 100 M photon/s from a typically bright terahertz source would enable the delay time accuracy better than 0.1 ps in an integration time of 100 s. The required NEP for a photon counting is just less than 10^{-17} $W/Hz^{0.5}$ when a time resolution is 1 ns.This sensitivity can be realized by using a low leakage current superconducting tunnel junction detectors.

Combination of PCTI and a double Fourier interferometer is proposed toachieve a good u-v coverage for aperture synthesis imaging in terahertzfrequencies.Shorter baselines are covered by the double Fourier interferometer andlonger baselines by PCTI.With maximum baseline length of 20 km at 3 THz, angular resolution of 1milli-arcsecond can be obtained.In terahertz frequency region there are more than 100,000 catalogedpoint sources brighter than 1 Jy, which will be targets for the spaceterahertz interferometer.

Since PCTI can be applied to the very long baseline intensity interferometer (VLBII), satellite control will be similar to space VLBI with heterodyne receivers. Moreover, photon counting detectors realize much higher sensitivityand wider bandwidth to enable imaging thermal emission sources, such asstars and exo-planets.