Spectral broadening of laser pulse during generation of powerful THz radiation from gas-cluster target

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Gas plasma is a promising source of terahertz radiation, enabling conversion of intense ($> 10^{18}$ W/cm^2) laser pulses with relatively high efficiency. THz radiation is created by accelerated relativistic electrons, with transition radiation being the only thoroughly studied mechanism, mostly coherent [1], rarely incoherent [2]. Gas-cluster targets are more promising for THz generation than solid-state ones, providing high local density and necessary transparency without contaminating the interaction chamber. Through experiments at the terawatt laser facility at the NRC "Kurchatov Institute" (800 nm, 30 fs, up to 310 mJ in this series, up to 10 TW) electrons were efficiently accelerated to 10 MeV, capable of generating terahertz radiation with energy up to 20 μJ, in 10 nm nitrogen and oxygen clusters. The obtained radiation has a spectrum up to 3 THz and conical divergence at $\approx 20°$ with nearly circular polarization outside the vacuum chamber. THz demonstrates a full correlation with electron charge, while synchronous analysis with visible spectra modification provides deeper understanding of laser plasma processes, particularly electron concentration. Visible spectra are shown to be a convenient criterion for optimizing THz generation mode, with THz field intensity potentially exceeding MV/cm at the point of further use. Together, all signals provide a platform for picosecond time-resolved studies, where THz, electrons and laser can interchange roles between pumping and probing.

[1] Kang Y, Wang R, Chen W, Tu L, Zhang K and Feng C 2023 *Frontiers in Physics* **11** ISSN 2296-424X

[2] Schroeder C B, Esarey E, van Tilborg J and Leemans W P 2004 *Physical Review E* **69**(1) 12 ISSN 1063651X