Strong terahertz bursts driven by intense fem to second laser pulses

With the support by the National Natural Science Foundation of China and the Ministry of Science and Technology of China, Prof. Li Yutong (李玉同) at the Institute of Physics, Chinese Academy of Sciences, in collaboration with Prof. Zhang Jie (张杰) and Sheng Zhengming (盛政明) at Shanghai Jiao Tong University, demonstrated the generation of high-energy, coherent terahertz (THz) radiation from ultra intense fem to second laser-solid interactions, which was published in *Phys Rev Lett* (2016, 116: 205003).

THz radiation with a typical frequency range from 0.1 to 10 THz lies between far-infrared and microwaves in the electromagnetic spectrum. It is a big challenge to generate intense THz radiation, which is significantly important for THz sciences and applications in many interdisciplinary fields. Currently THz radiation pulses with energies over 100 μJ are usually obtained with relativist electron beams from huge-sized conventional accelerators. The damage problem with nonlinear crystals or semiconductors when using optical methods to generate THz radiation is a serious obstacle to improve the THz intensity. Laser-plasma interactions provide a unique opportunity to achieve high-field THz radiation. To take advantages of ultra intense laser pulses whose focused intensity can be well above 10^{18} W/cm^2, Prof. Li's group explored the generation of strong THz radiation by intense laser pulses interacting with solid targets. In the past few years, they have investigated systematically the radiation from the front surface of targets, and experimentally demonstrated THz generation mechanisms such as transient current model (*Appl Phys Lett*, 2012, 100: 254101) and mode conversion from electron plasma waves to THz waves (*Phys Rev Lett*, 2015, 114: 255001).

Recently, from the rear side of a 5 μm thick metal foil irradiated by a 2 J/ 30 fs laser pulse, they have obtained an intense THz pulse with an energy of ~400 μJ, which is comparable to the energy of the THz sources based on conventional accelerators. The measured THz radiation covers a bandwidth up to 30 THz, and has a "double-wing-like" angular distribution. The physical scenario of THz generation is depicted as follows (Figure): a high charge (nC—μC) MeV fast electron beam is first generated during intense laser—solid interactions. Then such a relativistic electron beam induces coherent transition radiation (CTR) in the THz regime when crossing the rear surface of the thin solid foil. Mass-limited and metal-plastic layered targets are used to verify the radiation mechanism. Both CTR theoretical calculations and two-dimensional particle-in-cell simulations can well reproduce the experimental observations.

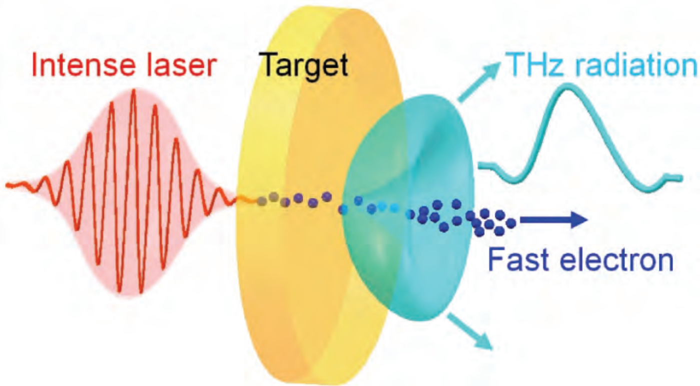

Figure Schematic diagram illustrating the THz generation via CTR by intense laser-driven fast electron beams crossing the rear surface of a foil target.

The intense-laser-plasma-based THz transition radiation presented would be a promising compact, brilliant THz source. Moreover, it may provide a potential noninvasive diagnostic to infer the spatiotemporal distribution of fast electron beams generated in laser-solid interactions.