Radiation-pressure-driven ion Weibel instability and collisionless shocks

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The Weibel instability driven from counter-streaming plasma flows is a basic process of outmost importance for the formation of collisionless shock in astrophysics. It has motivated recent experimental efforts worldwide that aim at recreating collisionless shocks using high-energy moderately intense laser systems such as NIF [1]. In this work, we investigate the possibility to recreate similar collisionless processes using ultra-high intensity picosecond laser systems [2].

Using two- and three-dimensional Particle-In-Cell (PIC) simulations, we investigate suitable configurations for driving the ion Weibel instability (IWI) from a fast quasi-neutral flow launched into a target via the radiation pressure of an ultra-intense laser pulse. The use of S-polarized light at oblique incidence is found to be optimal to drive a fast neutral flow that in turns triggers the IWI into the dense target. This configuration is shown to mitigate the production of hot electrons, thus preventing the growth of competing (electron) instabilities and allowing for a longer operating time of the laser piston. This configuration is also shown to eventually lead to the formation of a Weibel-mediated collisionless shock.

[1] J. S. Ross et al., Phys. Rev. Lett. **118**, 185003 (2017).

[2] A. Grassi et al., Phys. Rev. E **96**, 033204 (2017).