PROPERTIES OF TERAHERTZ WAVE GENERATED BY LASER INDUCED AIR PLASMA

Danas Buožius[1], Maksym Ivanov[1], Illia Thiele[2]

[1] Vilnius University Laser Research Center, 10 Sauletekio avenue, LT-10223 Vilnius, Lithuania
[2] Chalmers University of Technology, 2B Fysikgarden, SE-41296 Gothenburg, Sweden
danas.buozius@ff.stud.vu.lt

Currently due to many applications in imaging and spectroscopy, terahertz (THz) radiation is a subject of great interest. One of the most efficient methods of creating very strong electric fields of THz radiation is using bichromatic femtosecond laser pulses consisting of the first and second harmonics (FH and SH, respectively) to create a plasma filament where THz pulses are emitted[1, 2]. In this research we examine polarization of THz wave as a function of polarizations of FH and SH and found conditions for the most efficient THz radiation generation. In addition, we have also conducted experiments studying properties of THz signal (modulation of intensity and azimuthal phase), emitted from laser induced plasma in air, when the SH pump was carrying an optical vortex charge. For the experiments we have used a Ti:sapphire laser system (Legend elite duo HE+, Coherent Inc.), delivering pulses with duration of 40fs (FWHM), central wavelenght of 800nm and a repetition rate of 1 kHz.

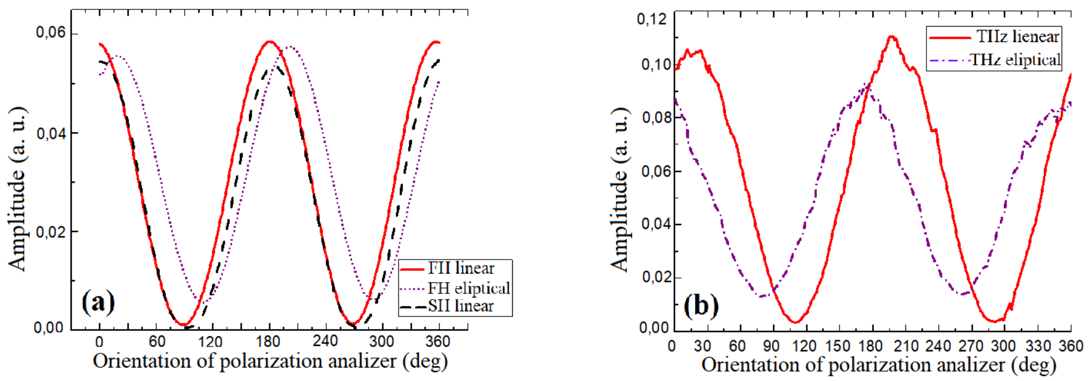

Fig. 1. (a) - FH and SH wave signal dependencies on orientation of analyzer; (b) - THz wave signal versus orientation of the analyzer for different ellipticies of the THz wave.

In the first experiment we used a Glan prism as an analizer to monitor polarizations of FH and SH, and a quarter-wave plate to change elipticity of these waves. By measuring amplitude ratios between the peak and minimum points (fig. 1(b)) it was found that THz frequency radiation has a higher elipticity of polarization than that of the pump (fig. 1(a)). We deduced that THz wave polarization depends on angle between lineary polarized pump beams as well as elipticities of FH and SH beams. Making pump polarizations parallel to each other not only increased THz signal but also decreased elipticity of THz wave. When polarizations of FH and SH were slightly eliptical (1:10 and 1:122 for the FH and SH, respectively), THz elipticity was higher, 1:7. This ratio increased to 1:25 after changing elipticities of FH and SH to 1:58 and 1:122.

In the second experiment we used s-waveplate in order to generate an optical vortex in the SH beam. FH beam remained Gaussian. Using method of THz wave generation from air plasma, radiation is being generated in a conical shape [3] thus, no significant change in beam shape is being observed when changing shape of a pump beam. We used a thermographic camera to observe THz signal spatial distribution. To estimate azimuthal phase distribution of the THz wave we used a Mickelson interferometer or a cilindrical mirror. We have compared THz beam profiles obtained under two different generation conditions: when there was an optical vortex charge in one of the excitation beams; and when both pump beams were Gaussian. We have found that when SH is an optical vortex, THz radiation also carries some properties of optical vortex which was found by examining its intensity distributions in focal plane of the cilindrical mirror, as well as by observing shifts of fringes in the THz interferogram.

Therefore we investigated THz wave polarization dependence on pump wave polarizations; and THz signal when there is an azimuthal phase modulation one of pump beams. We believe that the presented investigations will open new routes towards an active control of ultra-broadband THz beam properties.

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