Resonant effects in terahertz generation with laser-induced gas plasmas

Thiele, I.; Zhou, Binbin; Nguyen, A.; Smetanina, E.; Nuter, R.; De Alaiza Martínez, P. González; Kaltenecker, Korbinian J.; Déchard, J.; Bergé, L.; Jepsen, Peter Uhd; Skupin, S.

Published in:
EPJ Web of Conferences

Link to article, DOI:
10.1051/epjconf/201819503011

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Resonant Effects in Terahertz Generation with Laser-Induced Gas Plasmas

I. Thiele 1,2, B. Zhou 3, A. Nguyen 4, E. Smetanina 1,5, R. Nuter 1, P. González de Alaiza Martínez 1, K. J. Kaltenenecker 3, J. Déchard 4, L. Bergé 4, P. U. Jepsen 1, and S. Skupin 1,6

1Univ. Bordeaux - CNRS - CEA, Centre Lasers Intenses et Applications, Talence, France
2Department of Physics, Chalmers University of Technology, Göteborg, Sweden
3DTU Fotonik, Technical University of Denmark, Kongens Lyngby, Denmark
4CEA/DAM Ile-de-France, Bruyères-le-Châtel, 91297 Arpajon, France
5Department of Physics, University of Gothenburg, Göteborg, Sweden
6Institut Lumière Matière, Université Lyon 1 - CNRS, Villeurbanne, France, stefan.skupin@univ-lyon1.fr

Research on intense terahertz (THz) electromagnetic sources has received an increasing attention owing to numerous applications, for example, in time-domain spectroscopy, biomedical imaging or security screening [1]. Among the various techniques employed to generate THz radiation, focusing intense two-color femtosecond pulses in air or noble gases provides interesting features like absence of material damage, large generated bandwidth (up to ~100 THz) and high amplitudes of the emitted THz pulses (> 100 MV/m) [2]. First reported by Cook et al. [3], THz emission from intense two-color pulses was initially attributed to optical rectification via third-order nonlinearity. However, it was shown later that the plasma built-up by tunneling photoionization is necessary to explain the high amplitudes of the THz field [4], and a quasi-de plasma current generated by the temporally asymmetric two-color field is responsible for THz emission [5].

Numerous experimental results show that the laser-induced free electron density has a strong impact on the THz emission [4,6,7]. While it is frequently observed that a larger free electron density leads to broader THz spectra, the origin of the effect remains controversial. In [6,7], homogeneous plasma oscillations were proposed as an explanation, even though those oscillations are in principle non-radiative [8,9]. Moreover, nonlinear propagation effects have been held responsible for THz spectral broadening as well [10].

On the other hand, the gas plasma produced by the fs laser pulse is a finite conducting structure with a lifetime largely exceeding the fs time scale. Thus, one can expect that the gas plasma features plasmonic resonances which may have a strong impact on the THz emission properties [11]. However, no direct evidence of plasmonic effects in laser-induced gas-plasmas was observed so far: To make an evidence of plasmonic effects, those need to be distinguished from nonlinear propagation effects. Also from the theoretical point of view capturing plasmonic effects is not trivial: plasmonic effects require at least a full two-dimensional Maxwell-consistent description, and reduced models like the unidirectional pulse propagation equation [12], which are frequently used to describe plasma-based THz generation [5,7,10], are by construction not capable of capturing such resonant effects.

In this work, we consider the two-color-laser-induced plasma as a plasmonic structure, and investi-
Fig. 2. Experimental THz spectra for qTE (a) and qTM (b) polarization (see text for details). Corresponding on-axis THz waveforms are shown as insets. The dashed lines specify the estimated maximum plasma frequency.

References