Magnetic reconnection driven by high-energy laser beams

S. Egashira[1], Y. Sakawa[2], R. Kumar[1], M. Ota[1], T. Sano[2], T. Morita[3], N. Bolouki[4], K. Law[1], T. Minami[5], Y. Fujita[5], K. Sakai[5], D. Kamibayashi[5], K. Matsuo[1], Y. Kuramitsu[5], H. Habara[5], S. Fujioka[1], A. Yogo[2], Y. Fukuda[6], M. Kanasaki[7], and A. Morace[2]

[1] Graduate School of Science, Osaka University, Suita, Osaka, Japan
[2] Institute of Laser Engineering, Osaka University, Suita, Osaka, Japan
[3] Faculty of Engineering Sciences, Kyushu University, Kasuga, Fukuoka, Japan
[4]Department of Physics, National Central University, Taoyuan, Taiwan
[5]Graduate School of Engineering, Osaka University, Suita, Osaka, Japan
[6]National Institutes for Quantum and Radiological Science and Technology, Kansai Photon Science Institute Kizugawa, Kyoto, Japan
[7]Faculty of Maritime Sciences, Kobe University, Kobe, Hyogo, Japan

In the universe, there are high-energy charged particles whose energy distribution is not Maxwellian but power law. It means the particles are accelerated by non-thermal phenomena, and magnetic reconnection is considered to be one of them. In magnetic reconnection, ions can be accelerated to the Alfven velocity $v_A = B/\sqrt{\mu m_i n_i} \approx v_{out}$, here B is the magnetic flux density, m_i is the ion mass, and n_i is the ion density, and v_{out} is the outflow velocity. When v_A is a relativistic velocity ($v_A \approx$ c), it is called relativistic magnetic reconnection.

We conducted the magnetic reconnection experiment using Gekko XII Laser system (wavelength = 1053 nm, pulse duration = 1.3 ns, number of beams = 12, total energy = 900 J, Intensity < 5×10^{14} W/cm^2) at Institute of Laser Engineering, Osaka University, by focusing 6 beams each on one of the two capacitor-coil targets (CCT). This CCT can generate hundreds of Tesla B field, and by using two targets it is possible to make anti-parallel or parallel distribution of B field. Magnetic reconnection is driven by plasmas come from expanding coil part of the CCT. Vacuum chamber is filled with Hydrogen or Nitrogen gas, ionized by radiation from the ablation plasma, and magnetized ambient plasma is created. Diagnostics are as follows. Radio Chromic Film (RCF) and CR-39 stack, electron spectrometer and Thomson parabola for particle measurements; Collective Thomson scattering for plasma parameter measurements; three-axis B-dot probes to get the intensity of B field; and optical probe and visible self-emission for the spatial and temporal evolution measurements of plasmas.

CR-39 data suggested the existence of about 1 MeV proton for the anti-parallel distribution with 0.2 Torr of Hydrogen. A possible explanation is that protons are accelerated to the Alfven velocity $v_A \sim 10^7 m/s$ for $n_i \sim 7\times10^{21} m^{-3}$ and $B \sim 50$ Tesla.