Accretion Shocks on Young Stars: Plans for a Lab-Astro Experiment

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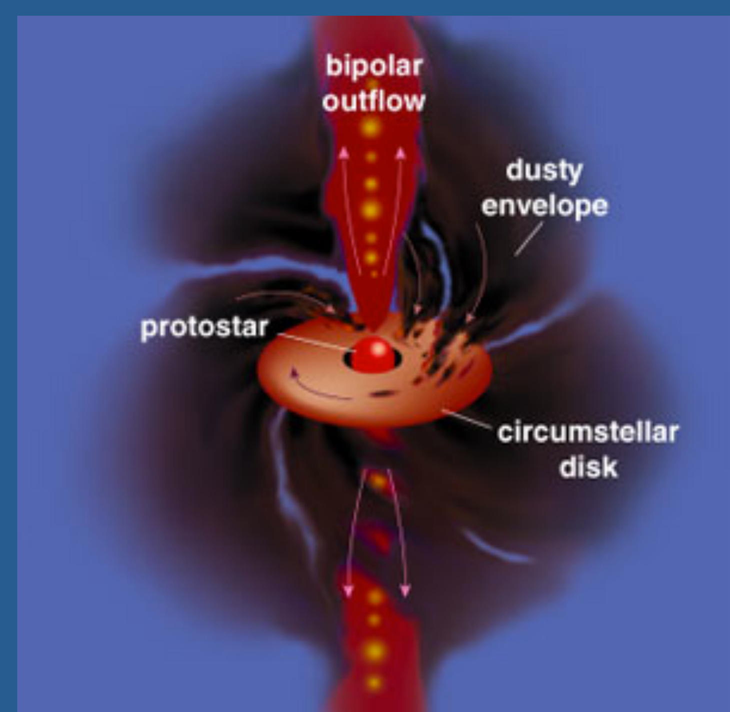
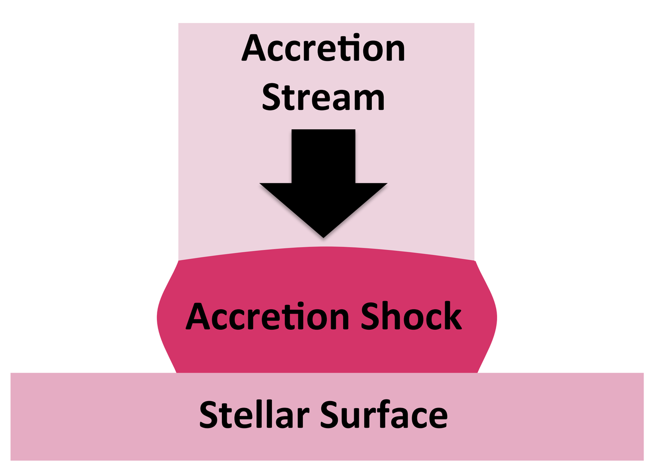
Accretion shocks form at the surface of young, growing stars

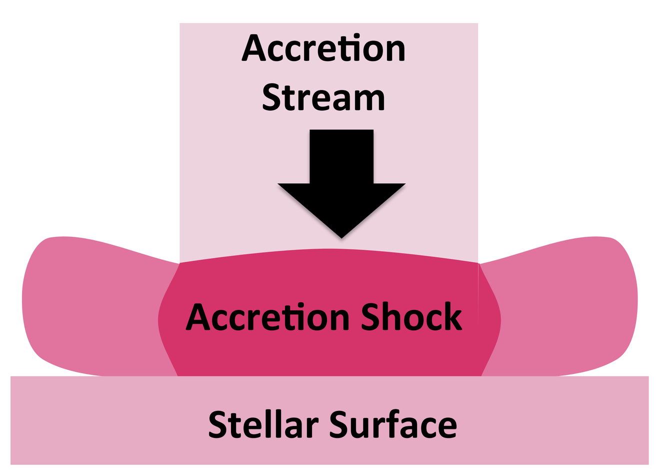
Left: The Omega Nebula is a major star forming region. (Image credit: ESO)



Right: Young stars form at the center of accretion disks. (Image credit: Thomas Greene, *American Scientist*)

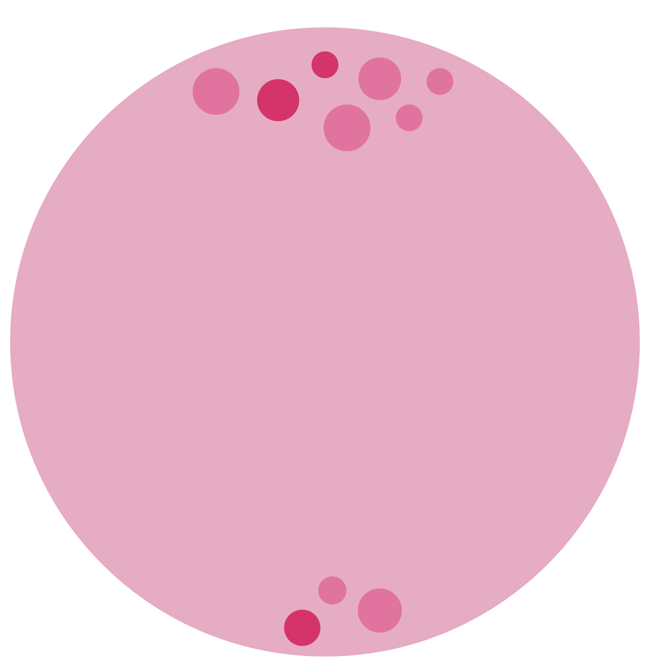
If researchers see evidence of both 3-MK and 2-MK hotspots on the surface of a T Tauri star, what does that mean? There are basically two scenarios, and they depend on how contained the accretion shock is at the star's surface.



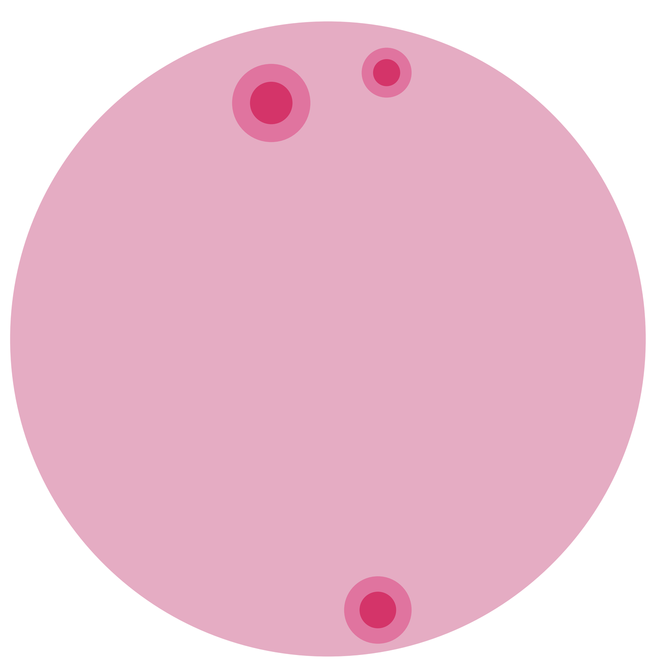


Scenario 1: The accretion shock is well-contained. Since we see both 3-MK and 2-MK plasma, this must be because there are accretion streams with different accretion rates.

Scenario 2: The accretion shock generates violent outflows of material (a big splat). The 3-MK plasma and the 2-MK plasma are both the products of the same accretion streams.

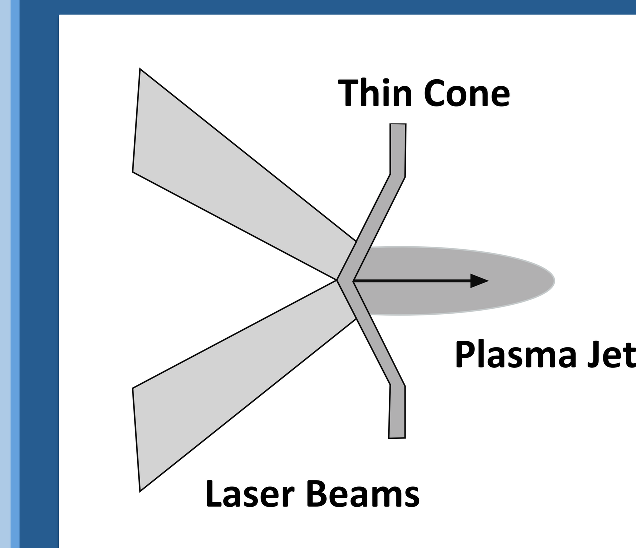


The 3-MK and 2-MK hotspots would be separate on the star's surface.



The 3-MK and 2-MK hotspots would be associated with each other on the star's surface.

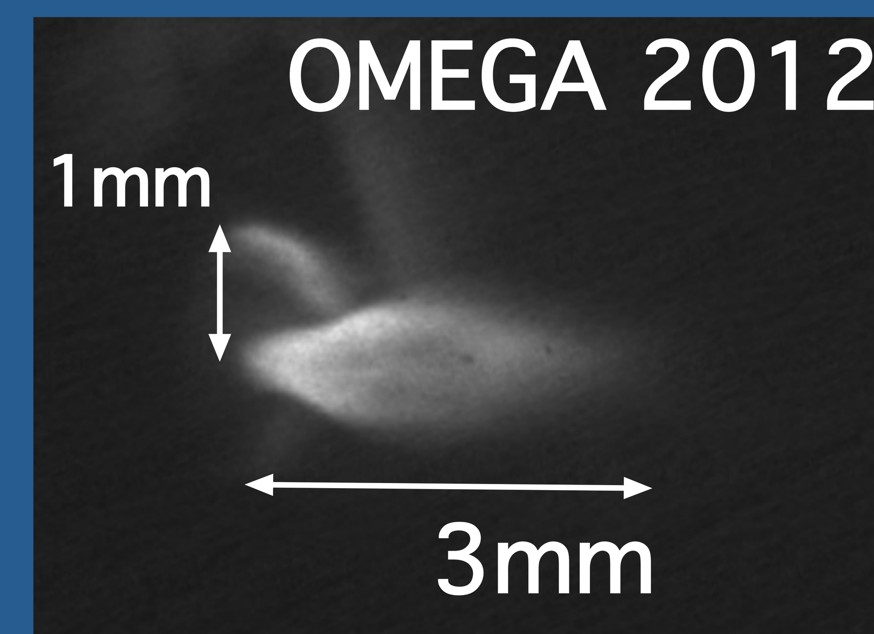
Prior experience generating collimated plasma jets on the OMEGA laser



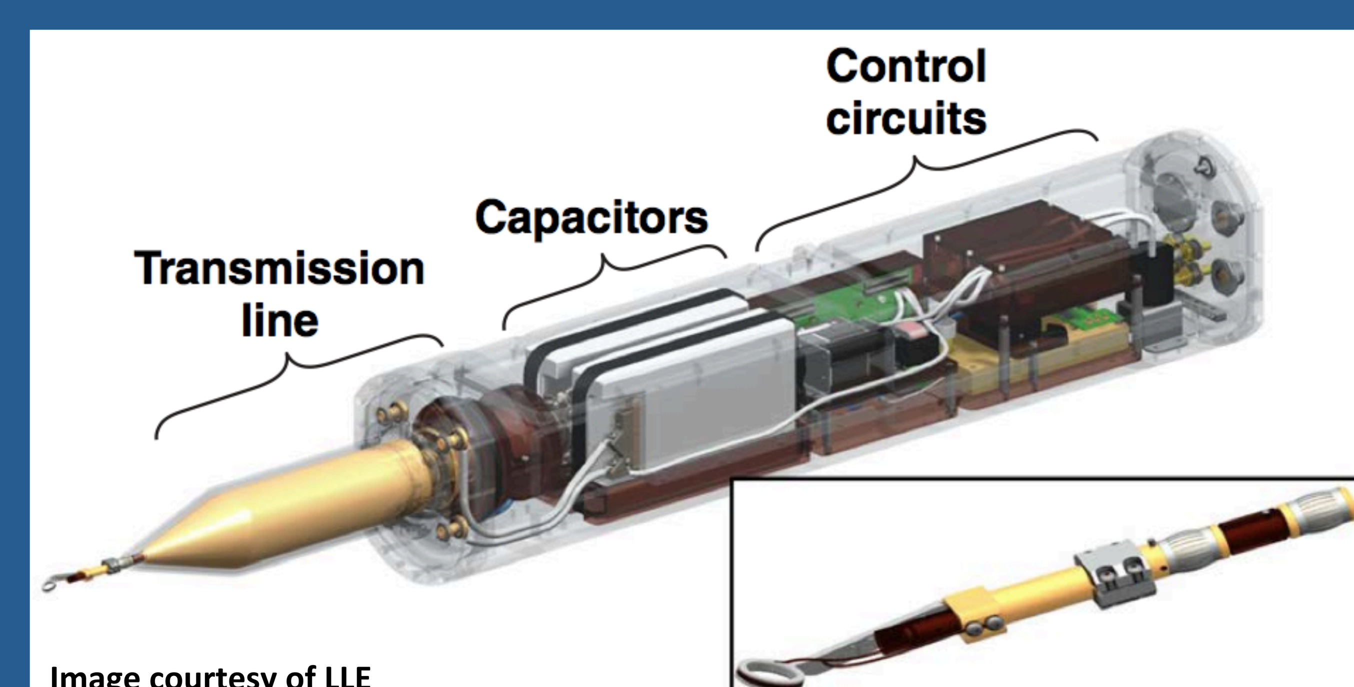
Laser beams rear irradiate a thin conical piece of acrylic, driving a shock through the acrylic. When the shock reaches the far side of the thin acrylic wall, it launches a rarefaction in the direction of the laser beams that collimates along the axis of the cone.

The Center for Laser Experimental Astrophysics Research (CLEAR, UM) has experience creating collimated plasma jets on the OMEGA Laser (LLE).

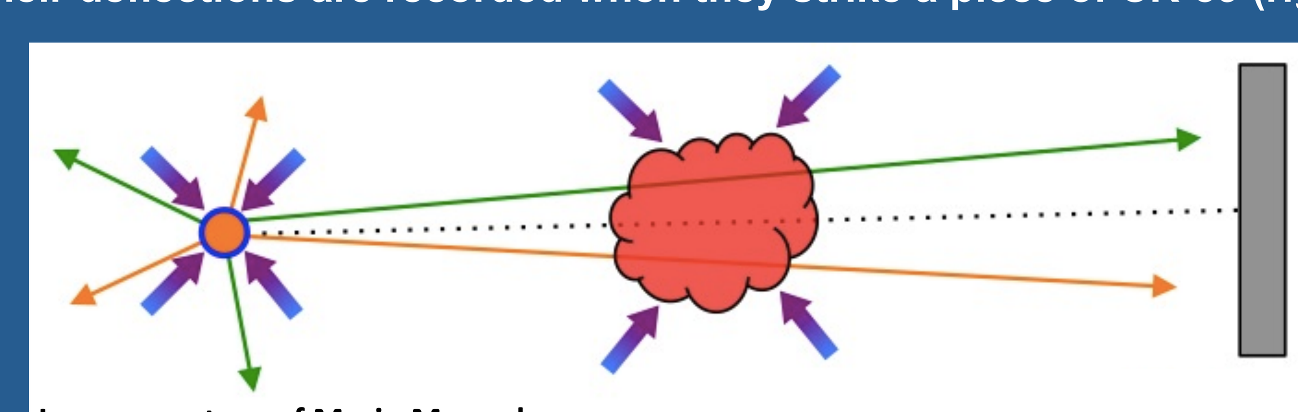
At right, a self-emission image from a 2012 experiment taken 20 ns after the laser pulse.



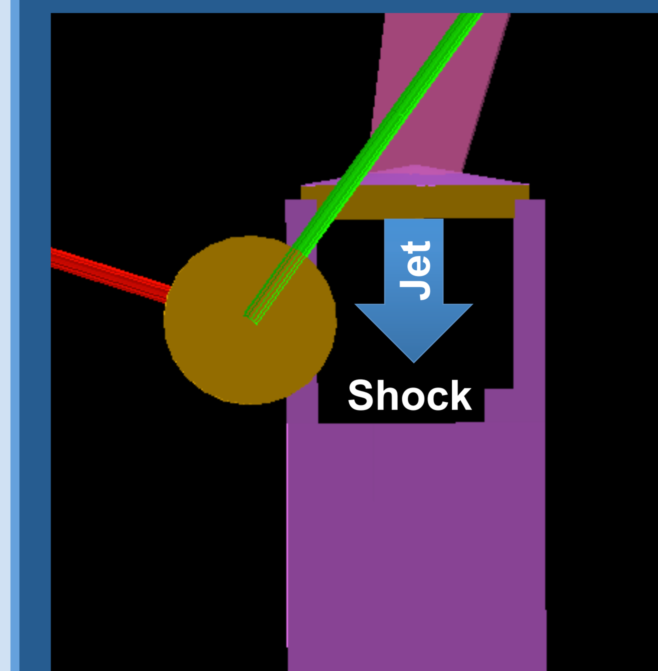
Generating and imaging magnetic fields on the OMEGA laser



Magnetic fields are generated with LLE-designed MIFEDS (Magneto-Inertial Fusion Electrical Discharge System) devices (above) and diagnosed by proton radiography (below). A laser-driven implosion generates protons (left), they are deflected by magnetic fields (center) and their deflections are recorded when they strike a piece of CR-39 (right).



Our May 2015 shot day experiment was designed to allow simultaneous proton radiography and visible light imaging.

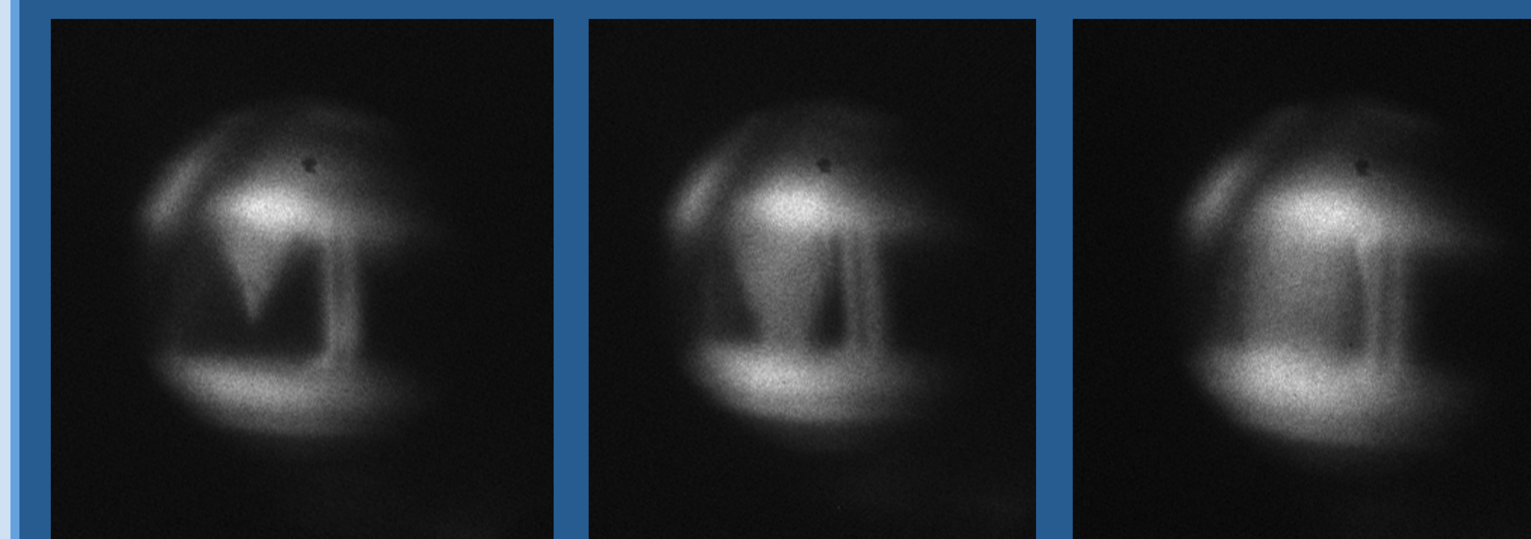


A single OMEGA beam (pink) strikes the cone-shaped top of the target. This launches a plasma jet off the opposite side of the target, which travels down (in the view) to hit the block below.

The proton backlighter is attached to the red stalk and the gold disc is a shield to protect the optics from the light burst of the backlighter.

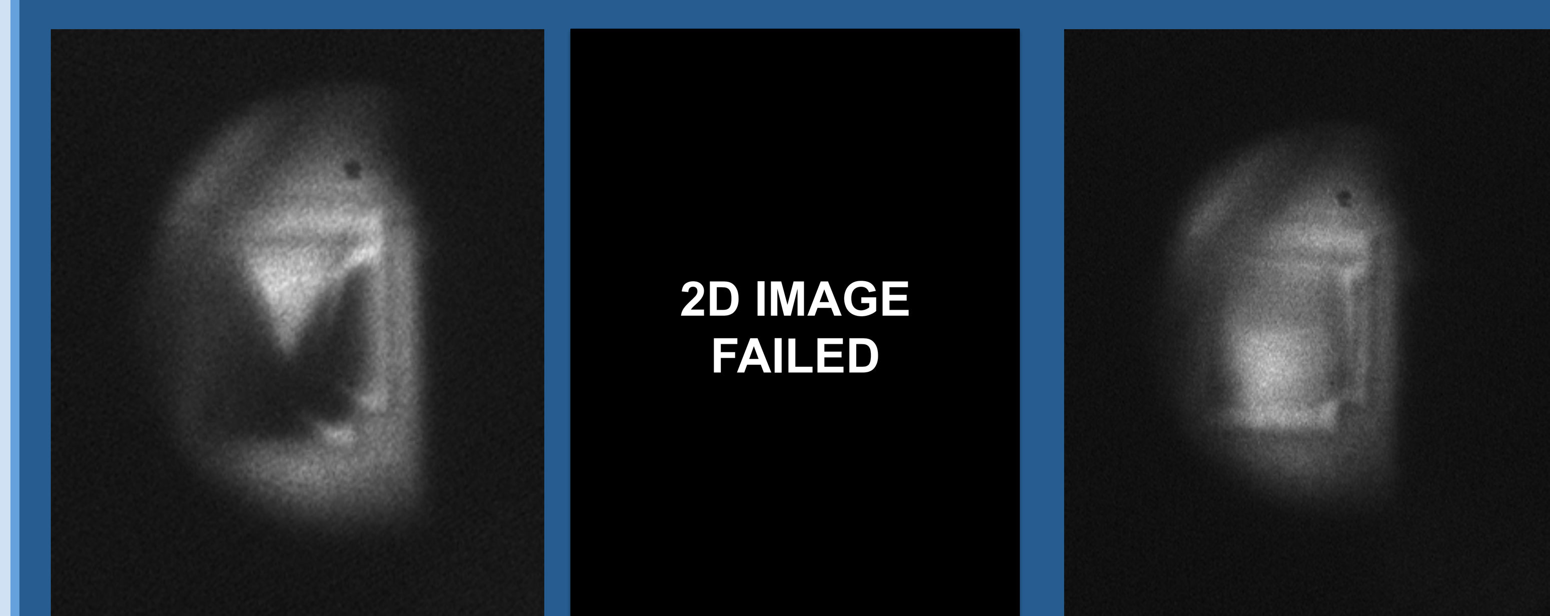
The magnetic field generator is not shown in this view.

7 T magnetic field, 450 J incident laser energy



Shot 77256, 23 ns | Shot 77258, 43 ns | Shot 77259, 63 ns

No magnetic field, 450 J incident laser energy



Shot 77260, 23 ns | Shot 77261, 43 ns | Shot 77260, 63 ns

Funding Statement

This work is funded by the NNSA-DS and SC-OFES Joint Program in High-Energy-Density Laboratory Plasmas, grant number DE-NA0001840, and by the National Laser User Facility Program, grant number DE-NA0000850.