The Study of Focal Length Influence on Two-Color Plasma THz Source Far-Field Angular Distribution

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Investigation of the angular distribution of terahertz (THz) radiation from two-color laser induced plasma is important task for the creation of directed broadband pulse sources. Such studies have been done during the last several years. However the influence of focal regimes of pump pulses on the angular distribution of THz radiation has not studied well. The purpose of this work was to investigate the influence of the geometrical focusing of laser beams on the THz emission angular distribution.

For the experimental study to provide THz radiation generation we use laser radiation of Ti:Sapphire laser system ($\lambda = 775$ nm, 2.5 mJ, 150 fs, 12 mm, 1 kHz repetition rate). Laser radiation was used to generate second harmonic radiation with 10\% conversion efficiency in BBO-crystal (I-type, $10 \times 10 \times 0.2$ mm$^3$). To produce more powerful THz generation, two-color laser pulses with collinear polarizations of fundamental and second harmonic radiation by means of time compensator plate and dual-frequency wave plate were created. This two-color pulse then was focused by parabolic mirrors with different focal length ($f = 1, 4, 8$ inch) to produce optical-breakdown plasma – THz source under investigation. For THz energy measurements we used Golay detector (Tydex GC-1P) with lock-in-amplifier (laser modulation frequency 20 Hz). For each focus and THz plasma source an angular scale with 2.5\degree (8\' focal length) or 5\degree (1\prime, 4\prime focal lengths) step was marked. THz source-detector distance was 20 cm for 1\prime parabolic mirror and 25 cm for 4\prime and 8\prime mirrors. So that it was far-field zone for plasma dimensions. To eliminate optical radiation yield a 2 mm thick PTFE screen was mounted between plasma and Golay detector normally to the source-detector axis about 5 cm from the plasma. For the numerical study we use a unidirectional pulse propagating equation (UPPE). During the investigation we obtained the angular distribution of THz emission (see Fig. 1). This demonstrates that the increase of numerical aperture leads to the increase of angular diagram of THz emission.