8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

# Laboratory investigations on the origin and interactions with astroplasmas of magnetic fields in the Universe by using high-power lasers

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Magnetic fields permeate the entirety of the universe, which are believed to be closely related to some high-energy explosive events therein, through magnetic reconnection, electromagnetic shock, etc. How these magnetic fields originate and interact with astroplasmas is one of the most profound problems in astrophysics. Because high-power lasers can produce plasmas similar to astrophysical scenarios, it is considered and proved to be a promising method to model astrophysical processes in laboratory. In this talk, I shall give a review on our experimental and theoretical progresses on these studies in the last five years, using various large laser facilities in China, such as ShenGuang-Ⅱ (SG-Ⅱ), ShenGuang-Ⅱ-Upgrade (SG-Ⅱ-Up) and XingGuang-Ⅲ (XG-Ⅲ). Firstly, by manipulating the micro-conditions of laser-produced plasmas and developing a novel 3D synchronous proton radiography (as shown in Figure 1), we successfully modeled and identified that the kinetic Weibel instability driven by temperature gradient is an important mechanism for magnetic field generation in weakly-collisional astroplasmas [1]. Secondly, we have studied a class of collisional-collisionless asymmetric hybrid magnetic reconnection that commonly exists in solar/stellar atmospheres, and find that the Coulomb collisions has a significant impact on the reconnection rate and current sheet [2]. Lastly, we have experimentally modelled the interaction between the astrophysical supersonic outflow and prescribed magnetized turbulence, and carefully investigated the associated shock particle acceleration [3, 4]. It is found that the magnetized turbulence can modulate the collisionless shock formation and effectively enhance the associated particle acceleration. Our discoveries and achievements have advanced the understanding and diagnosis of the nonlinear coupling of astroplasmas and the self-generated magnetic fields.

References

[1] Z. H. Zhao et al., Sci. Adv. 10, eadk5229 (2024).
[2] Z. H. Zhao et al., Comm. Phys. 5, 247 (2022).
[3] Z. Lei et al., Commun. Phys. 7, 107 (2024).
[4] Y. Xie et al., Science Bulletin 68, 1857 (2023).

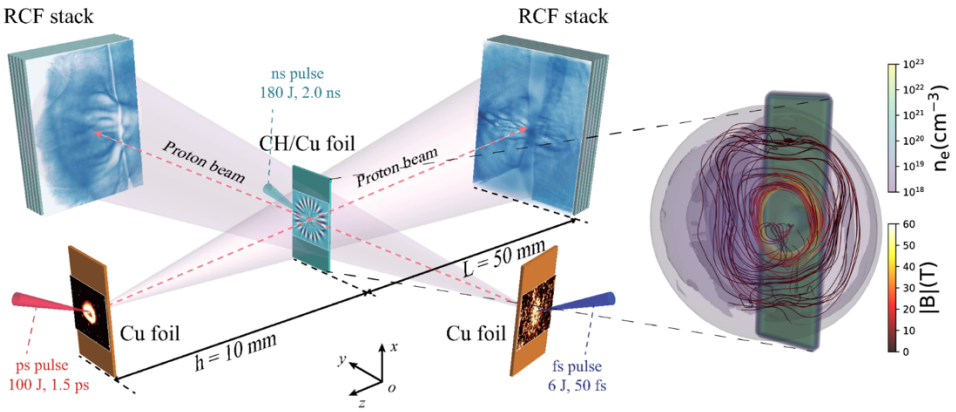


Figure 1. Schematic of the experimental setup for three-dimensional synchronous proton radiography of dynamic magnetic fields in laser-produced high-energy-density plasmas, which is carried out on XG-III laser facility.