超短超强激光与物质相互作用研究组（L05组） 典型工作简介

自主建立了由超短超强激光系统、物理实验装置及诊断设备、大型数值模拟程序组成的强场物理先进研究平台。
利用这一平台，对高能量密度物理、强场物理的若干前沿问题进行了深入而系统的研究；在与快点火激光核聚变相关的核心物理问题、基于激光等离子体的新型粒子加速、新型辐射源、超强激光脉冲在大气中长距离传输等方面取得了一系列原创性成果。

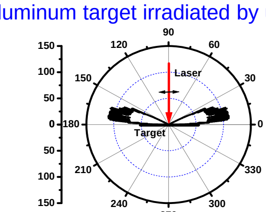
在Physical Review Letters
PRL 96, 165003 (2006); PRL 96, 084802 (2006)
PRL 96, 025003 (2006); PRL 96, 110501 (2006)
PRL 94, 095003 (2005); PRL 91, 225001 (2003)
PRL 90, 165002 (2003); PRL 88, 055004 (2002)
PRL 87, 225001 (2001); PRL 85, 005340 (2000)
等影响因子大于2. 0的国际学术刊物上发表论文63篇。

Introduction

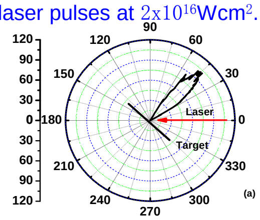
We are interested in the interactions of ultrashort ultrahigh intensity lasers with matters and their applications. Main research subjects include: generation and transport of energetic particles relevant with the fast ignition of fusion targets, advanced particle acceleration driven by intense lasers, propagation of intense femtosecond laser pulses in air, femtosecond laser pumped X-ray lasers, novel radiation sources from relativistic laser-plasma, laboratory astrophysics and laser-driven high energy density physics. Our studies have been performed with the high-power laser systems, experimental facilities, and numerical simulation codes developed by ourselves in this group. Close collaboration with the research groups in Japan, Europe, and USA has also been established.

I. Effects of Laser Polarization on Jet Emission of Fast Electrons

Effects of laser polarization on fast electron emission are studied from an aluminum target irradiated by ultrashort laser pulses at $2\mathrm{x}10^{16}\mathrm{Wcm}^2$.



For *s*-polarized laser pulse jet emission of outgoing fast electrons collimated in the polarization direction is observed.

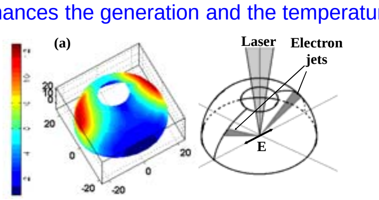


For *p*-polarized laser pulse jet emission of outgoing fast electrons is found in the direction close to the normal of the target.

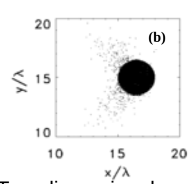
L. M. Chen, *et al.*, Phys. Rev. Lett. 87, 225001 (2001).

II. High-Energy Electron Emission from Water Plasmas

High energy electrons emitted by water plasmas produced by a single or a multiple laser pulse are investigated. The multipulse mode greatly enhances the generation and the temperature of hot electrons.



Directional emission of high energy electrons is observed in two symmetric directions with respect to the laser axis and at 46° from the directions of the laser electric field.

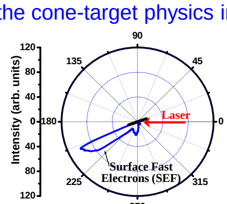


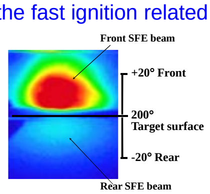
Two-dimensional particle-in-cell (PIC) simulations reproduce well the experimental results.

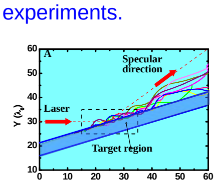
Y. T. Li, *et al.*, Phys. Rev. Lett. 90, 165002 (2003).

III. A Fast Electron Beam Emitted along the Target Surface

A novel fast electron beam emitting along the surface of a target irradiated by intense laser pulses is observed. The beam is found to appear only when the plasma density scale length is small. Numerical simulations reveal that the electron beam is formed due to the confinement of the surface quasistatic electromagnetic fields. The results are of interest for potential applications of fast electron beams and deep understanding of the cone-target physics in the fast ignition related experiments.



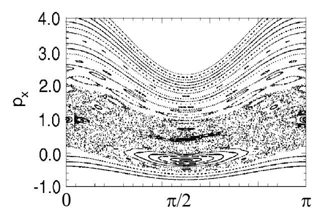




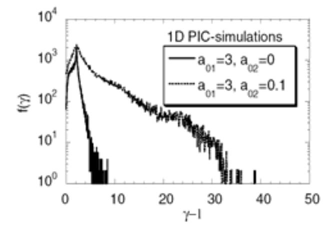
Y. T. Li, *et al.*, Phys. Rev. Lett. 96, 165003 (2006).

IV. Stochastic Heating and Acceleration of Electrons

When two laser pulses counter-propagate in underdense plasma, stochastic heating and acceleration occur when the pulse amplitudes exceed certain threshold values. The counter-propagating laser pulse can be produced by Raman backscattering or the reflection part of the incident pulse.



Longitudinal phase space plot of a test electron in counter-propagating electro-magnetic waves with different amplitudes.

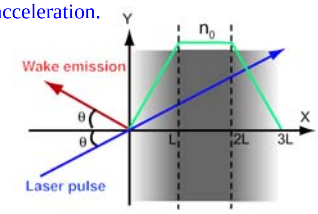


A comparison of the electron energy distributions with or without a counter-propagating laser pulse.

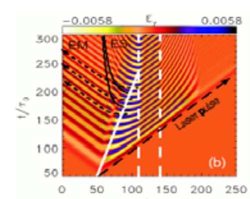
Z.-M. Sheng, *et al.*, Phys. Rev. Lett. 88, 055004 (2002).

V. Powerful THz Emission from laser Wakefields

Powerful terahertz (THz) emission can be produced from the laser-driven large-amplitude plasma waves at the vacuum plasma boundary by mode conversion from electrostatic to electromagnetic waves, where the plasma inhomogeneity plays a crucial role. Such emission can both serve as a high power THz source at the MW level and an easy diagnostic tool for the wakefield produced for particle acceleration.



Schematic of electromagnetic emission from a wakefield generated by a laser pulse incident obliquely to the plasma density gradient.



PIC simulation shows the space-time plot of the wakefield component Ey, which contains both electrostatic and electromagnetic components.

Z.-M. Sheng, *et al.*, Phys. Rev. Lett. 94, 095003 (2005).

VI. Interaction of Femtosecond Light Filaments in Air

The interaction of two light filaments propagating in air is simulated. Simulations show that the interaction of the two light filaments displays interesting features such as attraction, fusion, repulsion, and spiral propagation, depending on the relative phase shift and the crossing angle between them. A long and stable channel can be formed by fusing two in-phase light filaments. The channel becomes unstable with the increase of the crossing angle and phase shift.

The energy fluence distribution of two merging(left) and repulsing(right) light filaments.

Ting-Ting Xi, *et al.*, Phys. Rev. Lett. 96, 025003 (2006)

Contact information

组长(Group leader): 张　杰 Jie Zhang (jzhang@aphy.iphy.ac.cn)
成员(Group member): 盛政明 Zhengming Sheng (zmsheng@aphy.iphy.ac.cn)
李玉同 Yutong Li (ytli@aphy.iphy.ac.cn)
鲁　欣 Xin Lu (luxin@aphy.iphy.ac.cn)
董全力 Quangli Dong (qldong@aphy.iphy.ac.cn)　和全体学生