URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Space Terahertz Intensity Interferometry

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Intensity Interferometry, known by the names Hanbury-Brown and Twiss, can be applied to long baseline space interferometry using high sensitivity direct detectors. By using fast direct detectors, complex visibility can be measured in terms of delay time obtained using intensity fluctuation caused by photon bunches, enabling aperture synthesis imaging. Modern superconducting detectors can be used as the fast and sensitive detectors in terahertz frequencies. Typical photon rate from bright compact sources (~1 Jy source) is estimated to be approximately 100 Mphoton/s. Using detectors with NEP less than 10^{-17} W/Hz$^{0.5}$ with nanosecond time resolution, photon counting will be realized. The terahertz intensity interferometry could be based on such photon counting detectors.

System requirements to terahertz intensity interferometry can be like VLBI, since correlation analysis can be made after detector signals are collected on each telescope. But, requirements to phase stability is different from heterodyne interferometry. Since coherent time of intensity fluctuation is inverse of radiation bandwidth, intensity correlation is not much affected by phase fluctuation and stable correlation signal can be obtained in terahertz frequencies. On the other hand, delay time or phase calibration need longer integration than heterodyne interferometry when sensitivity is the same. But, high sensitivity of direct detector, say noise temperature of 10 mK, sensitivity can be improved appreciably, enabling delay time (phase) calibration in terahertz frequencies.

Image quality of intensity interferometry can be another issue to be studied. Since correlation drops faster as a function of source structure due to second order correlations, requirements to baseline configuration is different from heterodyne interferometry. Requirement to the large dynamic range measurements of intensity interferometry should be studied further.

Potential merit of intensity interferometry is its high sensitivity in terahertz frequencies using cryogenic telescopes in space, such as Origin Space Telescope and Millimetron Space Observatory. Combining VLBI technologies, such as accurate attitude measurements, time reference and fast data recorders, with cryogenic telescopes in space with fast photon counting detectors, it will be possible to realize Space Terahertz Intensity Interferometry (STII).

It is of great interest to image active galactic nuclei with high sensitivity using atomic lines in terahertz frequencies to resolve broadline regions and accretion discs. Imaging exoplanet forming sites are another topic of interest for STII, such as imaging ice feature in protoplanetary disks or even imaging exoplanets themselves.

References

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