Investigating guide field reconnection in HED plasmas

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Magnetic reconnection (MR) is a process which occurs in many astrophysical plasmas, e.g. in solar flares, in coronal mass ejecta, or at the outer boundary of the Earth magnetosphere. However, as of now, the fundamental microphysics implied in this process is far from being well understood. Most of the investigations on this long standing issue come from numerical studies and space observations. Laboratory modelling of plasmas, including those that can be generated by high-power lasers, offer now new perspectives to investigate MR and the processes governing it.

Investigating MR in high-energy-density plasmas (HEDP) such as those produced by lasers is also, beyond allowing progress on its fundamental understanding, an important issue for Inertial Confinement Fusion (ICF). In ICF, a number of laser spots irradiate the inner holhraum cavity and around each of these irradiated spots, a toroidal magnetic field is self-generated. Between the close-by magnetic ribbons, magnetic reconnections can occur and the process converts the magnetic potential in kinetic energy and heat which might affect the overall drive of the inner DT fuel.

We will present recent experiments, performed using the LULI2000 facility, aimed at investigating the dynamic of magnetic reconnection in a non-coplanar configuration between two magnetic toroids induced by two near-by laser spots irradiating solids targets. Despite being distinct from the astrophysical plasmas where the beta parameter is low (∼10^-3 in solar corona and∼ 1 in solar winds), such HEDP reconnection experiments are of interest to investigate fundamental issues in MR such as the influence of a guide field and of a quadrupolar Hall structure of the magnetic field on the dynamic of the MR. A non-coplanar configuration between the two laser-irradiated targets, as was investigated in our experiments, allows to initialize a guide field or a quadrupolar Hall structure of the magnetic field. The reconnection rate in the experiments has been diagnosed with proton radiography which provides a unique way to measure and map directly the distribution of the strong magnetic fields and their evolution. We observe that the Hall component and the guide field speed up or slow down the MR, depending on the setup between the two laser-irradiated targets, and hence between the two magnetic toroids that are made to interact. The measurements are compared to simulations performed by a hybrid simulation code, the 3D HECKLE code. This simulations have been initialized, with respect to the initial magnetic toroid, by calculations using a hydro-radiative code (FCI2) and experimental measurements.