Laboratory Astrophysics Experiments to Study Magnetized Rayleigh-Taylor Relevant to the Crab Nebula

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Astronomical observations of the Crab Nebula using the Hubble Space Telescope produce some of the most iconic imagery of Rayleigh-Taylor (RT) growth in an astrophysical system. Due to its close proximity, the Crab is one of the most observed objects in the sky beyond our solar system. Because of the detail in which this object can be studied, it provides a fantastic laboratory for comparing theory, observations, and experiments. The Crab can be broken into four major components [1], moving out radially these are: the pulsar itself, the pulsar wind nebula (PWN), the thermal filaments forming a cage around the PWN, and the freely expanding ejecta. It is this third component whose characteristic filamentary structures are due to the magnetized RT instability [2].

A classically RT-unstable interface is formed at the boundary of the dense, thermal ejecta and the lighter synchrotron plasma driving the outward expansion. Perturbations in the thin, dense shell fall inwards and grow. The magnetic fields present in the system are predicted to stabilize short wavelength modes and are dragged with the RT spikes as they grow. B-fields within these spikes provide additional magnetic tension within the plasma that are predicted to prevent the characteristic Kelvin-Helmholtz roll-ups that occur during the nonlinear stages of the RT instability. Theoretical calculations of these magnetic effects in the Crab Nebula provide an explanation for astrophysical observations, but these phenomena have never been observed in a controlled laboratory experiment.

This talk will cover proposed laser-based, blast-wave-driven Rayleigh-Taylor experiments that will provide insight to the magnetic effects in plasma systems similar to those of the Crab Nebula. Magnetic field effects on high-energy-density plasmas can now be studied in the lab, opening many new opportunities to study magnetized astrophysical systems under controlled conditions.

[1] Hester, Ann. Rev. Astron. Astrophys. 46 (2008)

[2] Hester *et al.*, Astrophys. J. 456 (1996)