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High power laser experiment on collisionless shocks and the associated PIC simulation

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Collisionless shocks often play important roles in various high energy phenomena in space. The efforts of producing a collisionless shock in a laboratory using high power laser have been dedicated in recent years. We have developed the way producing a magnetized collisionless shock in a homogeneous gas plasma at rest by utilizing Gekko XII laser facility at Osaka University. The shock is formed by irradiating a target aluminum plate surrounded by a nitrogen gas. An aluminum ablation plasma pushes a gas plasma to form a forward shock in the gas plasma. Time evolution of the system is observed by both self-emission streaked optical pyrometer (SOP) and Thomson scattering (TS) measurement. The ambient magnetic field of ~3.6-3.8T is applied by using a Helmholtz coil driven by a portable pulsed magnetic field generation system [1]. Only when the magnetic field was applied, the SOP showed that a precursor which is a preheated upstream plasma formed in front of a shock disappeared. The TS measurement captured discontinuities after a long time evolution of the magnetized shock system.

We developed a simulation method to reproduce the interaction between a target plasma and a gas plasma by using one dimensional full particle-in-cell (PIC) code. A dense Maxwellian plasma is injected from the position at x=0 for a finite time in the system filled with a tenuous background magnetized gas plasma at rest. A magnetized shock is formed after about 40ns and evolves in time. The system is nonstationary in time. In addition to a forward shock, a reverse shock is formed in a later time. The results are compared with the experiment.

References

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