Laboratory Laser-Plasma Collisionless Shocks

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Collisionless shock waves (CSW) arise in plasma when an abrupt change in plasma conditions is not caused by binary collisions but the collective behaviour of the plasma. CSW are thought to be highly common in astrophysical environments due to the low ambient density. It is thought that shocks caused by supernova remnants expanding into the interstellar medium accelerate particles that are responsible for cosmic rays measured high in the Earth's atmosphere. CSW can also be found in our solar system as planetary bow shocks and interplanetary shocks [1][2][3].

Intense laser-plasma interactions provide a way to launch CSW in conditions relevant to astrophysical plasmas. The interaction of an intense laser pulse with a solid target produces dense plasma, which flows with high velocity, into an ambient background medium.

CSW are generated by the sudden expansion of this dense plasma into a tenuous ionized background.

The generation and reliable diagnoses of these shock waves in laser-plasma experiments is non-trivial. We will present results showing the experimental conditions under which it is possibly to generate such phenomena as confirmed via a series of experiments [4][5][6]over the past few years at several facilities including the VULCAN laser (Rutherford Appleton Laboratory, UK).

[1] J. E. Cross, *et. al.*, "Laboratory analogue of a supersonic accretion column in a binary star system," no. May, pp. 1–7, 2016.

[2] S. F. Martins, *et. al.*, "Ion Dynamics and Acceleration in Relativistic Shocks," *Astrophys. J.*, vol. 695, no. 2, pp. L189–L193, 2009.

[3] K. Koyama, *et. al.* , "Evidence for shock acceleration of high-energy electrons in the supernova remnant SN1006," *Nature*, vol. 378, no. 6554, pp. 255–258, 1995.

[4] H. Ahmed, *et. al.*, "Experimental Observation of Thin-shell Instability in a Collisionless Plasma," *Astrophys. J. Lett.*, vol. 834, no. 2, pp. 1–5, 2017.

[5] H. Ahmed, *et. al.,* "Time-Resolved Characterization of the Formation of a Collisionless Shock," vol. 110, 2013.

[6] A. J. Mackinnon and L. Romagnani, "Observation of Collisionless Shocks in Laser-Plasma Experiments," vol. 25004, no. July, pp. 1–4, 2008.