Laser-plasma-based THz pulse generation and its applications for plasma diagnostics

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Interaction of an intense fs (femtosecond) laser pulse and a plasma can produce a strong THz (terahertz) pulse and it can be used for diverse purposes. So far we have performed a series of experiments to produce intense THz pulses by using several methods based on laser-plasma interactions. For example, a fs laser pulse from a Ti:sapphire regenerative amplifier was focused in air, and a strong THz pulse was generated and analyzed by the THz TDS (time-domain spectroscopy) technique [1]. A fs Ti:sapphire laser pulse was also converted into a frequency-doubled laser pulse (400 nm) through a nonlinear BBO crystal and the two-color laser pulse, which is a mixture of the 800 nm and 400 nm wavelengths, was focused in air, leading to a more intense THz pulse.

The strong THz pulses from the various mechanisms of laser-plasma interactions have been employed for plasma diagnostics in our laboratory. This is important especially for plasma diagnostics in tokamaks because the plasma density in modern tokamaks is on the order of 10^{13} cm^{-3} and THz waves are ideal in this plasma density range. For this experiment to test some new concepts for plasma diagnostics using laser-plasma-based THz waves, we developed an argon-filled ICP (inductively-coupled plasma) source that is power by 13.56 MHz RF, which is designed to produce the tokamak plasma density. If the THz pulse propagate through the plasma, the THz wave will experience a phase shift and its analysis can provide the information about the plasma density. THz pulses from both of the single color and the dual color methods were used for plasma diagnostics in our laboratory. Furthermore, the THz TDS method and the spectral-encoding-based single-shot method [2] were tested, where the latter method can give the plasma density instantly and has a great advantage. Our results showed that both methods can provide reliable plasma density information successfully [3]. In this talk, all details about this research will be presented.

References

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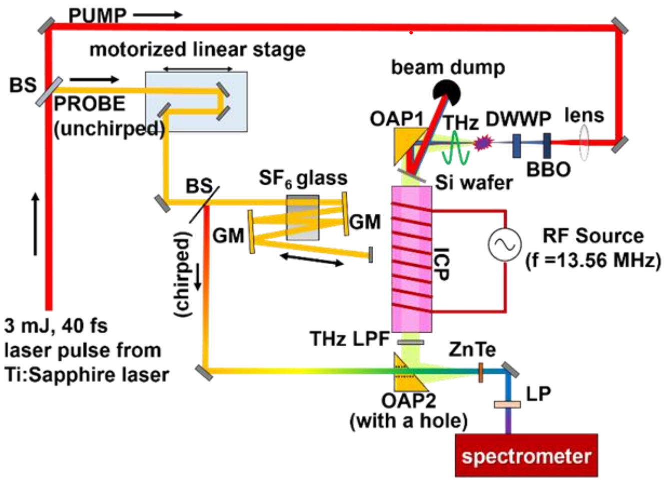

Fig. 1. Experimental setup for generation of an intense THz pulse using a dual colour method and its application for plasma density measurement. In the figure, the pump beam with a higher energy is focused in air for generation of a strong THz pulse and the THz pulse is sent through the plasma, while the probe beam with a small energy is frequency-chirped in the dispersive SF_6 glass and overlapped with the THz pulse in time at the location of the ZnTe nonlinear crystal. In this process, the envelope of the frequency-chirped probe beam is modulated, following the THz pulse shape.
BS: beam splitter, GM: gold-coated mirror, OAP: off-axis parabolic mirror, DWWP: dual wavelength waveplate, LPF: low-pass filter, LP: linear polarizer.