Particle-in-cell simulations of laser-driven, ion-scale magnetospheres in laboratory plasmas

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Ion-scale "mini-magnetospheres" provide a unique environment for studying kinetic-scale plasma physics, and have been observed around comets, weakly-magnetized asteroids, and localized regions of the moon. In this work, we present collisionless particle-in-cell (PIC) simulations of ion-scale magnetospheres that reproduce recent laboratory experiments performed on the Large Plasma Device (LAPD) at UCLA [1]. In the PIC simulations, a super-Alfvénic driver plasma flows against a dipole magnetic field that is embedded in a uniform magnetized background plasma. The simulations replicate the main magnetospheric structures observed in the experiments, namely the kinetic-scale magnetopause and structures of the plasma current distribution [2]. The properties of mini-magnetospheres created in this interaction are studied for different dipole and plasma parameters, and the conditions for their observation in the experimental setting available at LAPD are determined.

Additionally, we develop a semi-analytical model of the parameters that characterize the coupling between the driver and background plasmas from the available magnetic field data, and use it to provide bounds for the experimental driver parameters.

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References

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