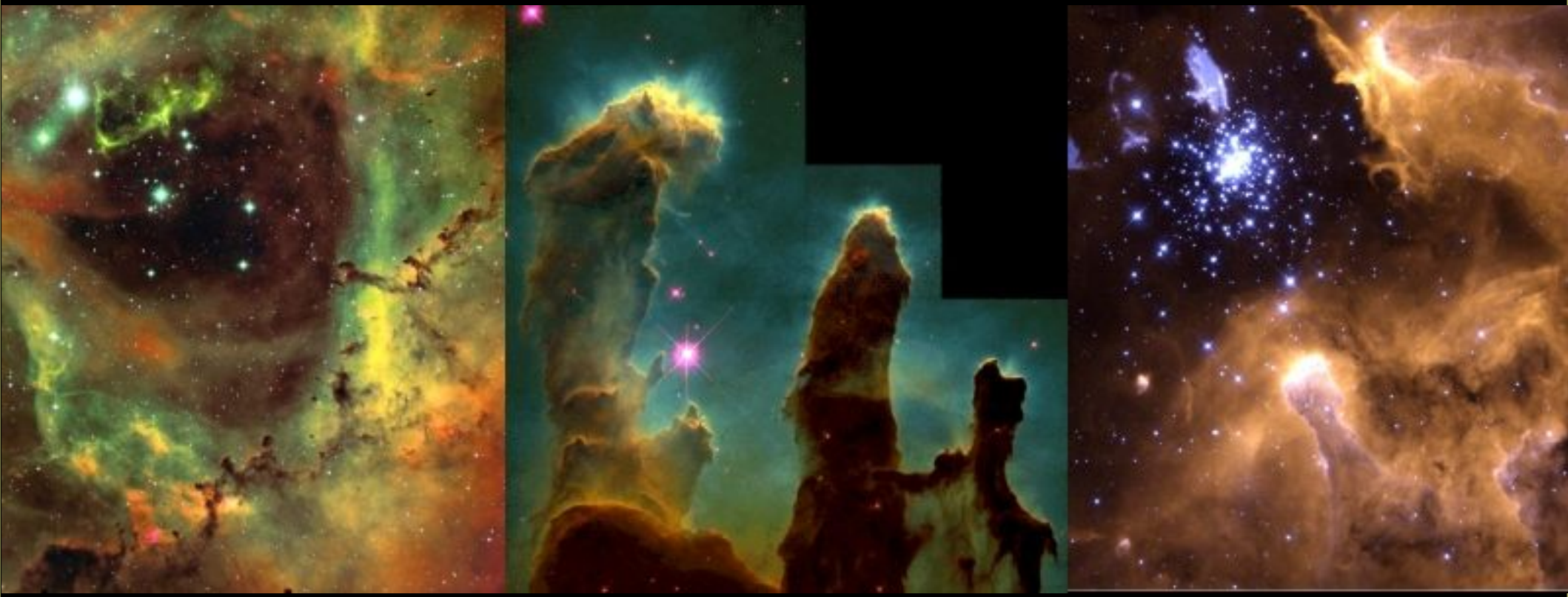
Pillars of Heaven



Marc Pound

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Presentation to NRC Plasma Science Committee

April 13, 2007

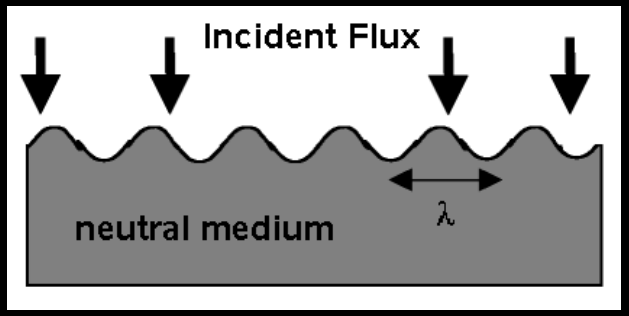
How do pillars form?

Photoionization
Ablation
Photodissociation

- Pillars (elephant trunks) common
- Formation mechanism unclear
  - Instabilities at cloud interface?
  - Pre-existing dense cores?

Observations of morphology alone cannot distinguish between models.

Formation Mechanism Examples

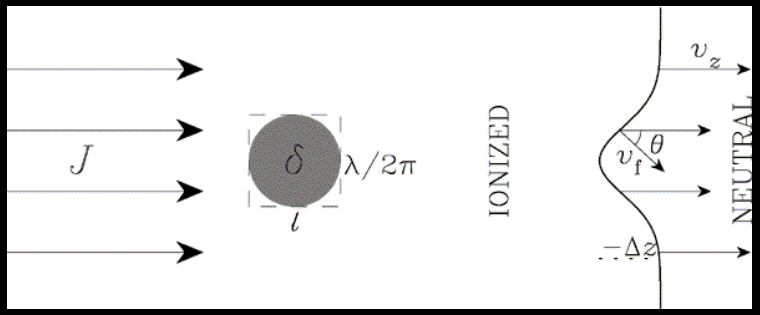


Ablative Rayleigh-Taylor instability

e.g., Spitzer (1954); Frieman (1954); Pound (1998); Kane et al. (2001), Mizuta et al (2005, 2006)

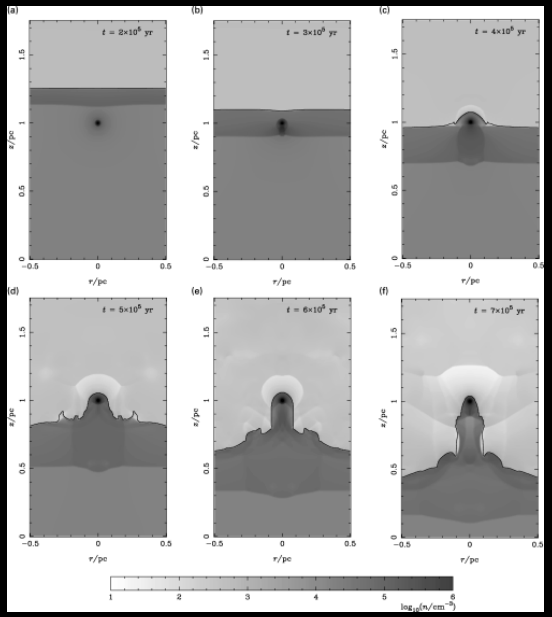
see also Tilted Radiation instability

Ryutov et al. (2003)



Shadowing Instability

e.g., Williams (1999)



Dense core/Cometary globule

e.g., Reipurth (1983); Bertoldi & McKee (1990); Lefloch & Lazareff (1994); Williams et al (2001)

In most of these scenarios, the formation timescale for L ~ 0.5 pc is a few X 10^5 yr

How we attacked the problem

(1) Obtained radioastronomical observations of pillars

(2) Got funding from NASA Astrophysics Theory Program

(3) Develop 2D hydro code that includes all relevant physics (energy deposition by UV photons, H recombination, radiative molecular cooling, magnetostatic pressure)

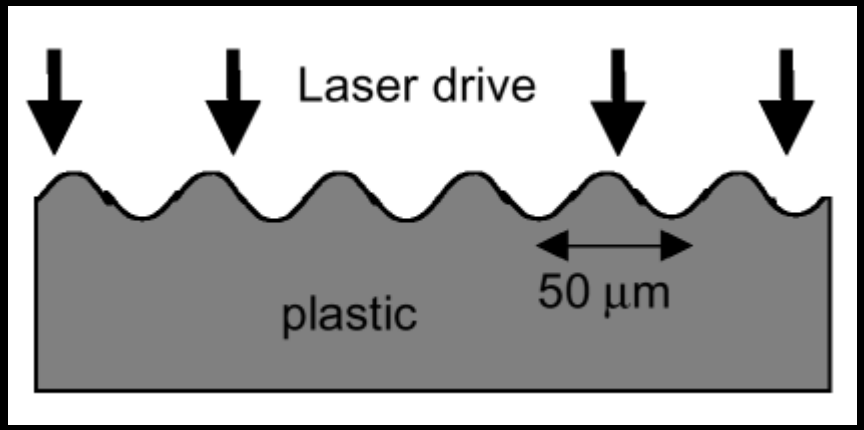
(4) Use observations to constrain geometry, initial and final conditions (temperature, pressure, density, turbulence, velocities, timescales, size scales)

(5) Create synthetic observations from models

(6) Compare to true observations, isolate best cases

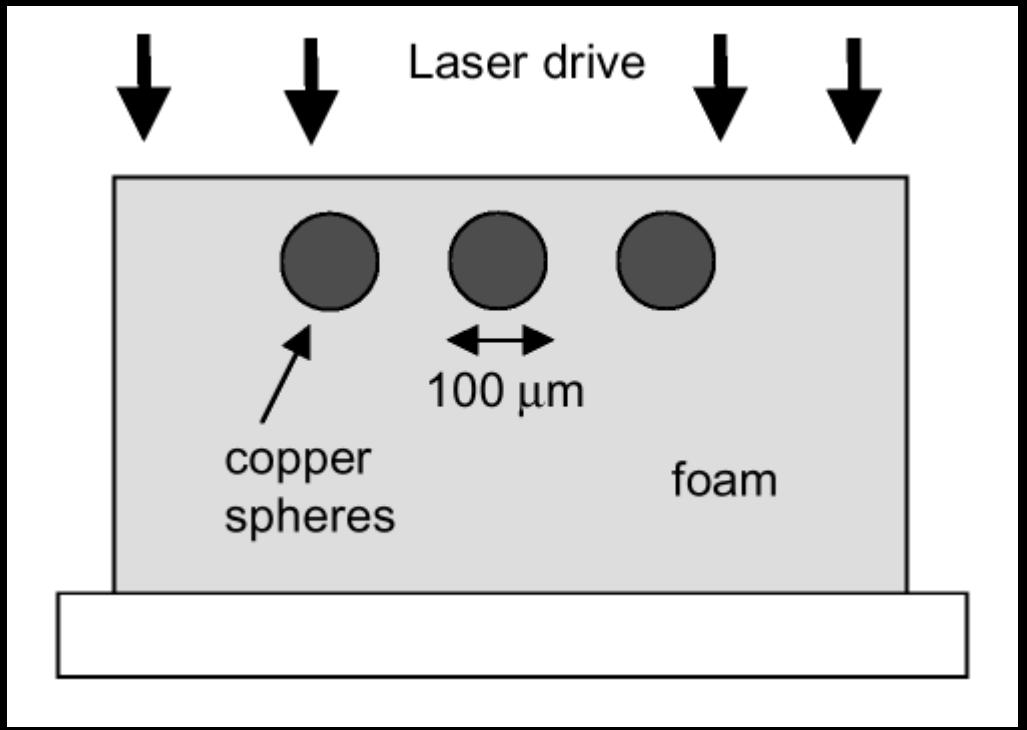
(7) Validate the code using scaled laser experiments of the best cases

Possible Scaled Laser Experiments



Ablative Rayleigh-Taylor Experiment

Embedded Dense Cores Experiment



These are simple examples. Need to take into account radiation direction, multiple modes, possibly even magnetic field.

HEDP – An Astronomer's POV

Biennial HEDLA conferences extremely successful

- More & more “pure astronomers” attend each year, including high-profile astronomers like Hester, Wheeler (AAS president), Bally.
- Excellent opportunity for cross-fertilization.
- Better likelihood of work being published in astronomy rather than physics journals – thereby raising profile.

HEDP – An Astronomer's POV

There still is some mystery (to me at least) surrounding how laser experiments get funded and who is eligible to apply.

- Limited funding opportunities for HED astrophysics:
  - LLNL collaborators can't take NSF funds, which makes it tough to write a winning proposal.
  - In 2001 when we began this work, NASA ATP was the only viable option. (3 years/$370K and that did *not* include laser experiments.)
  - NLUF can only cover small fraction of PI salary.

Certainly if more concrete, well-advertised opportunities existed, more astronomers would apply.

Nov 2006: met with M. Salamon (NASA), C. Keane (DOE), J. Dehmer (NSF) and others to clarify and broaden funding opportunities.