Simulation of stereoscopic EUVI image pairs

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The Goal

- Create a set of synthetic EUVI image pairs that can be used to test image reconstruction algorithms.
- Will make use of two techniques:
  - Aschwanden method: fit actual TRACE, EIT, and SXT images
  - Alexander method: start with a Sunspot model to define field lines

Aschwanden algorithm for Stereo Image Pair Creation

1. Select a structure-rich multi-wavelength image from TRACE, EIT, and/or Yohkoh database (with filament, flare, CME, fluxropes, etc.)

2. Trace linear features (loops, filaments, fluxropes) in 2D: $s(x,y)$

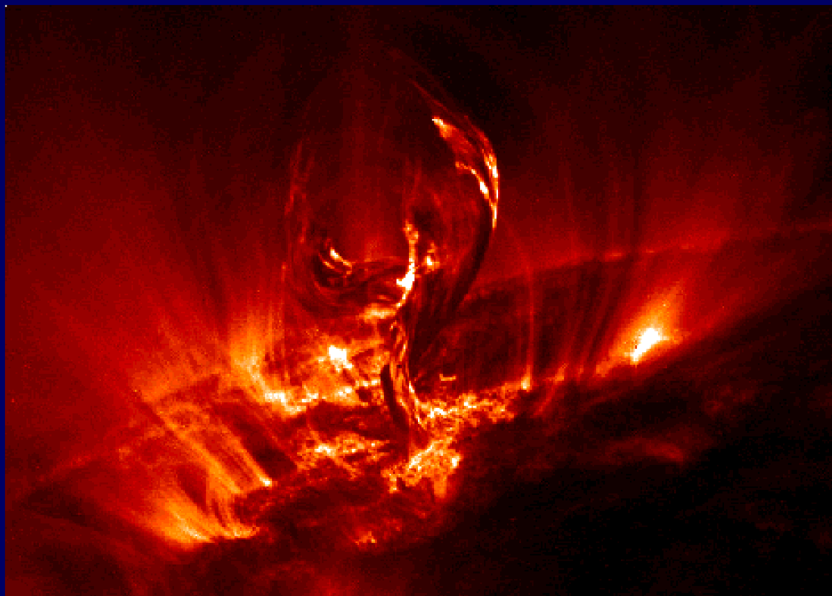
3. Inflate from 2D to 3D with prescription $z(x,y)$ $s(x,y) \rightarrow s(x,y,z)$

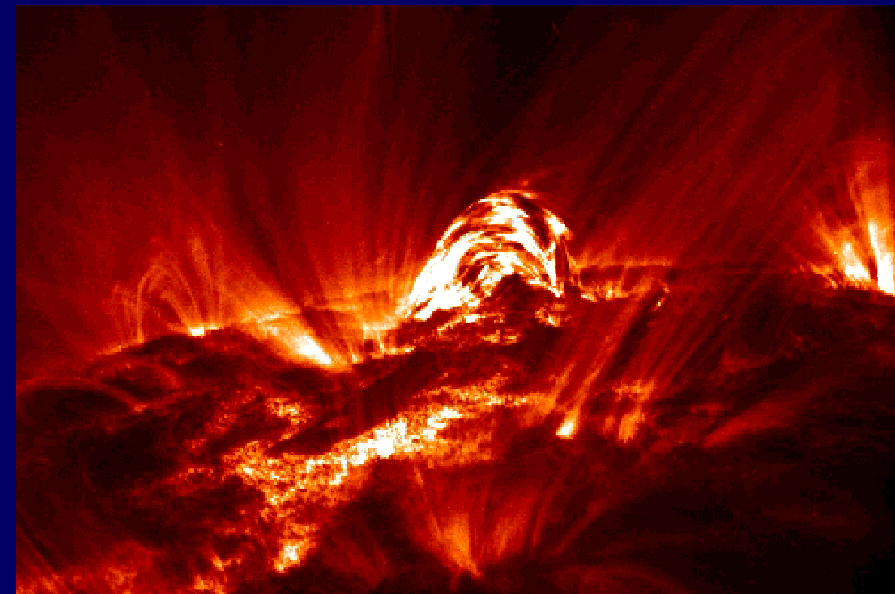
4. Physically model structures: $T(s)$, $n(s)$, $p(s)$, $EM(s)$

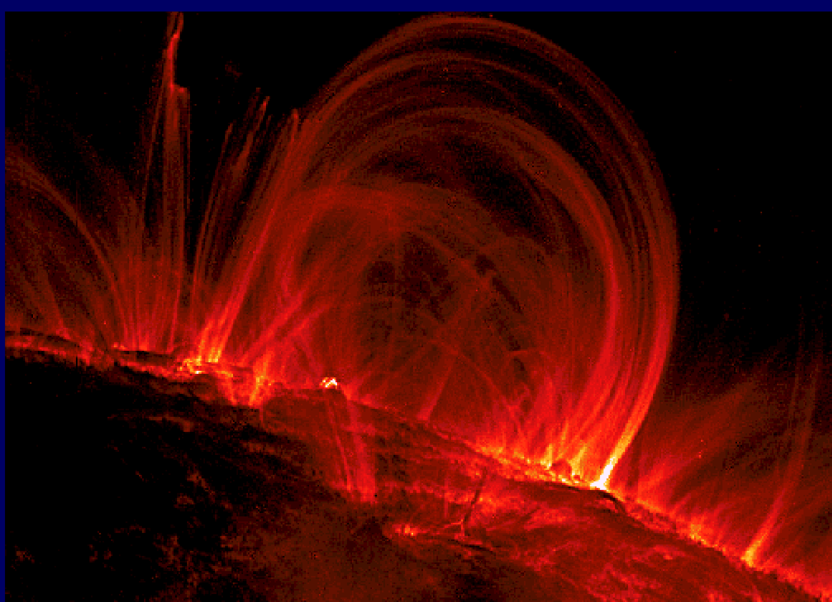
5. Geometrically rotate to different stereo angles $EM(x,y,z) \rightarrow EM(x',y',z')$

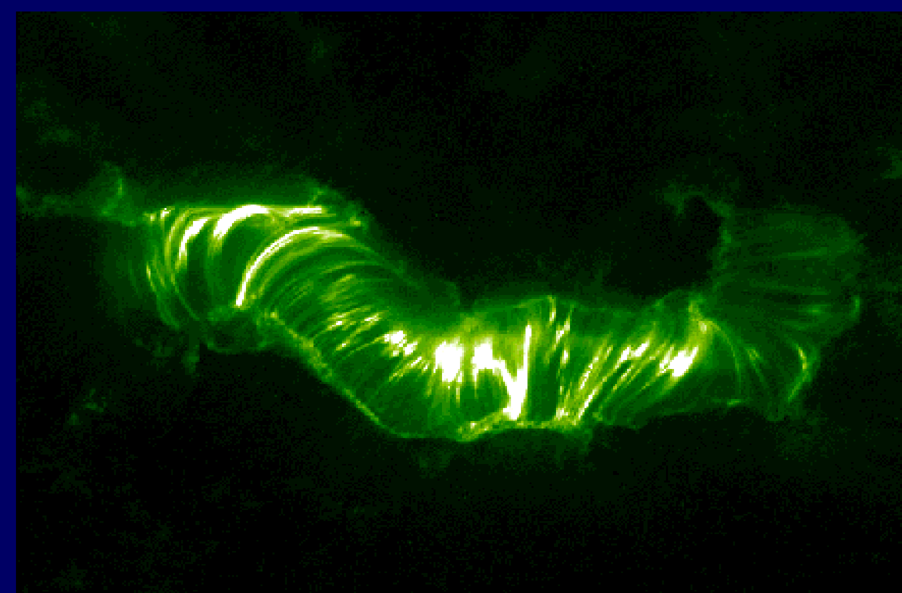
6. Line-of-sight integration $EM(x',y')=\int EM(x',y',z')dz'$ and convolve with instrumental response function

Step 1: Select structure-rich image

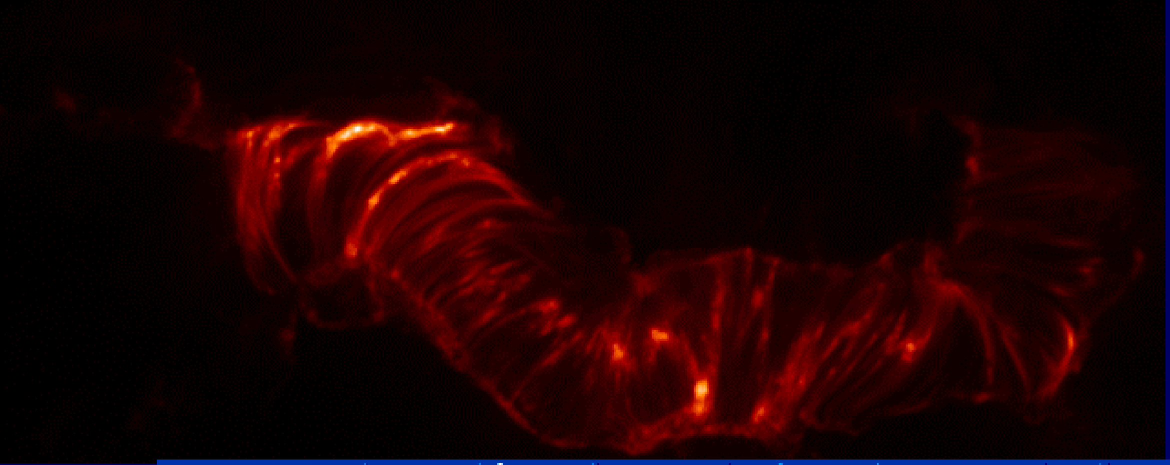


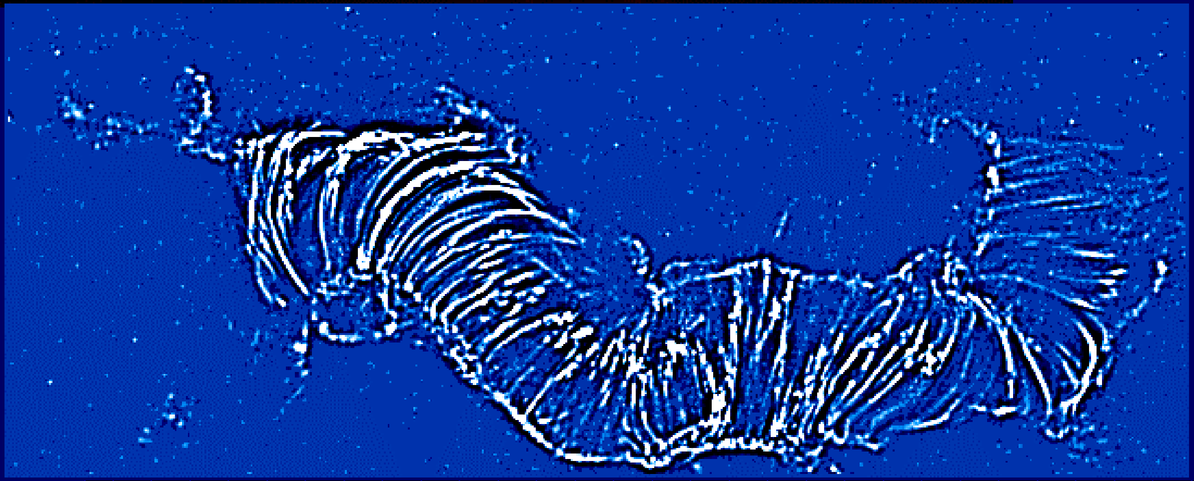




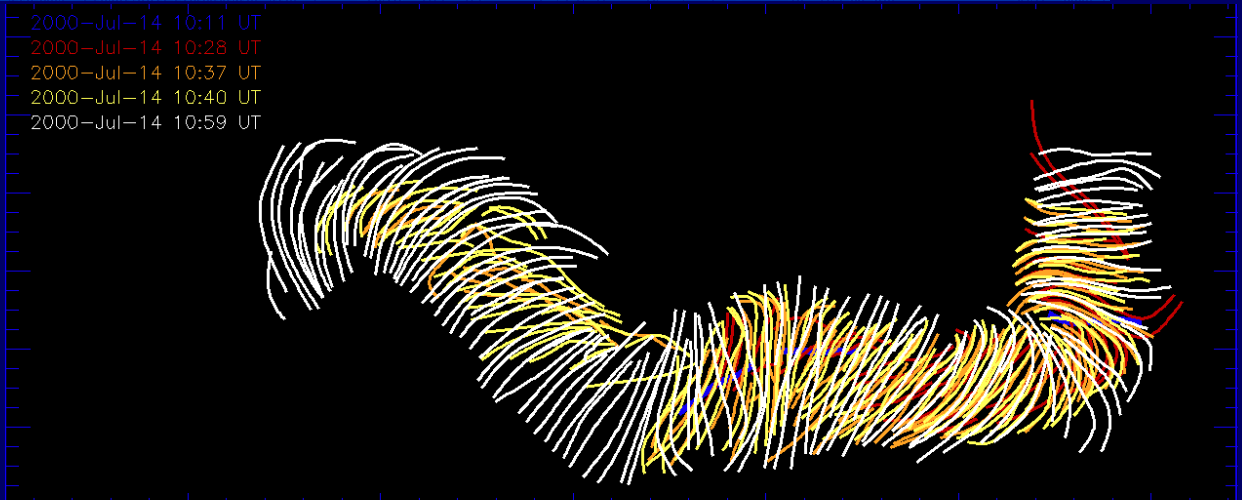


Step 2: Tracing linear features

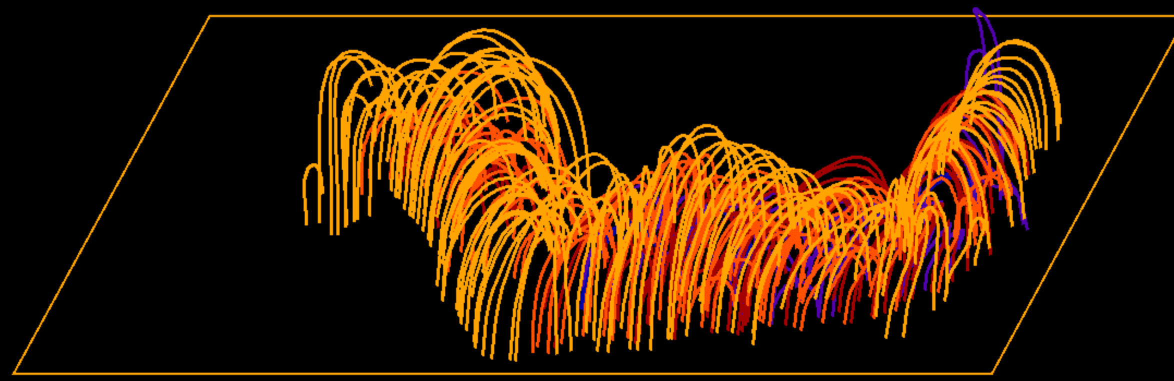




High-pass filtering



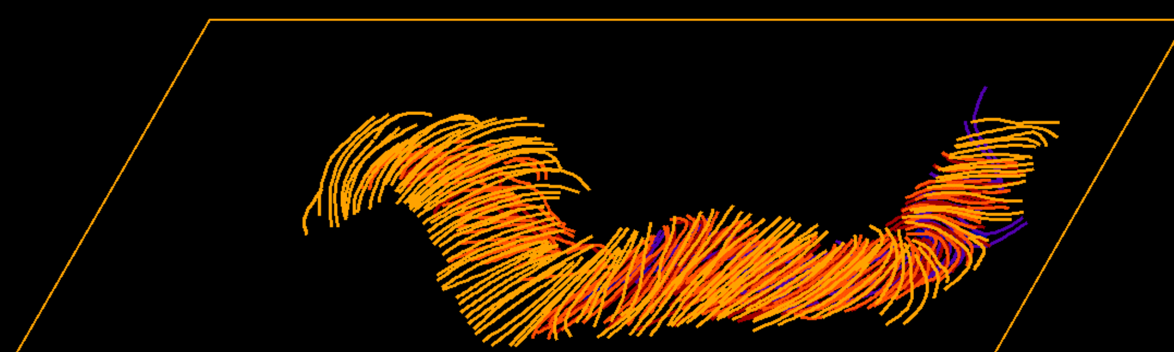
Feature tracing, reading coordinates, spline interpolation s(x,y,z)



Step 3:

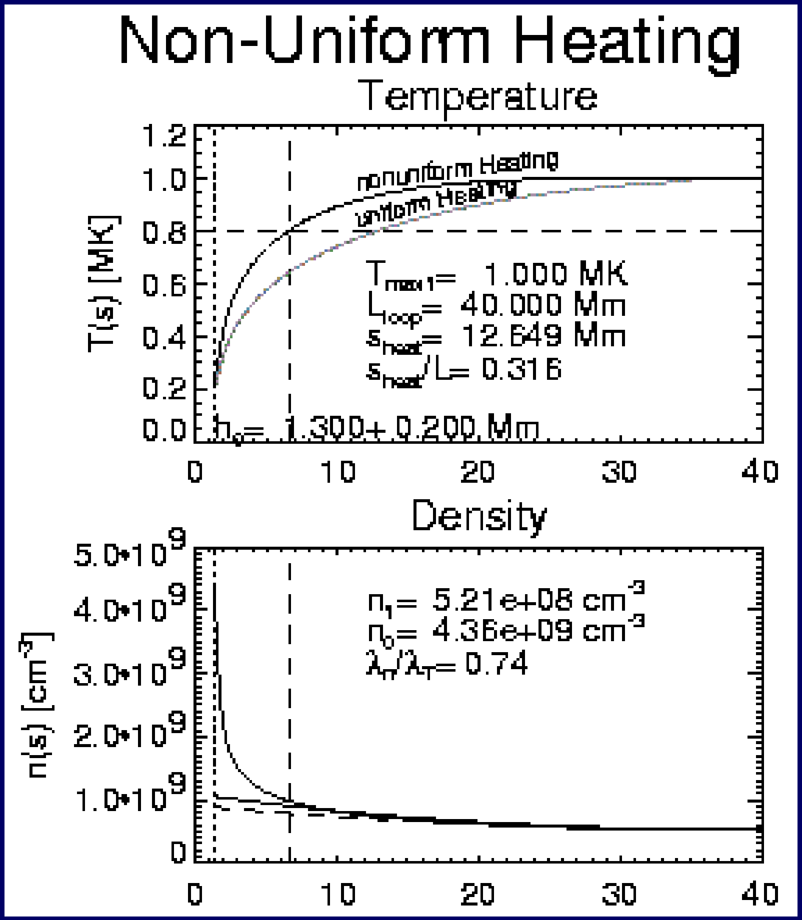
<u>3D Inflation:</u> z=0 -> z(x,y)

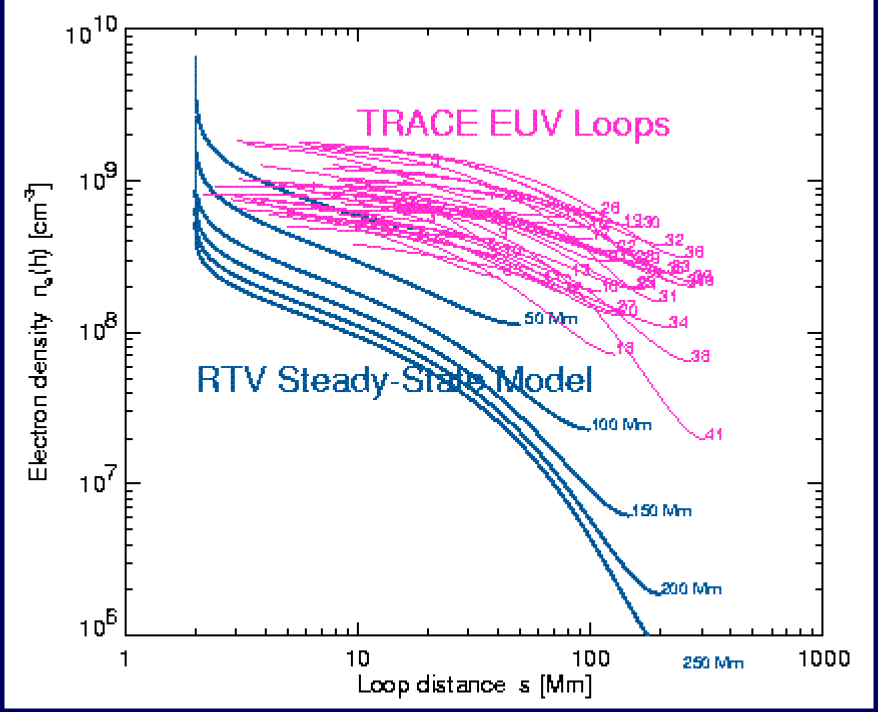
- model (e.g. semi-circular loops)
- magnetic field extrapolation
- curvature minimization in 3D



s(x,y)

Step 4: Use physical hydrostatic models of temperature T(s), density n(s), and pressure p(s), to fill geometric structures with plasma





HYDRODYNAMIC EQUATIONS

Mass Conservation,

$$\frac{dn}{dt} + \frac{1}{A}\frac{d}{ds}(nvA) = 0$$

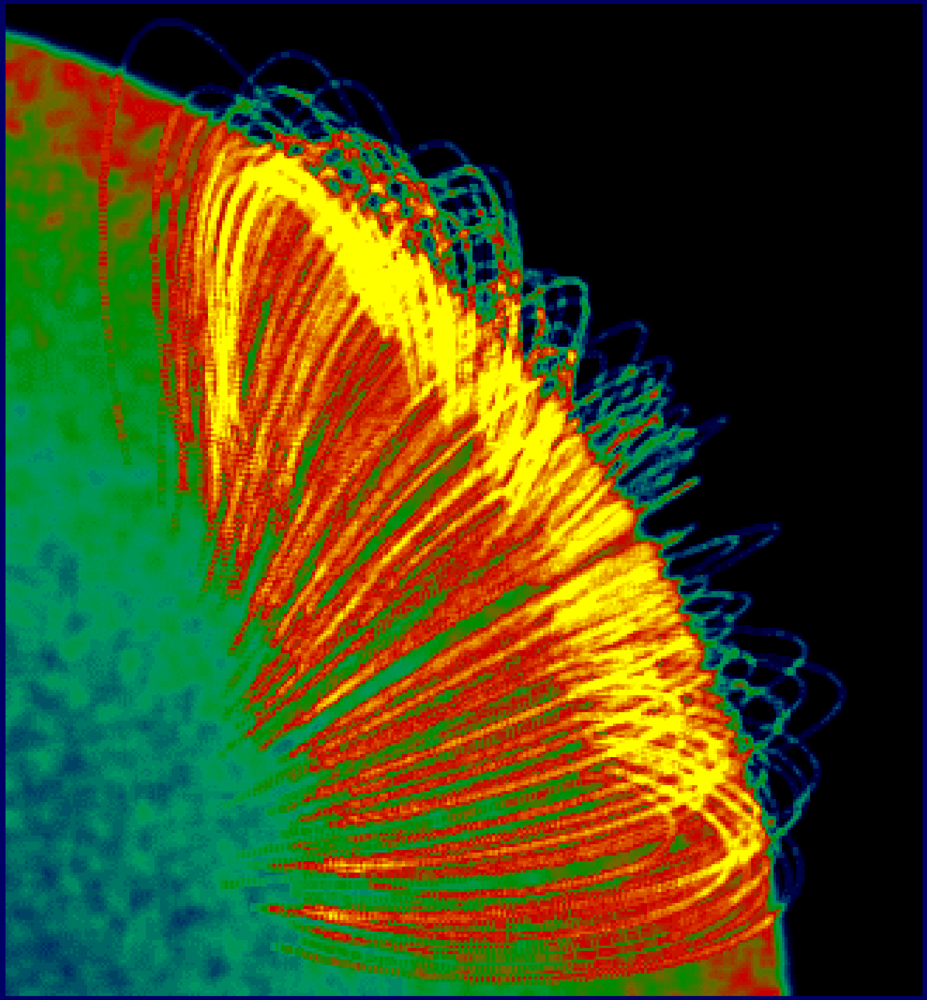
Momentum equation,

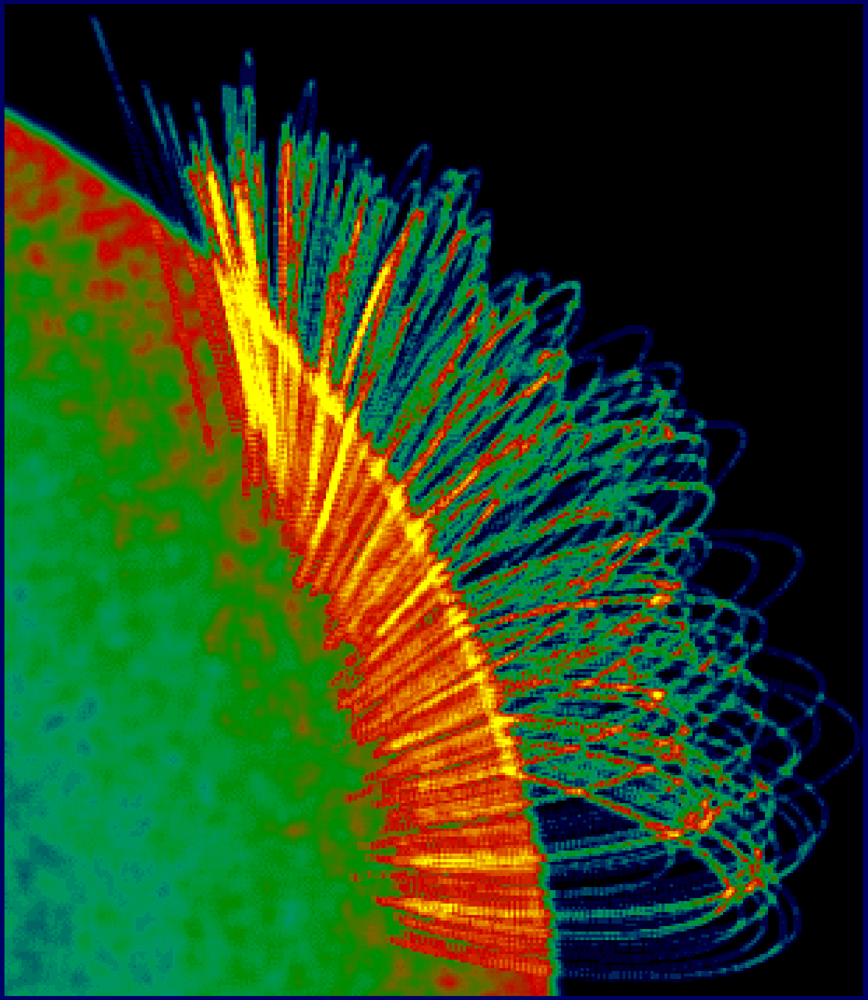
$$mn\frac{dv}{dt} + mnv\frac{dv}{ds} = -\frac{dp}{ds} + \frac{dp_{grav}}{dr}\left(\frac{dr}{ds}\right)$$

Energy equation (in conservative form),

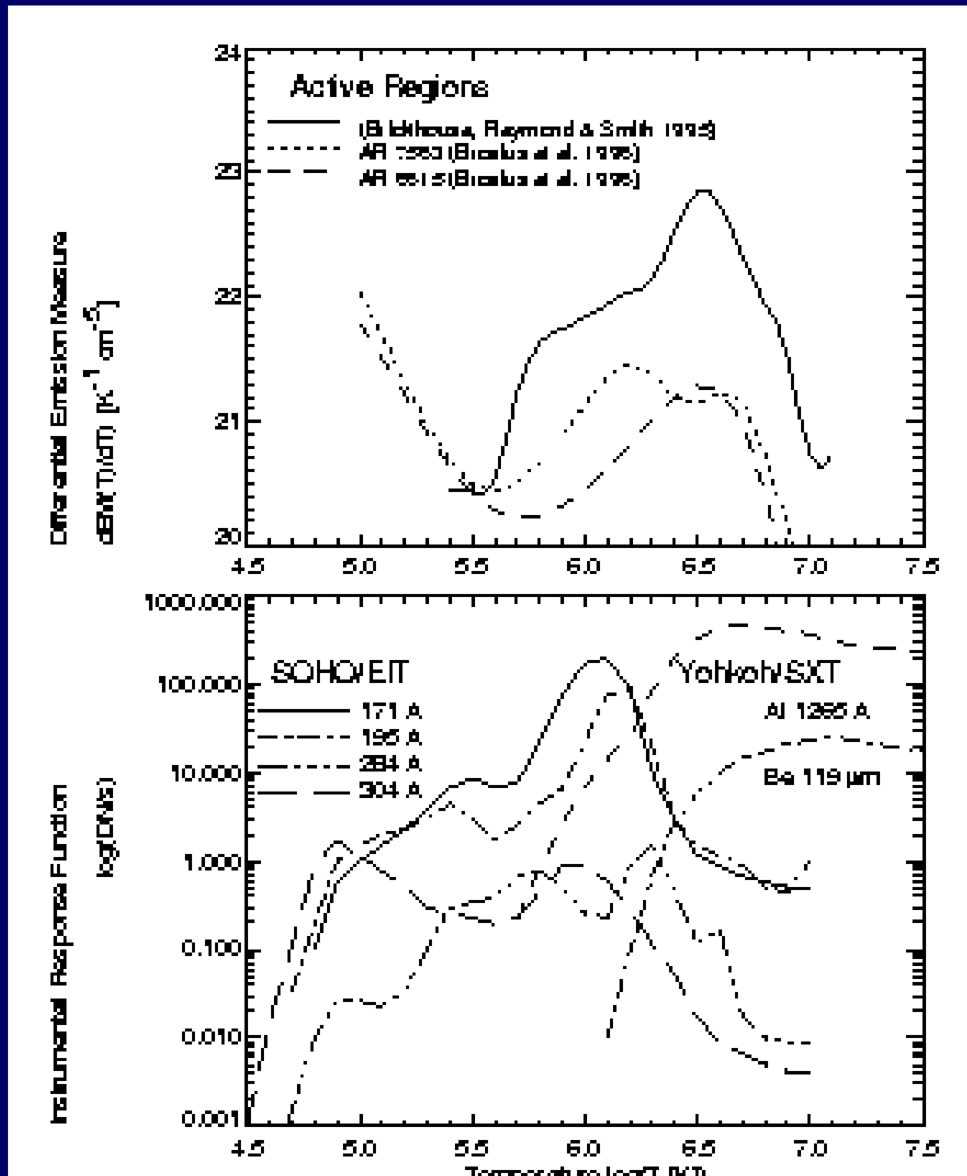
$$\frac{1}{A}\frac{d}{ds}(nvA[\epsilon_{enth} + \epsilon_{kin} + \epsilon_{grav}] + AF_{cond}) = E_{heat} + E_{rad}$$

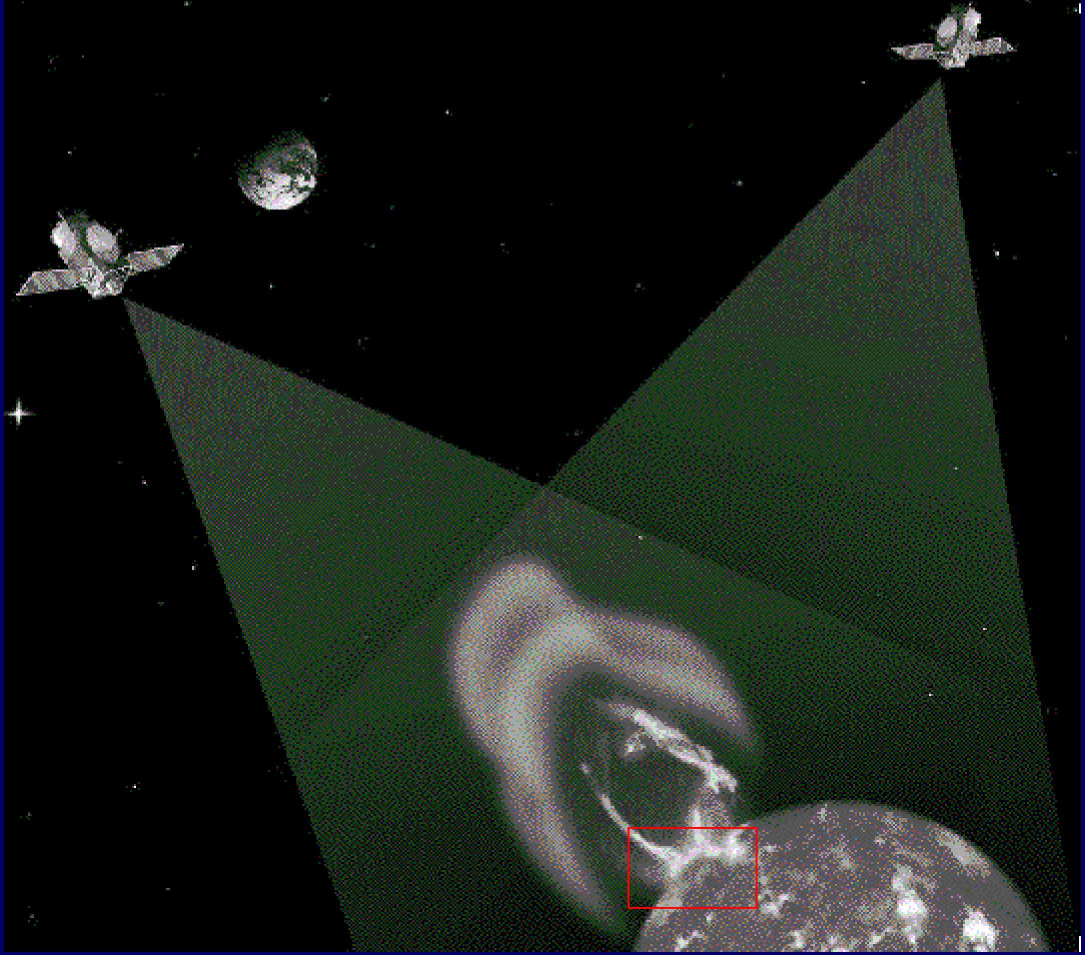
Step 5: Rotation to different stereo angles

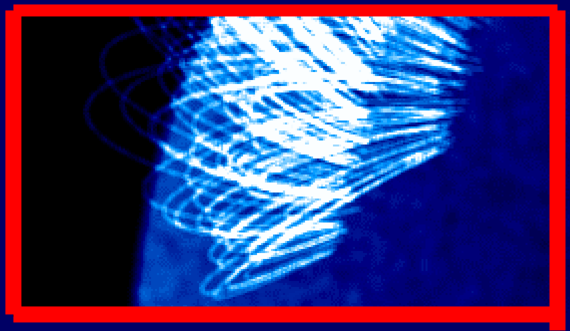




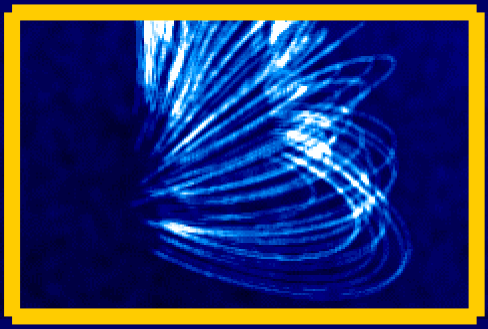
Step 6: Integrate along line-of-sight and convolve with instrumental response function







STEREO - A



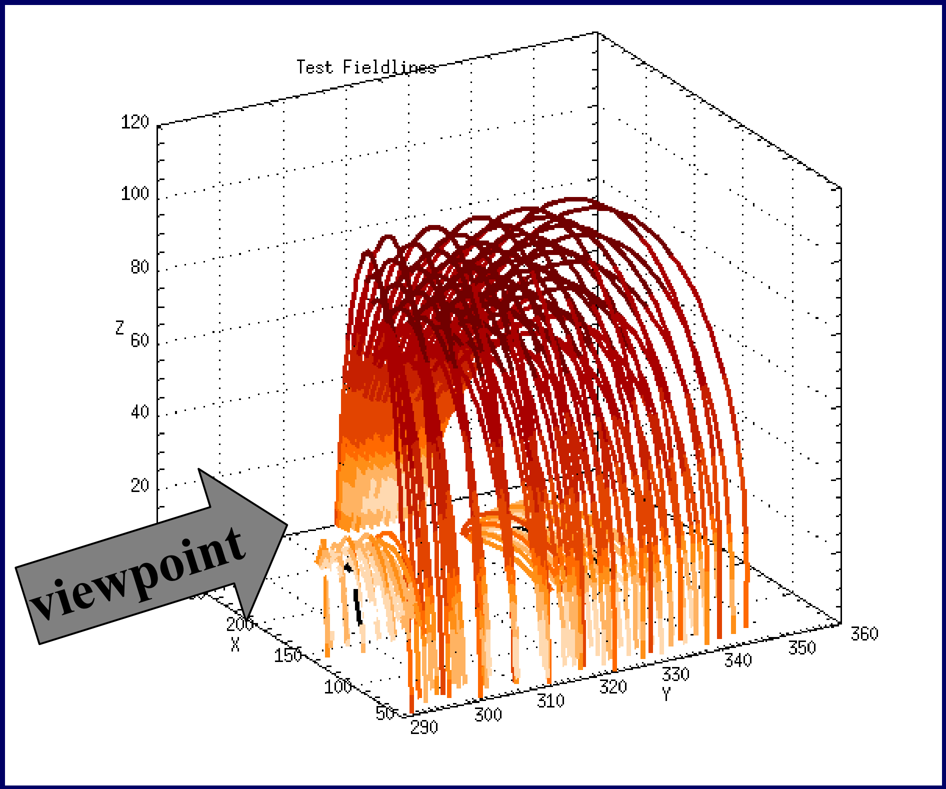
STEREO - B

Alexander algorithm for Stereo Image Pair Creation

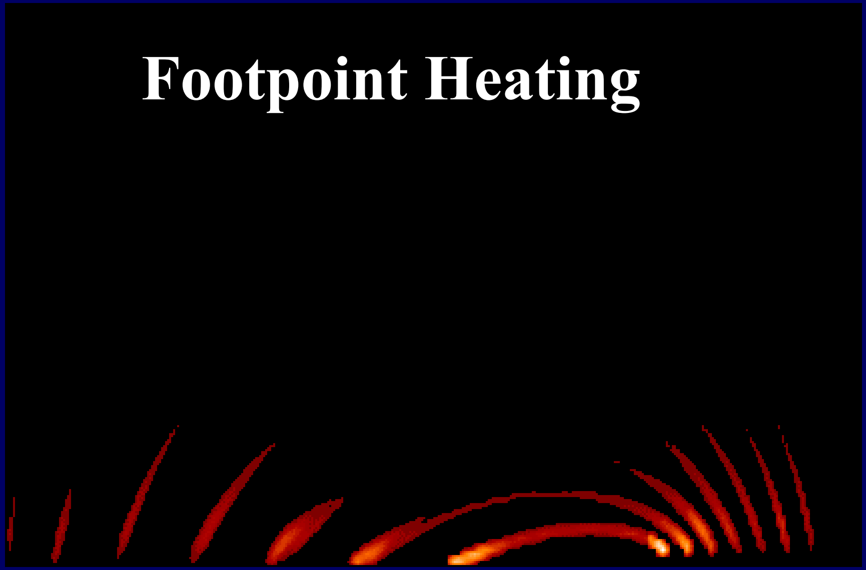
- Uses magnetoconvection sunspot model of Hurlburt to define boundary conditions for field and heating - fully 3D model calculated in wedge.
- Field extrapolation into corona assumes potential field at surface.
- Heating rate is determined from Poynting flux entering corona.
- Poynting flux is a result of interaction of surface flow dynamics with magnetic field: P=(vxB)xB.
- Uniform and footpoint heating s_h=10 Mm assumed in simulations.
- Fieldlines chosen reflect localized regions for which the Poynting flux is greater than 90% of maximum value: hence grouping into "fluxtubes".
- 3D volume created, therefore can simulate any viewing angle.

Neal Hurlburt’s Magnetoconvection model for Sunspot

Simulations of TRACE 171 emission



3D distribution of coronal field



- Base heating rate same 25x higher in footpoint heating case (not optimized)
- Projection yields “fluxtubes” from “field lines”
- Only highly energized loops included: no background structures

Plans for the Future :

- The LMSAL group is planning to produce a set of EUVI stereo pair images :
    - containing different phenomena (flare, CMEs, filaments)
    - in different wavelengths (171, 195, 284, 304 A)
    - from different stereo angles (0, 5, 10, 30, 60, 90 deg)
    - based on self-consistent hydrostatic models

- The EUVI stereo pair images will be distributed to other groups or individuals for general stereoscopic studies, simulations, visualizations, 3D rendering, etc.

- Plan to distribute the first set of images at the time of the Dec 2001 AGU meeting