Magnetic controlling of high-power laser pulses and their interactions with plasmas

S. M. Weng[1], Q. Zhao[1], Z. M. Sheng[1,2], W. Yu[3], L. S. Luan[3], M. Chen[1], M. Murakami[4], W. B. Mori[5]， B. Hidding[2], D. A. Jaroszynski[2], Jie Zhang[1]

[1] *Laboratory for Laser Plasmas, Shanghai Jiao Tong University, Shanghai, China*

[2] *SUPA, Department of Physics, University of Strathclyde, Glasgow, UK*

[3] *Shanghai Institute of Optics and Fine Mechanics(SIOM), CAS, Shanghai, China*

[4] *Institute of Laser Engineering, Osaka University, Osaka, Japan*

[5] *Department of Physics and Astronomy, University of California, Los Angeles, USA*

In the talk, we will firstly report an extreme case of the Faraday effect that a linearly polarized ultrashort laser pulse splits in time into two circularly polarized pulses of opposite handedness during its propagation in a highly magnetized plasma. This offers a new degree of freedom to manipulate ultrashort and ultrahigh power laser pulses. Together with technologies of ultra-strong magnetic fields, it may pave the way for novel optical devices, such as magnetized plasma polarizers. The latter could allow the generation of circularly polarized laser pulses as high power as 10 PW in up-to-date laser facilities. The resultant high-power circularly polarized pulses are particularly attractive for laser-driven ion acceleration, and optical control of mesoscopic objects. In addition, it may offer a powerful means to measure strong magnetic fields broadly existing in objects in the universe and in laser–matter interactions in laboratories.

Besides the manipulating of laser pulses by strong magnetic fields, we will also discuss about the magnetic controlling of laser-plasma interactions, such as laser wakefield acceleration. The ultrahigh acceleration gradients of laser wakefield accelerators (LWFAs) make them a promising next-generation ultra-compact technology suitable for high impact applications. However, controlling injection and optimizing beam loading are outstanding, unresolved issues, which have a crucial impact on the reliability and quality of beams from LWFAs. Here we propose a scheme to control the injection persistence and rate, through a combination of ionization and magnetic fields. Furthermore, beam loading is naturally compensated for because of the ensuing trapezoidal-shaped charge profile. Our scheme enables robust generation of high-charge electron beams with narrow energy spread suitable for applications that have wide impact.