Laboratory simulations of solar prominences

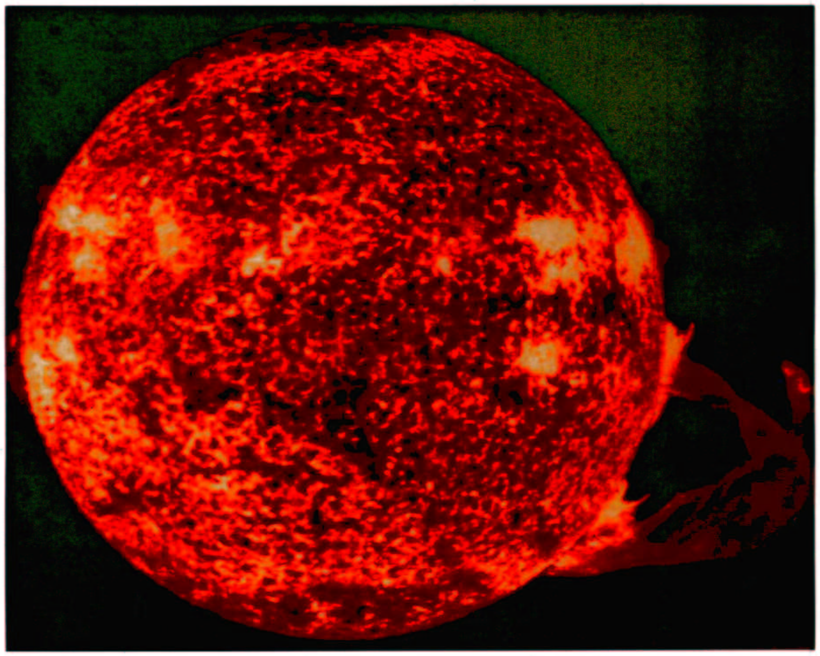
Freddy Hansen

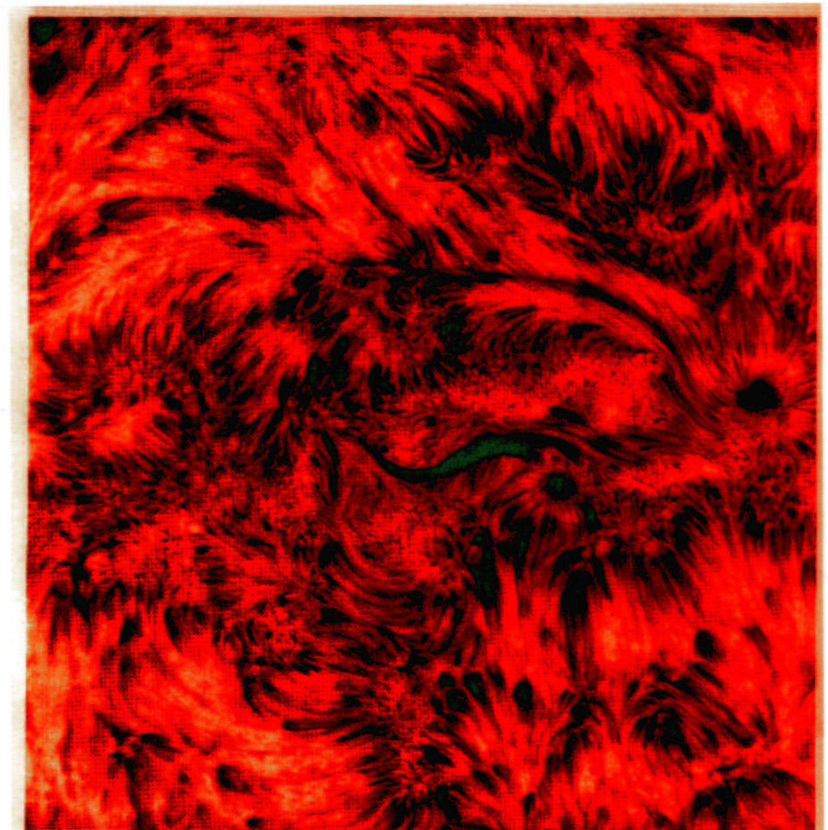
Thesis advisor: Paul Bellan

Outline

- Introduction
- Strapping fields
- Interaction between two prominences
- Summary

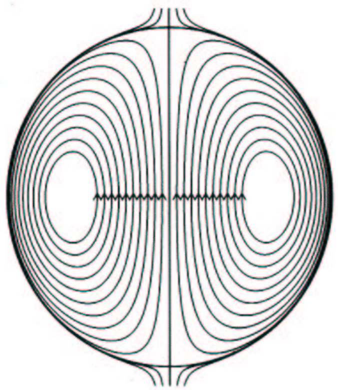
Solar prominence





Advantages of having a prominence-like plasma conveniently located in a laboratory:

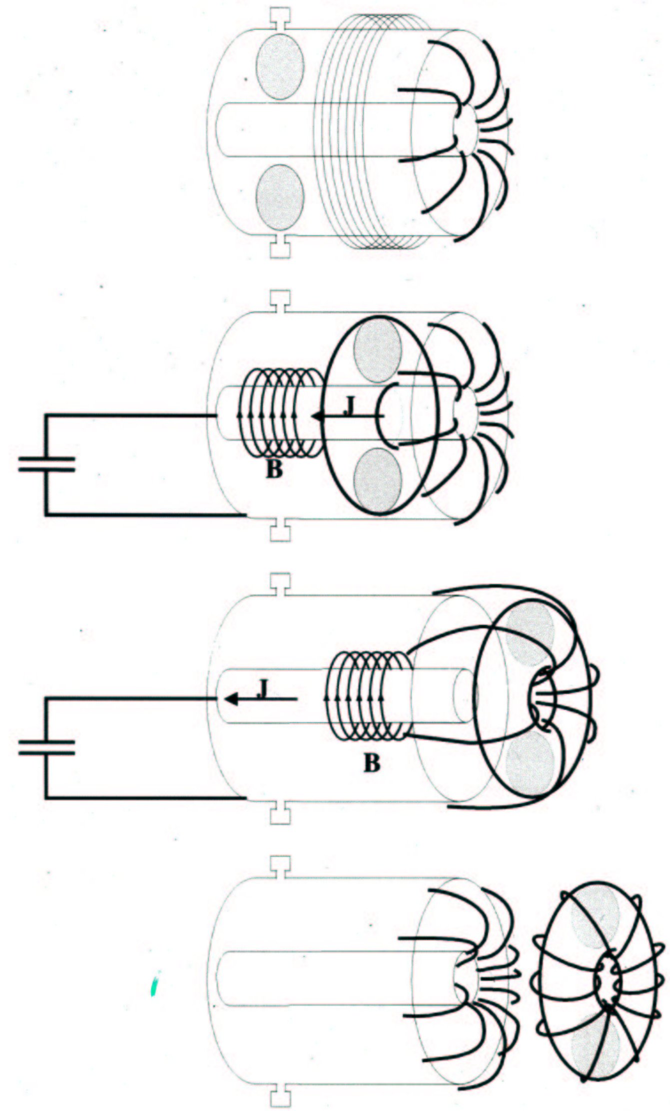
- Observations of the prominence from a vantage point of choice.
- Stereographic observation to better discern the three-dimensional shape of the prominence.
- In situ measurements of physical properties such as magnetic fields, electric potentials, densities and temperatures.
- Control of parameters that govern the creation and evolution of the prominence.

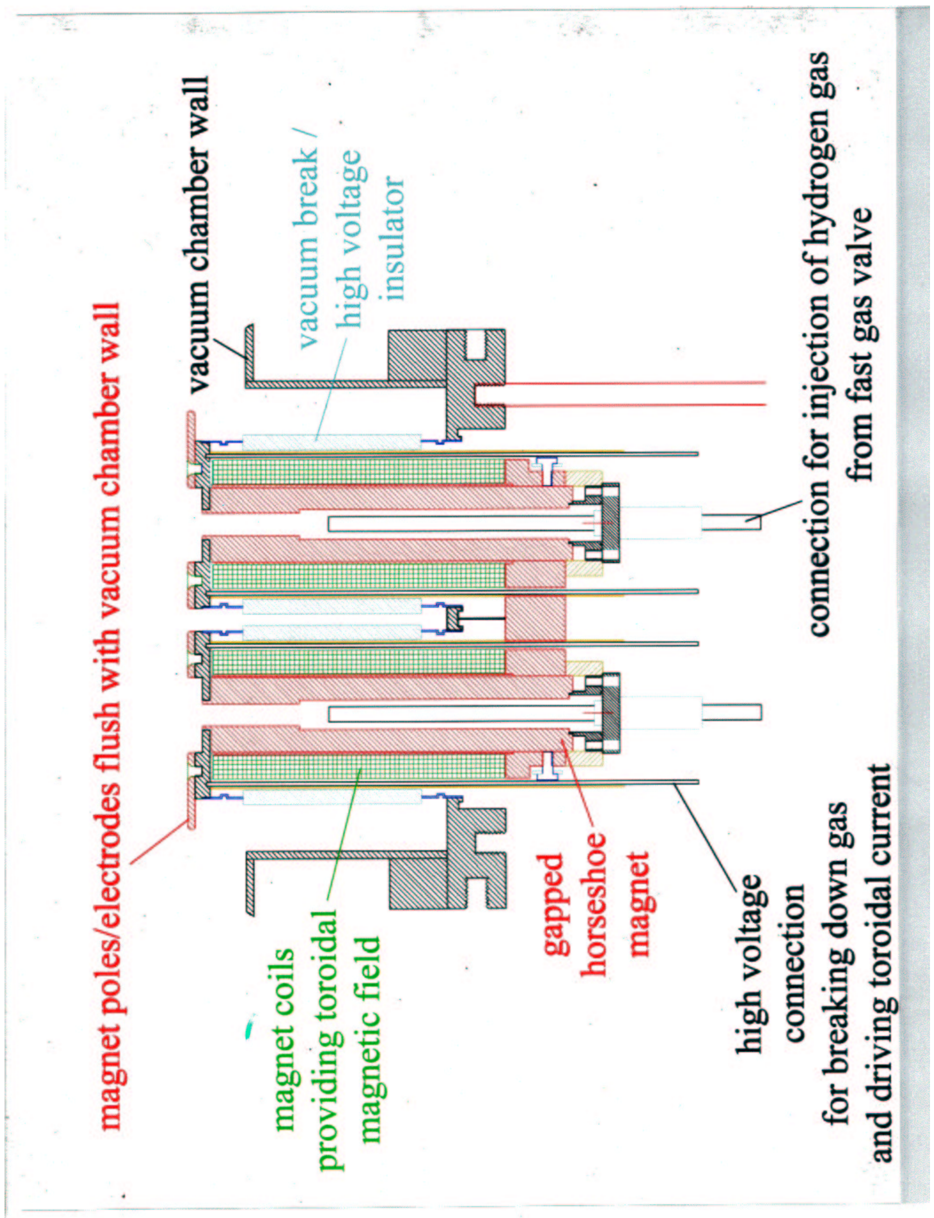


Motivation

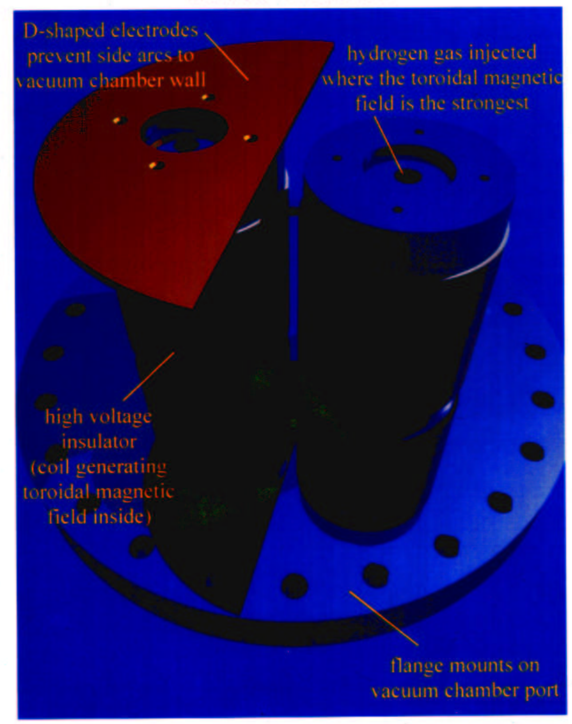
- Both solar prominences and spheromaks are characterized by force-free states in which currents and magnetic fields are parallel, or $J = \alpha'(r)B$.
- Magnetic helicity plays an important role in the evolution of both prominences and spheromaks: both will, by Taylor's theory, find minimum energy states given their helicity.
- Some conjecture that solar prominences spawn spheromak-like (simply connected in Woltjer-Taylor states) magnetic clouds.

Given these similarities, it is reasonable to ask if one can recreate a solar prominence in the laboratory, using technology similar to that utilized for spheromak experiments, but with modified boundary conditions appropriate to prominences.

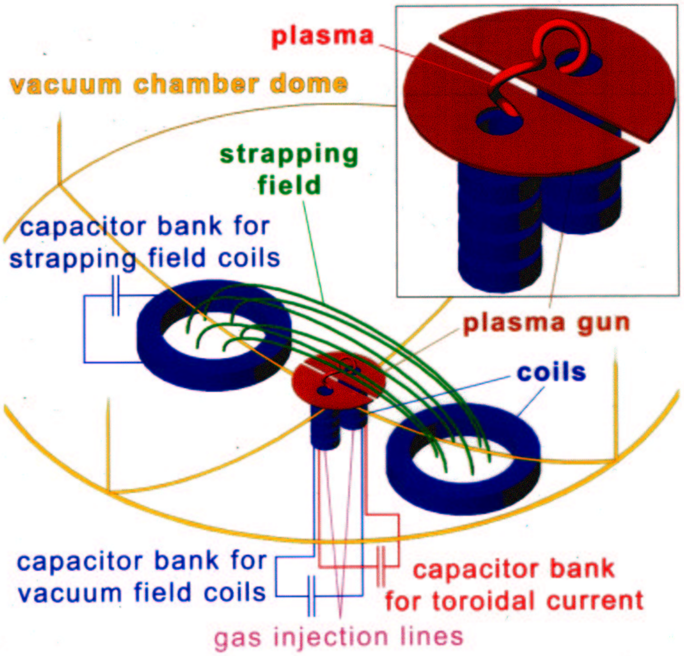




Solar device

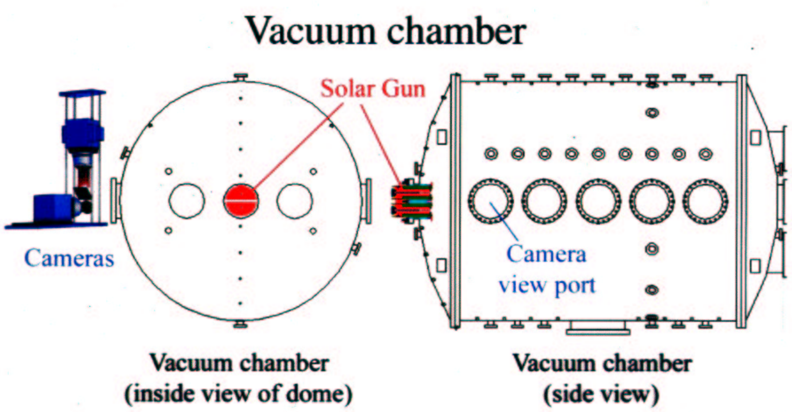


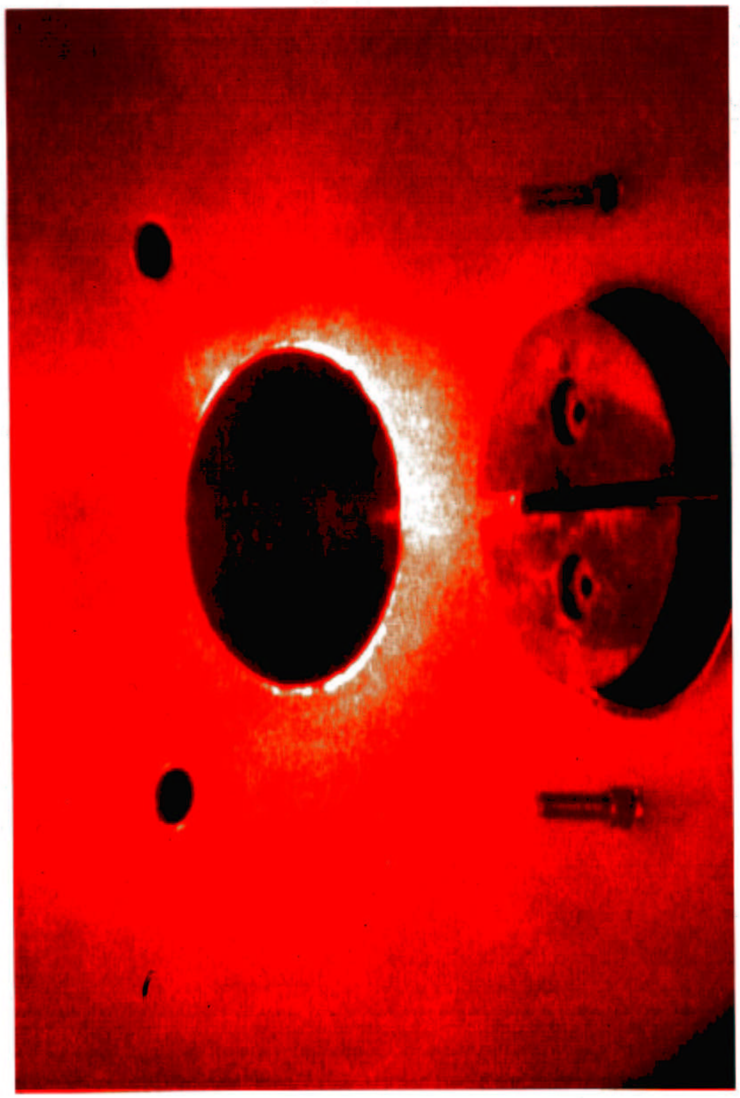
Experimental set-up



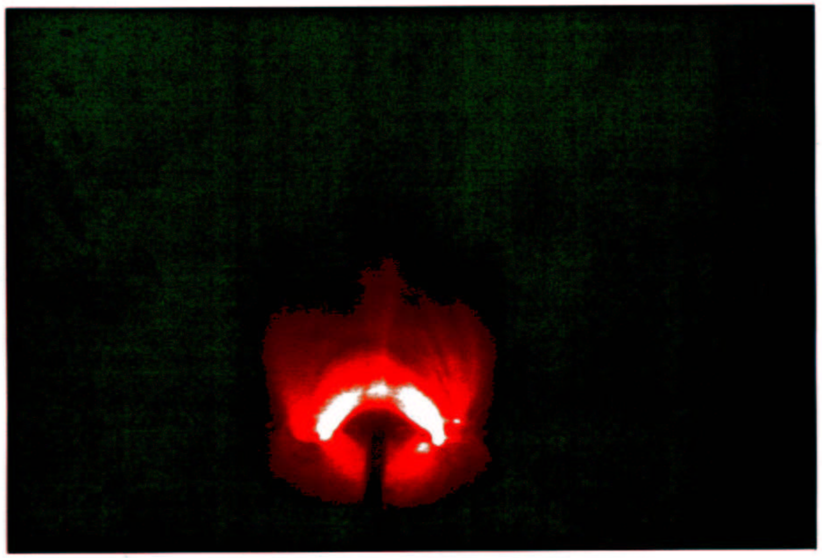
Diagnostics

- High voltage probes
- Rogowski coils
- Magnetic pick-up coils
- Hall probes
- Fast ion gauge
- Capacitance manometer
- Triple Langmuir probe
- Photodiodes, including x-ray bolometer diode
- Gated, intensified CCD cameras
- Ultraviolet/x-ray camera
- Energetic ions detector
- Laser interferometer
- Laser induced fluorescence


Vacuum chamber
Solar Gun
Cameras
Camera
view port
Vacuum chamber
(inside view of dome)
Vacuum chamber
(side view)

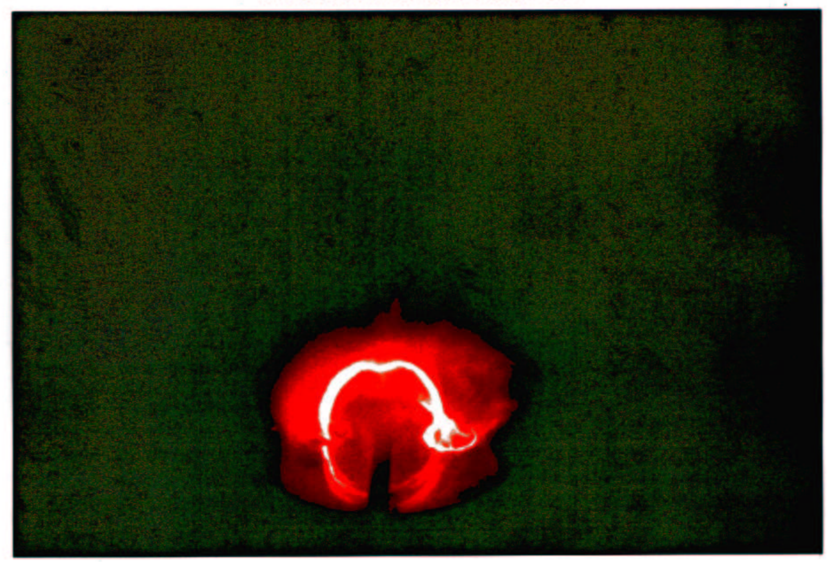


Plasma evolution 1



- A smooth, arced current channel forms upon initial breakdown.
- Brighter and darker strands twist around each other.

Plasma evolution 2



- A small kink develops.