Generation of anti-parallel kilo-tesla magnetic field and particle acceleration with laser-driven snail target

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Various schemes were reported to generate a mega-gauss level magnetic field using an intense laser pulse in the recent years. Generation of the strong magnetic field is of great interest for a wide variety of applications, like energy enhancement in the laser-based ion acceleration, fusion product confinement in the inertial confinement fusion, and magnetic field annihilation in the laboratory astrophysics. We have demonstrated the generation of a several kilo-tesla quasi-static magnetic field by illuminating on the inner surface of the "snail target" by an intense laser pulse. A particle-in-cell simulation shows that the snail target is filled with two distinguished plasmas that are magnetized with anti-parallel directed magnetic fields. Both two magnetized plasmas flow toward their boundary and their magnetic energy is converted into electrons kinetic energy, likely through “magnetic reconnection” process, especially well-known in magnetized plasma studies.

The experiment has been performed using LFEX laser facility at Institute of Laser Engineering, Osaka University. A magnetic field strength was measured to exceed 2 kT at the maximum by using the proton deflectometry method. Besides this magnetic field characterization, we would also report about the particle acceleration along the boundary. In the direction along the boundary, we observed a proton beam with maximum kinetic energy exceeding 16 MeV, which was even higher than that of TNSA (Target Normal Sheath Acceleration) accelerated proton beam measured at the same time. We would discuss this experimental result, as an evidence of particle acceleration due to the energy conversion process through the magnetic field reconnection occurred in the laser-driven snail target. Experimental results and three-dimensional particle-in-cell simulation results for further understanding of the obtained result would be presented and its implication would be discussed in the conference.