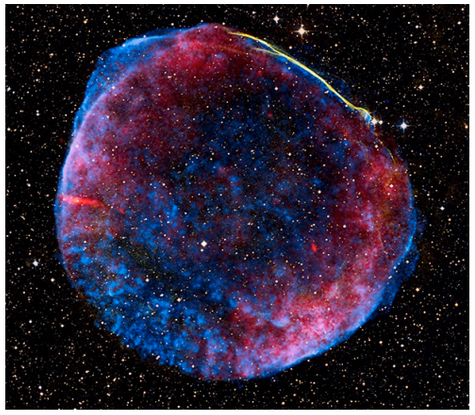
Astrophysical Weibel instability in counter-streaming laser-driven plasmas

jointly between the University of New Hampshire, PPPL, and University of Rochester

Problem: many astrophysical shocks are collisionless, where the mean-free-path far exceeds the shock width. These shocks are of great interest as sites of cosmic ray acceleration

Collisionless collective effects in the plasma must mediate the shock formation



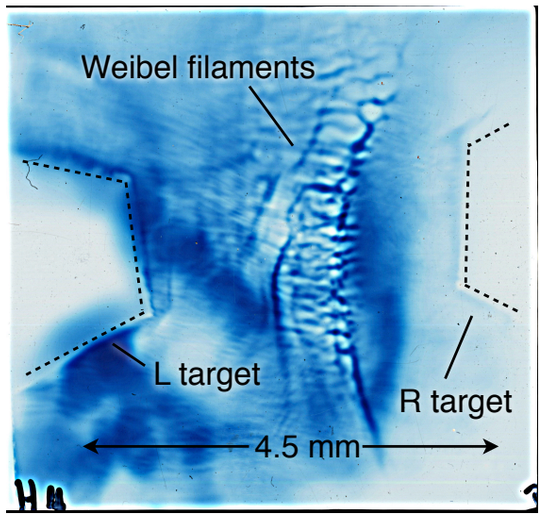
Supernova remnant SN1006 with shock front

Impact: The Weibel instability has been predicted to mediate collisionless shocks in weakly magnetized plasmas

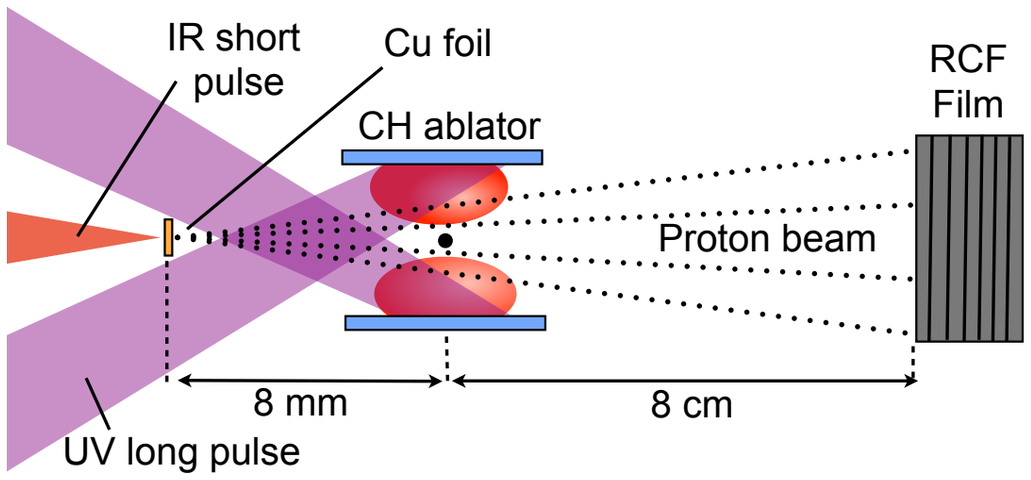
- Observation of the Weibel instabiltiy confirms this astrophysical process, and paves the way for laboratory study of fully-formed collisionless shocks
- Similar Weibel-type instabilities can driven by heat flux or relativistic electron beams and are directly relevant to inertial fusion and laser-plasma interactions.

Advancement: We directly observe this astrophysically relevant Weibel instability between counterstreaming laser-produced plasma plumes

- OMEGA EP laser creates high-temperature plasma, establishing relatively collisionless interaction between two counterstreaming plumes
- Growth of characteristic elongated Weibel-driven filaments is observed with laser-driven proton radiography
- Supercomputer simulations (conducted on ORNL Titan) of counterstreaming plasmas matching to the experimental ablation profiles observe the Weibel instability and thereby confirm the identification of this instability.



Proton radiograph in OMEGA EP experiment, t = 4.8 ns



OMEGA EP experimental setup

Reference: Fox, Fiksel, Bhattacharjee, et al, to appear in Phys. Rev. Lett. (2013).
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