Improved Terahertz Detection Based on Terahertz Field-Induced Second Harmonic Generation

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Since the development of femtosecond laser technology, various THz generation schemes have been proposed, and the demand for high-power THz sources has grown rapidly due to their potential for a wide range of applications. Among them, plasma-based THz source driven by high-power lasers typically exhibit electric field strengths on the order of MV/cm and broadband spectra (up to 30 THz).

TFISH (Terahertz-Field-Induced Second Harmonic) technique does not require electro-optic crystals, but instead utilizes the THz field in free space—typically air—to induce second harmonic generation via four-wave mixing with the laser. [1] This method is inherently free from phonon absorption, has no intrinsic limitation on the detectable spectral range, and maintains waveform fidelity even under high THz field strengths, making it more suitable for the characterization of THz radiation generated by high-power laser-induced plasma.

We employ a 1 TW Ti:sapphire femtosecond laser system delivering 800 nm pulses with a duration of 40 fs (FWHM), energy up to 40 mJ, and a repetition rate of 10 Hz. The beam is split into a pump and a probe. The pump undergoes second harmonic generation in a BBO crystal and generates THz via a two-color laser plasma. The probe beam is focused by a lens and directed to spatially and temporally overlap with the THz field at the focal point of an off-axis parabolic (OAP) mirror with a central aperture, initiating the TFISH process. The generated second harmonic signal is detected using a photomultiplier (PMT) tube or a spectrometer and used to retrieve information about the THz field.

In this presentation, we report on the characterization of THz radiation generated by a 1 TW femtosecond laser using the TFISH phenomenon. The results demonstrate that TFISH-based detection is applicable to broadband THz pulses with high peak field strengths. As higher laser energies are essential for generating stronger THz radiation in future applications, the TFISH technique offers a suitable alternative for THz diagnostics in this regime.

References
[1] J. Dai, X. Xie, and X.-C. Zhang, Phys. Rev. Lett. 97, 103903 (2006).

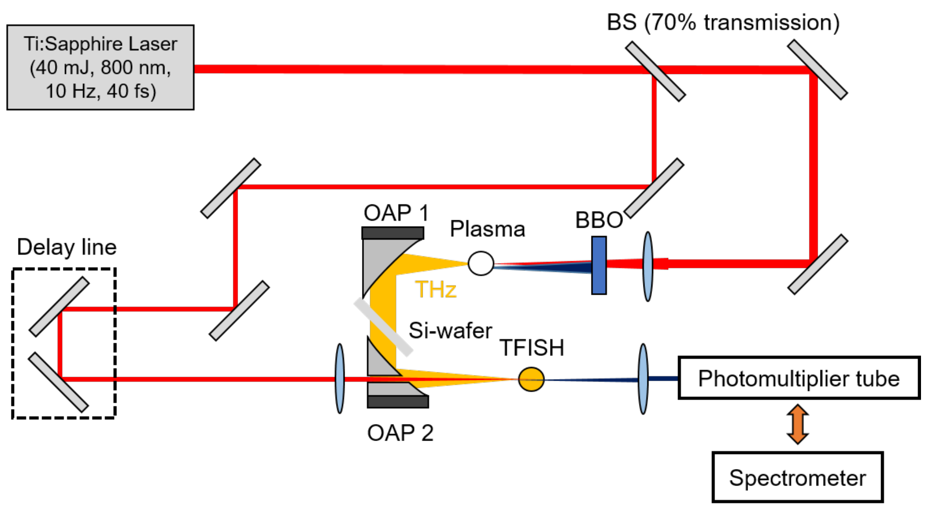

Figure 1. Schematic of the experimental setup for two-color laser-induced THz generation and TFISH-based detection using a 1 TW femtosecond laser system. (BS: Beam splitter, OAP: off-axis parabolic mirror, TFISH: Terahertz field induced second harmoni