Generation of terahertz radiation by irradiating small Ar and Kr clusters with relativistic laser pulses

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Powerful, single-period terahertz (THz) pulses are a promising modern tool for non-ionizing and non-thermal effects on substances. The search for a method for generating THz pulses from subpetawatt lasers without output saturation and without contamination of optical elements is relevant. One method is laser-plasma sources. Laser pulses varying in power ($5 * 10^{18}$ W/cm^2) were emitted from a gas-cluster target obtained by successively elongating a gas (Ar or Kr) through a conical nozzle in a vacuum. Rayleigh scattering and changes in gas pressure were used to control cluster size. Due to rapid ionization, charge separation, or electron acceleration, the THz energy collected by a Golay cell and electro-optical detection was closed. It was found that, depending on the gas pressure and, consequently, the cluster diameter and plasma concentration, different THz generation mechanisms predominate. At pressures above 8 bar, THz are generated by accelerated electrons crossing the plasma-cluster medium boundary [1]. As the pressure decreases by 5–8 bar, the contribution of accelerated electrons is reversed, but a new THz maximum appears. The second maximum THz yield corresponds to a cluster radius of 2–4 nm. Measuring the spectrum, polarization, and directivity of THz suggests a quadrupole generation mechanism [2]. This study aims to better understand the processes of high-power THz generation in laser-induced cluster plasmas.

[1] Nazarov M M and et al 2025 *Bulletin of the Lebedev Physics Institute* **52**(4) 364–376

[2] Jahangiri F and et al 2013 *Applied physics letters* **102**(19) 191106