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Parallel collisionless-shock experiments at the Large Plasma Device

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Previous research on parallel collisionless shocks, which constitute an important part of the Earth's bow shock region, has been limited to satellite measurements and simulations. However, whether and how these collisionless shocks form depends on a wide range of parameters and scales, some of which can be established and measured more easily in a laboratory experiment.

Using a kJ-class laser, an ongoing experimental campaign at the Large Plasma Device (LAPD) at UCLA in Los Angeles is expected to produce the first laboratory measurements of the formation of a parallel collisionless shock. We present hybrid kinetic/MHD simulations which show how ion-beam instabilities in the background plasma can be driven by ablating carbon ions from a polyethylene target, causing non-linear density oscillations which eventually develop into a propagating shock front.

The free-streaming carbon ions can excite both the resonant right-hand instability and the non-resonant firehose mode, the latter of which has also received a lot of attention among astrophysicists as Bell's instability. We present measurements from a first trial experiment at LAPD, in which we have identified these instabilities, and discuss their respective roles for future shock formation and the basic microphysical processes which drive them.