Simultaneous Emission/Detection of THz Wave and X-ray from Water Flow Irradiated by Intense Femtosecond Laser Pulses in Air

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Introduction: Photon emission induced by intense femtosecond laser-matter interaction such as THz wave and X-ray is independently expected for various applications from industry to security control and so on. Targets, for THz wave emission in particular, are limited to solids and there have been no reports with water until recently [1,2], while X-ray emission from aqueous solutions have been extensively studied [3]. Furthermore, combination usages of THz wave and X-ray pulses are highly expected for further applications [4] though reports on the simultaneous emission are still quite limited except one paper with gas clusters in a vacuum chamber [5]. In this presentation, simultaneous emission/detection of THz wave and X-ray pulses from water flow irradiated by focused femtosecond laser pulses in air will be introduced.

Experiments: Femtosecond laser pulses (800 nm, >35 fs, 500 Hz, linearly-polarized) were tightly focused by using an off-axis parabolic mirror (f = 50.8 mm) onto a thin water flow (~15 μm thick). An automatic stage moved the water flow along the incident laser axis (z-axis) from the downstream side to the upstream. THz wave and X-ray emission intensities were measured with different positions of the water flow along the z-axis by time-domain spectroscopy with EO detection using ZnTe (110) and a Geiger counter as in the previous reports [3], respectively.

Results: Figure 1 shows THz wave and X-ray intensities as a function of the flow position, where the laser intensity was 1 mJ/pulse and the laser pulse is negatively-chirped. Apparently, the FWHM of THz wave emission is wider at 262 μm than that of X-ray emission at 105 μm. This naturally indicates that the THz wave emission can be induced even under lower laser power conditions, while X-ray emission is induced only under the tight focusing conditions. The peak position of the THz wave emission also shifts toward the downstream side at -24 μm, which may imply that the second harmonic which is the part of white light continuum results in further enhancements of THz wave emission even after the laser focus. Further discussion will be performed with additional experimental results such as simultaneous emission of THz wave and X-ray under double-pulse excitations.

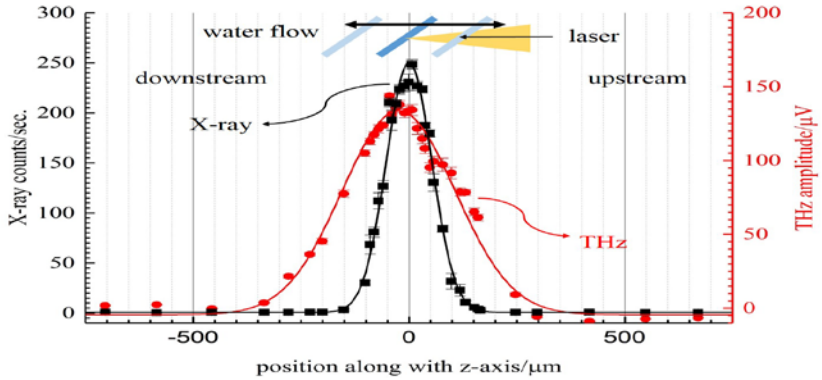

Figure 1 Simultaneous detection of THz wave and X-ray from water flow irradiated by femtosecond laser.

References

[1] Q. Jin, *et al.*, **Appl. Phys. Lett.**, **111**, 071103 (2017)
[2] I. Dey, *et al.*, **Nature Commun. 8**, 1184 (2017).
[3] F. C. P. Masim, *et al.*, **ACS Photonics**, **3**, 2184 (2016), W. –H. Hsu, *et al.*, **Opt. Exp.**, **25**, 24109 (1027) and references therein.
[4] X. C. Zhang, *et al.*, **Nature Photonics, 11**, 16 (2017).
[5] A. Balakin, *et al.*, **IEEE Trans. Terahertz Sci. Tech.**, **7**, 70 (2017).