

# 3D Topology of the Magnetic Field in the Solar Corona

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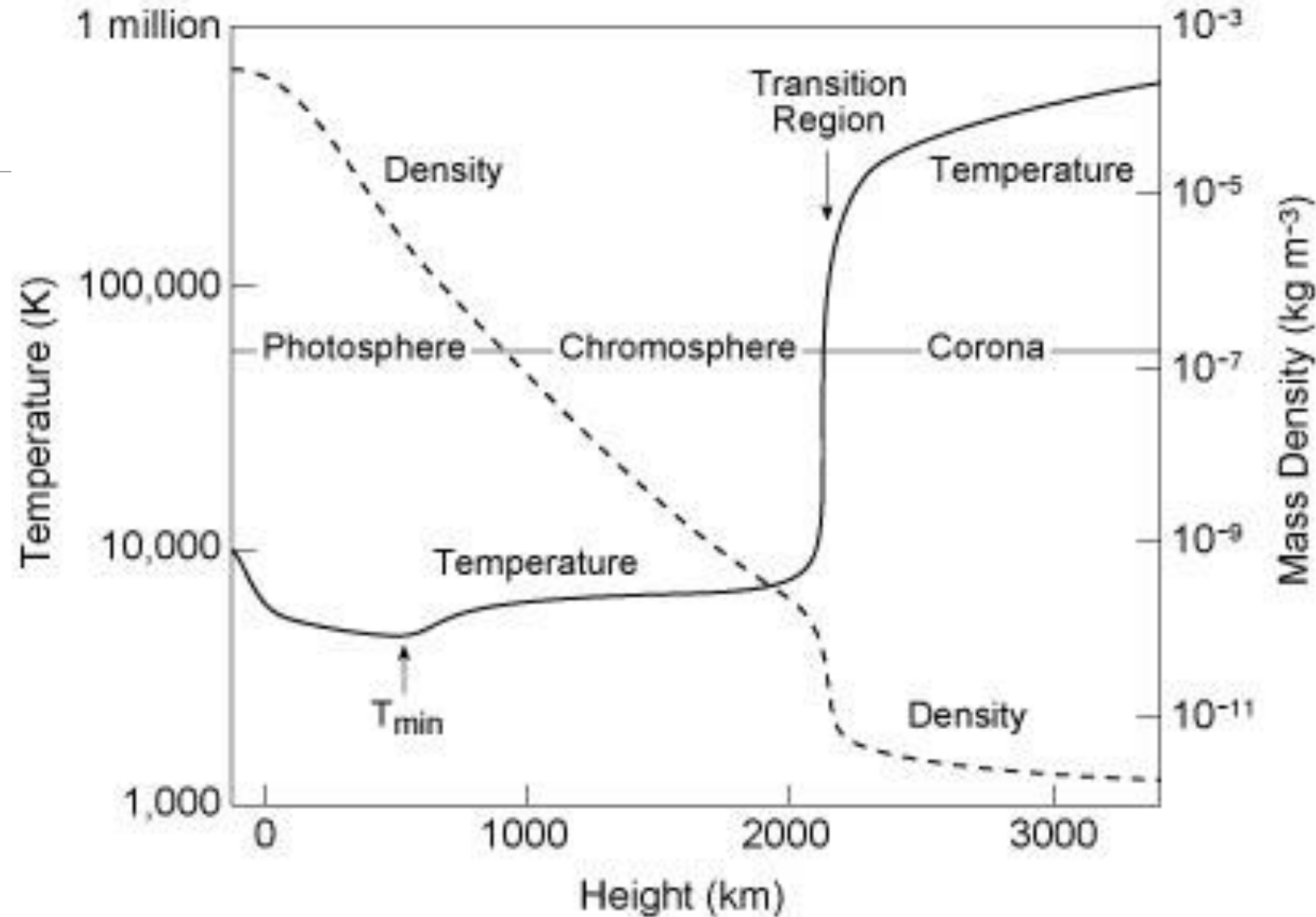
# Introduction

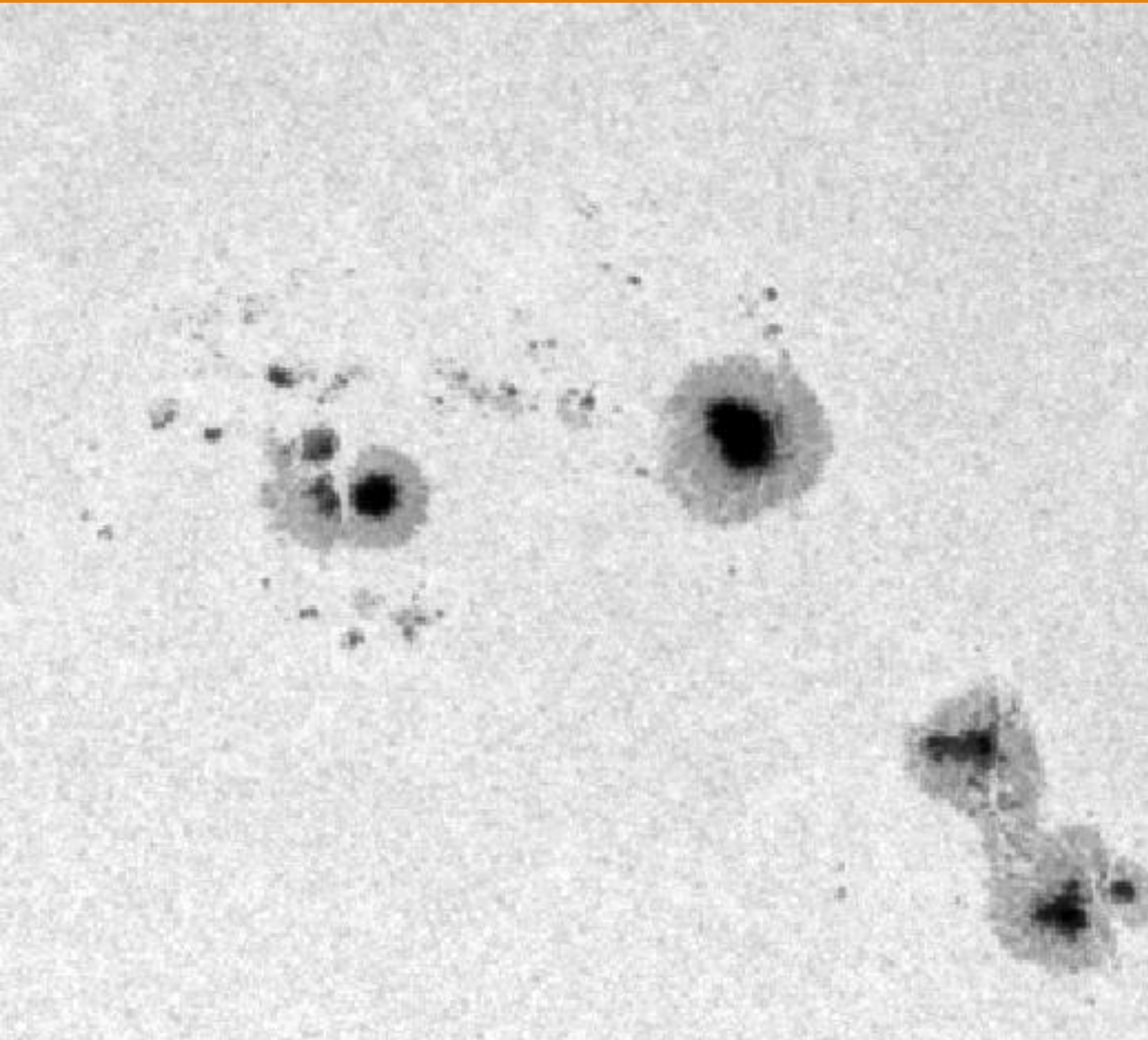
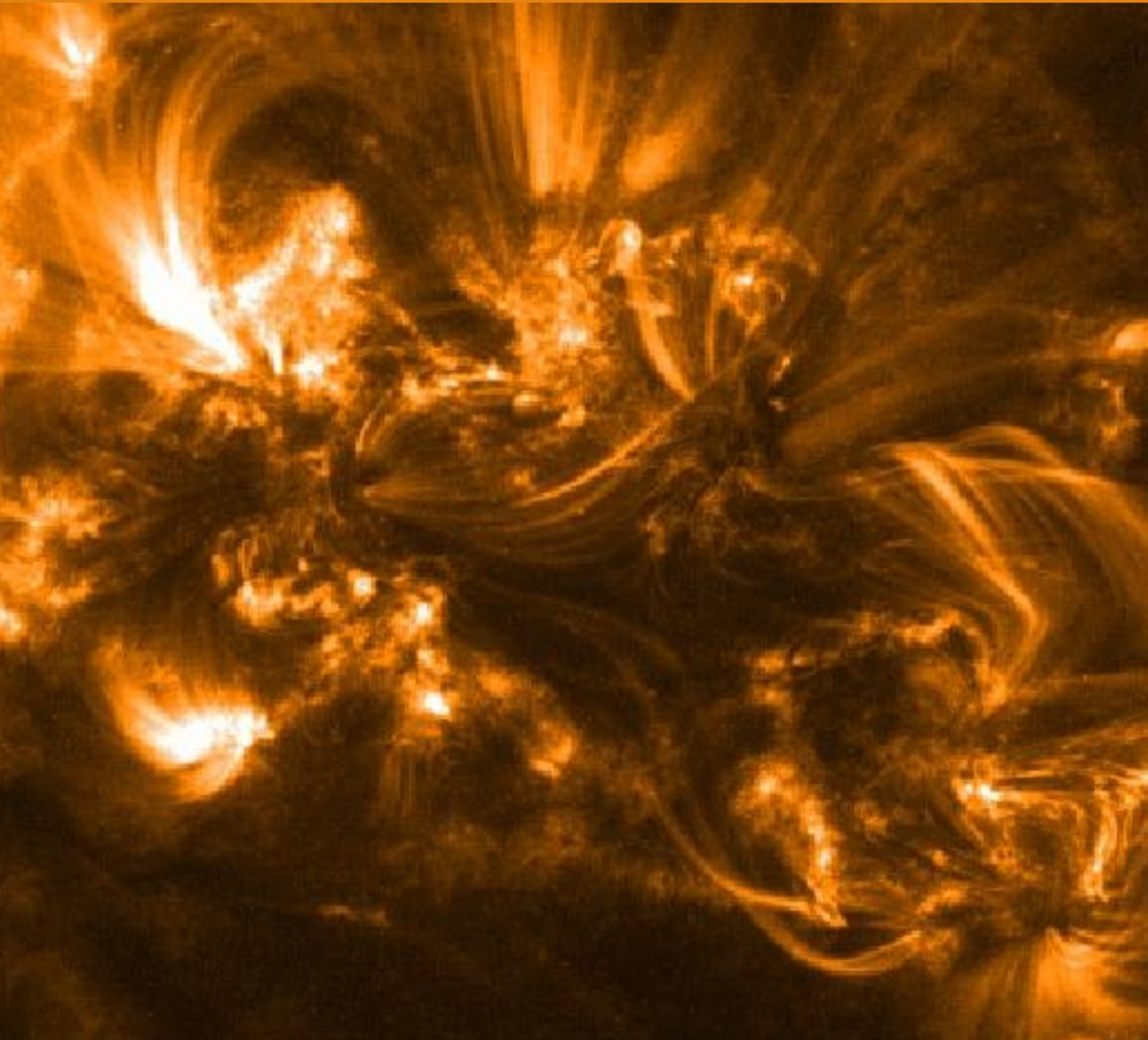
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1. The Sun
2. Magnetic Topology
3. Case Studies
4. Future Work

# Layers

- Photosphere
  - 5,800k ,  $10^{-9}\text{g/cm}^3$
- Chromosphere
  - 40,000k ,  $10^{-12}\text{g/cm}^3$
- **Transition Region**
- Corona
  - 3,000,000k ,  $10^{-16}\text{g/cm}^3$



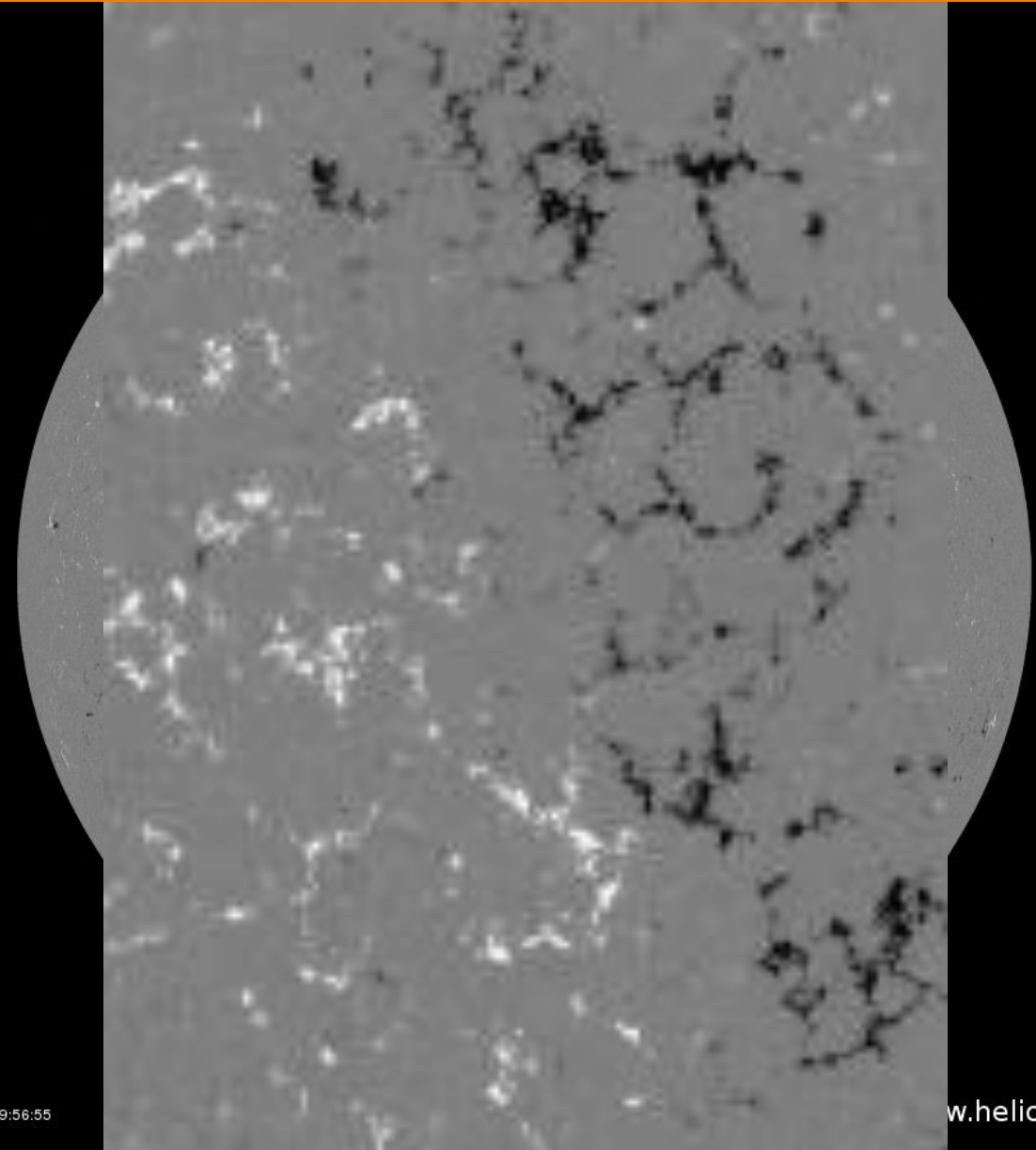


**TRACE: Fe IX & WL**

**6:18 20/5/2000**

# Photosphere

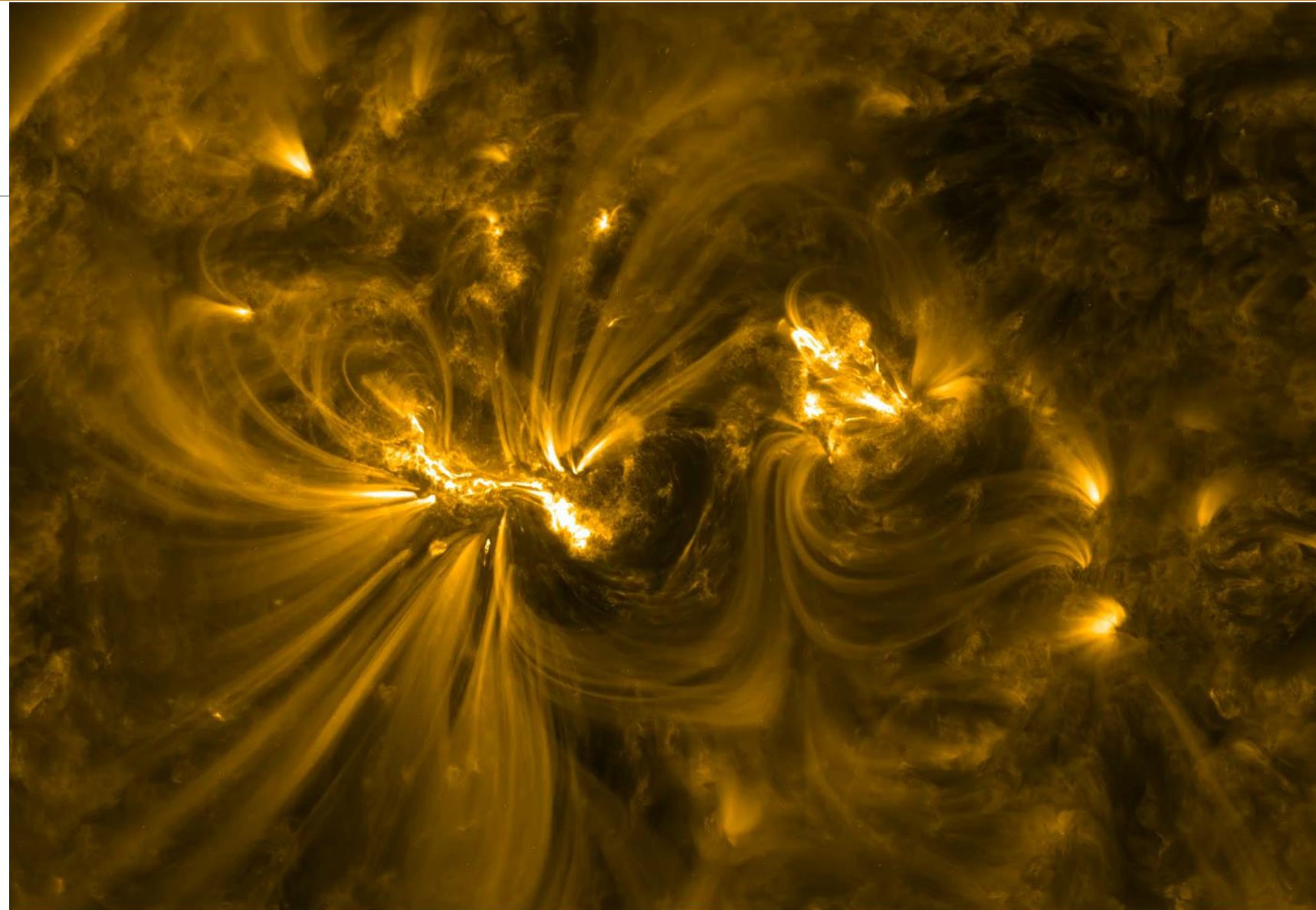
- Activity dominated by B-field
- B-field has foot points in photosphere
- Variety of magnetic properties
  - Granulation
  - Super Granular Cells
  - Ephemeral Regions
  - Active Regions



# Corona

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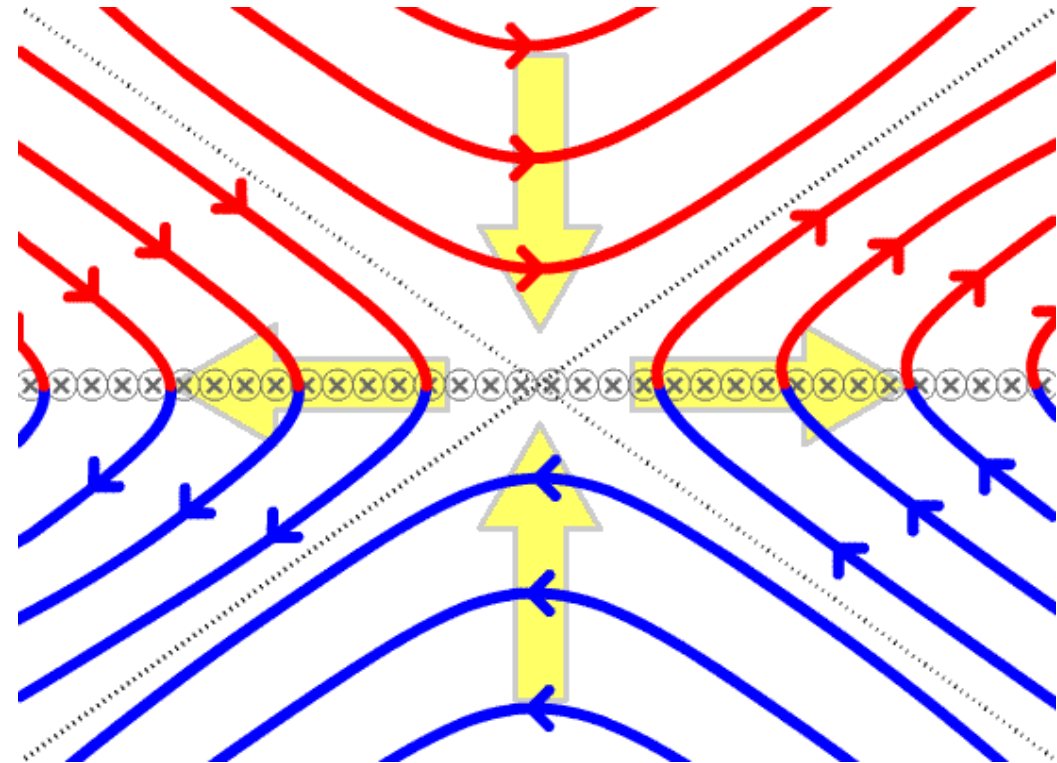
- Two solar flares
  - X-5.4
  - X-1.2
- Post-flare, field lines change connectivity



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# 2D Reconnection

- Well understood
- Restricted, can only occur at X-Type null
- When two flux tubes reconnect
  - they break at X-point
  - reform to form two new flux tubes
- 2D properties don't transfer to 3D



# 3D Reconnection

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- Ongoing field of research
- Not restricted to X-Type nulls
  - Occurs at various topological features
- Flux tubes don't reform perfectly
- Releases stored magnetic energy
  - Heat, light and particle acceleration

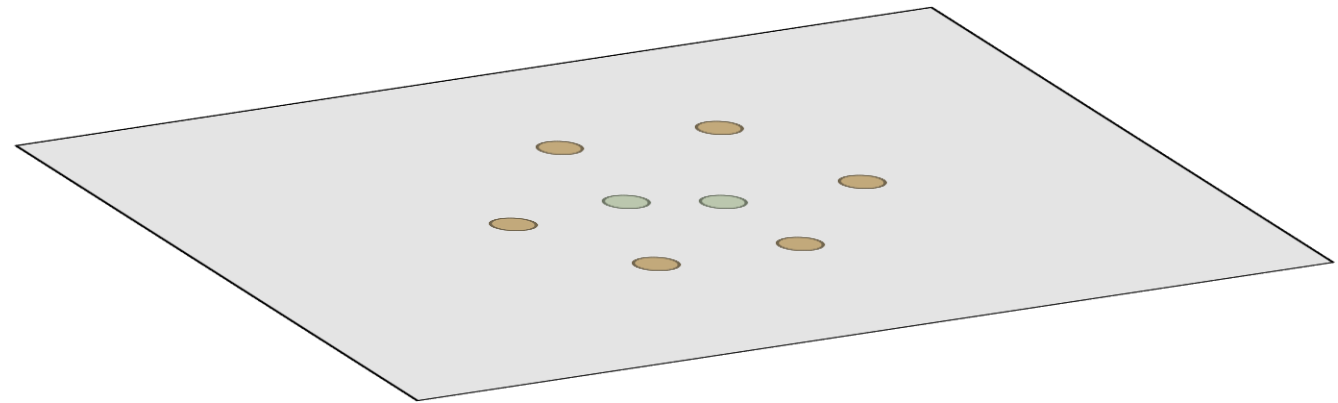


# Potential Field - Source Surface Model

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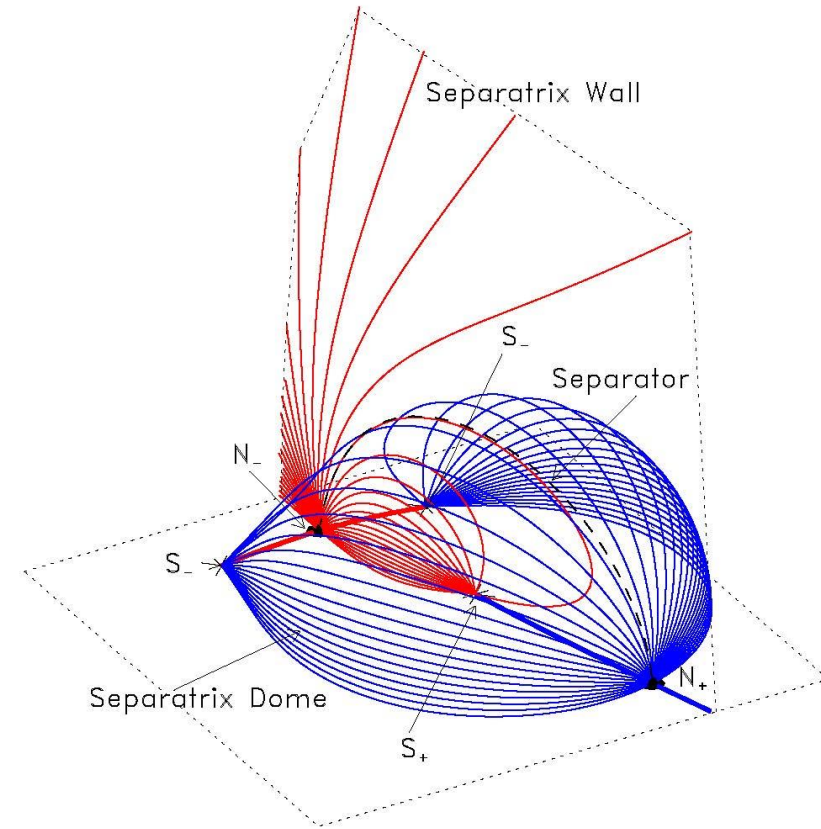
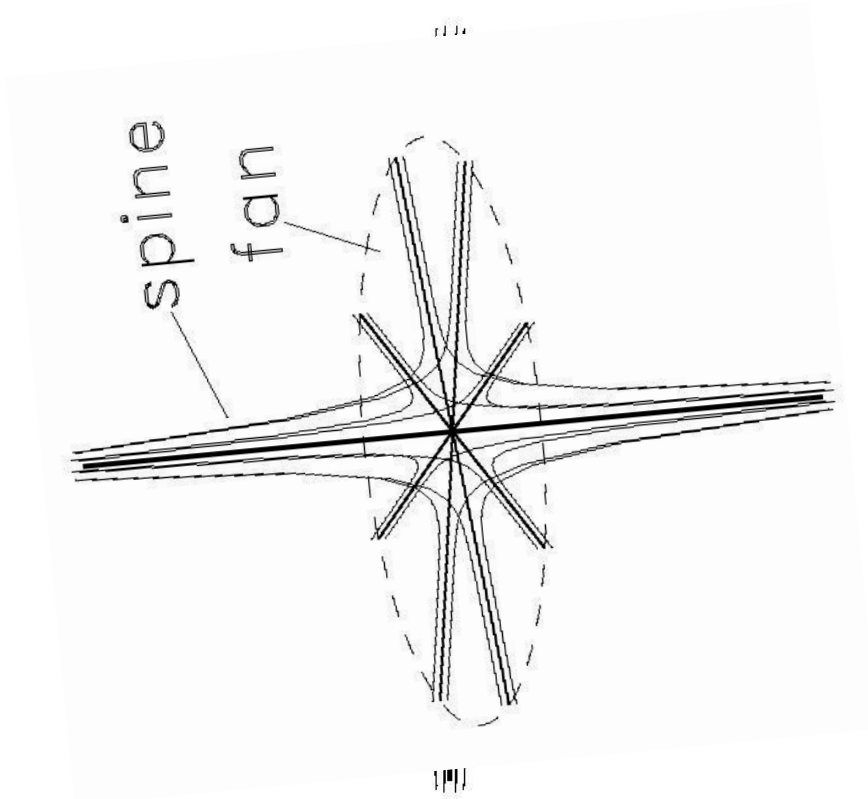
- Simplest, useful model
- Best model for structural simulations
- Assumes  $\mathbf{j}=\mathbf{0}$
- Treat photosphere as  $z=0$  plane
- Scatter sources of flux on the plane

$$\mathbf{B}(\mathbf{r}) = \sum_i \epsilon_i \frac{\mathbf{r} - \mathbf{r}_i}{|\mathbf{r} - \mathbf{r}_i|^3}$$



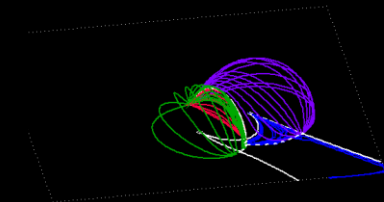
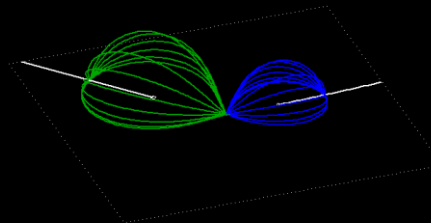
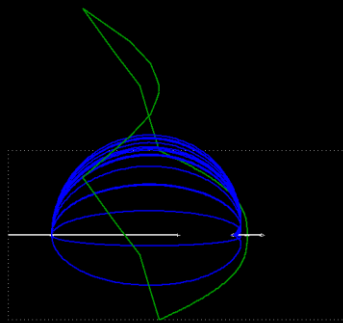
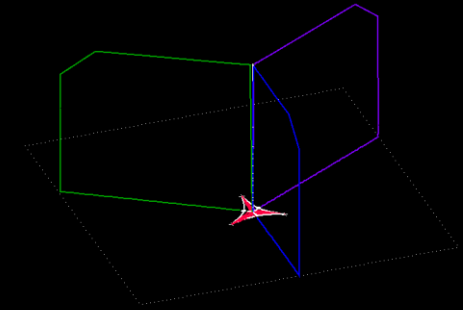
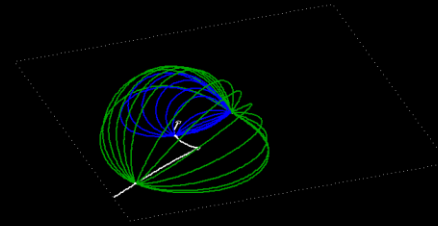
# Skeleton

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# 3 Source cases

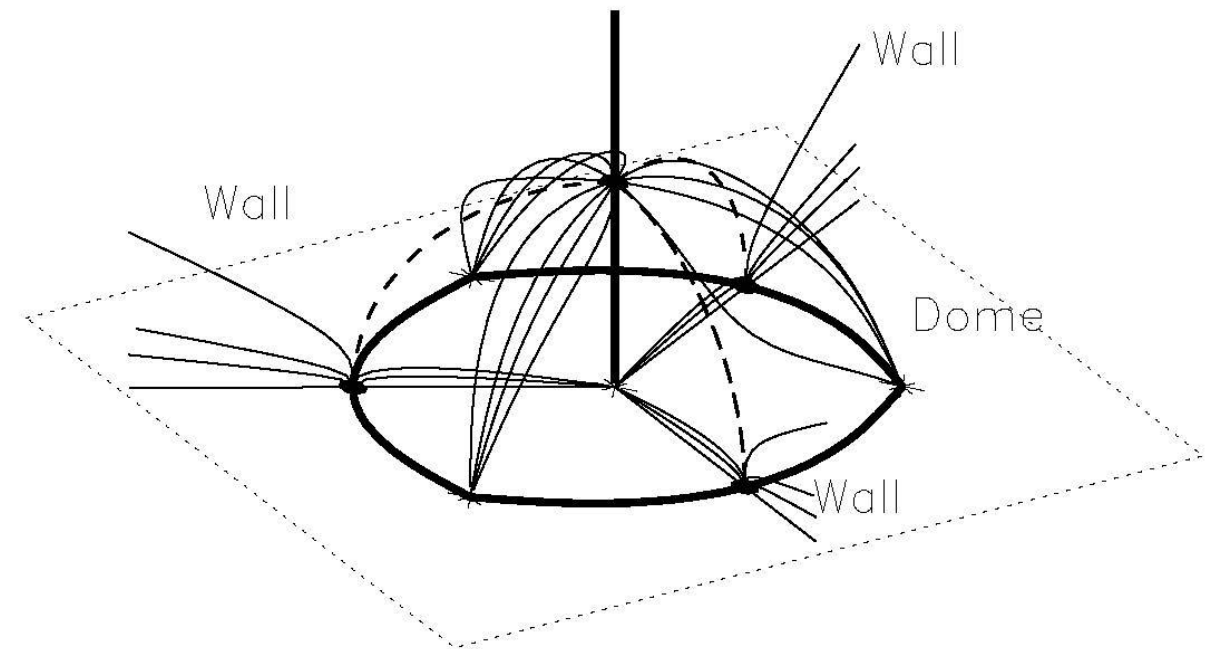
- Brown and Priest (1999)
- Various topological structures
- Building blocks for complex cases



# Coronal Nulls

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- Null points not restricted to plane
- Flares occur in corona
- Hence want reconnection sites in corona



# Bifurcations

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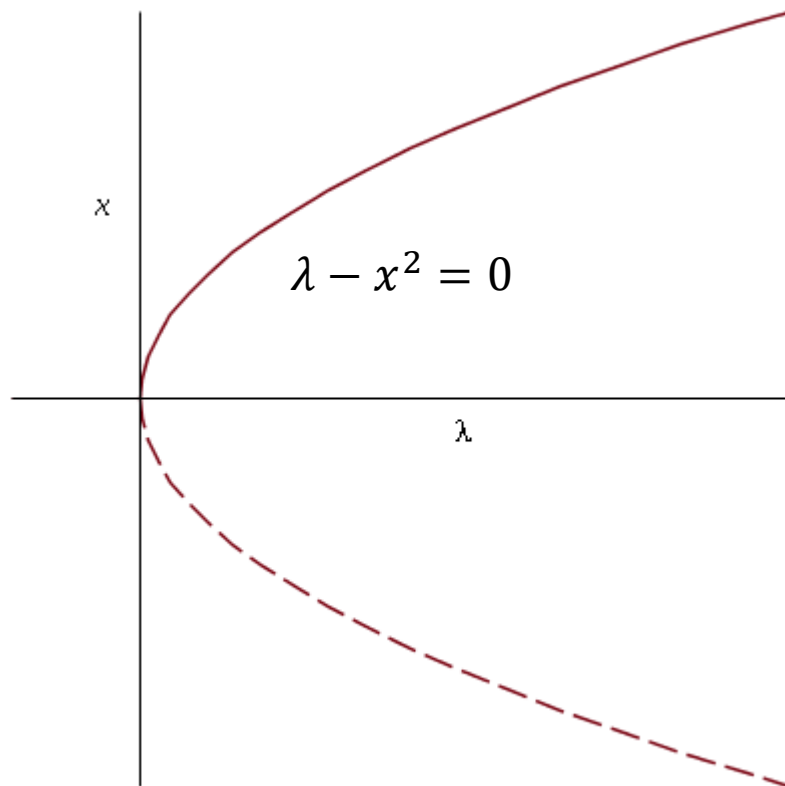
- Consider a system depending on  $\lambda$ ,

$$\dot{x} = f(x, \lambda)$$

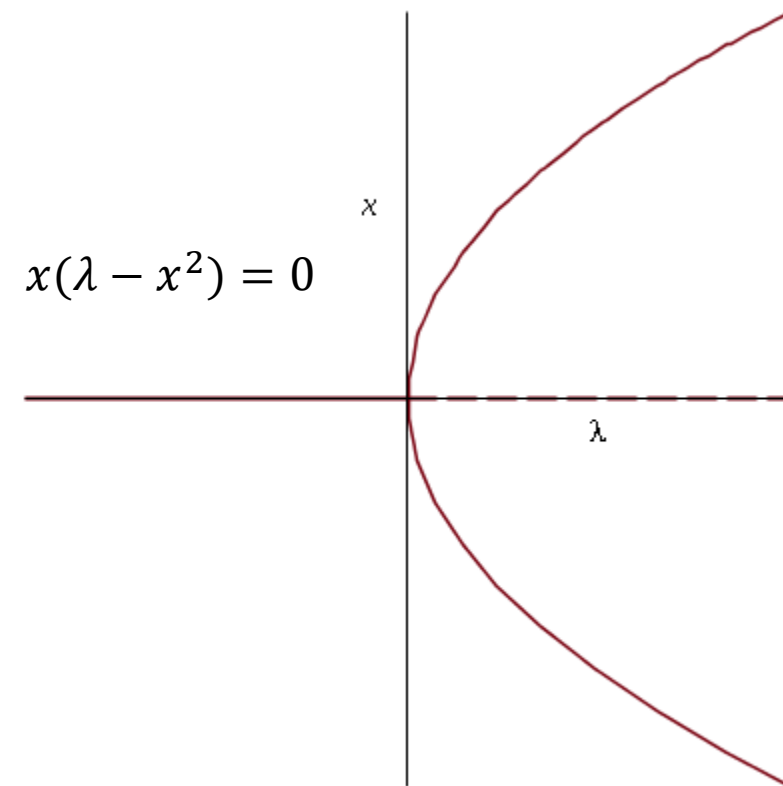
- Nature of solution can change dramatically at critical values of  $\lambda$
- This is called a bifurcation point
- Bifurcations fall in two categories;
  - Local – Changes in the solutions of the null points
  - Global – Changes the dynamics of the system
- Dynamics refers to behaviour of field lines and their connectivity

# Bifurcations

Turning Point Bifurcation

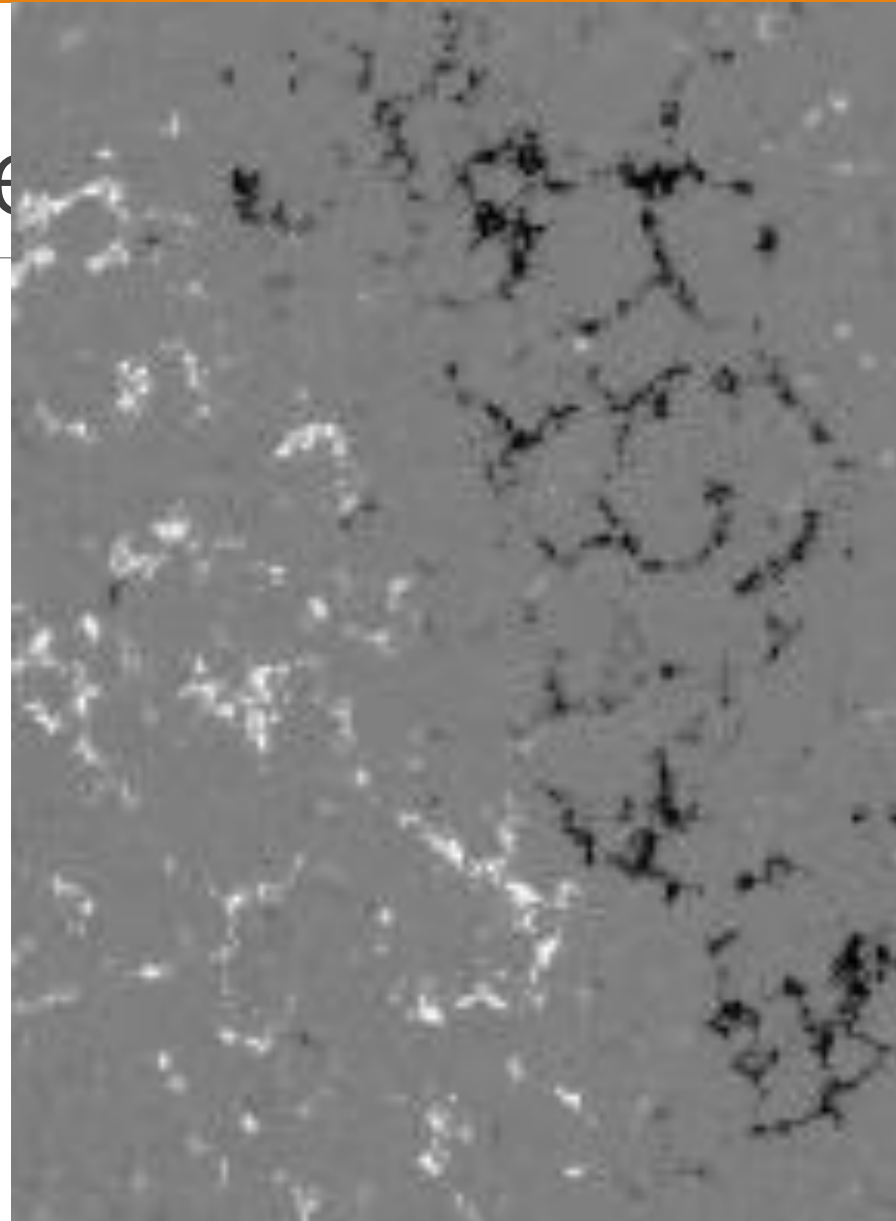
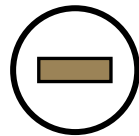


Pitchfork Bifurcation



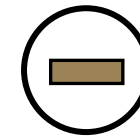
Potential Field

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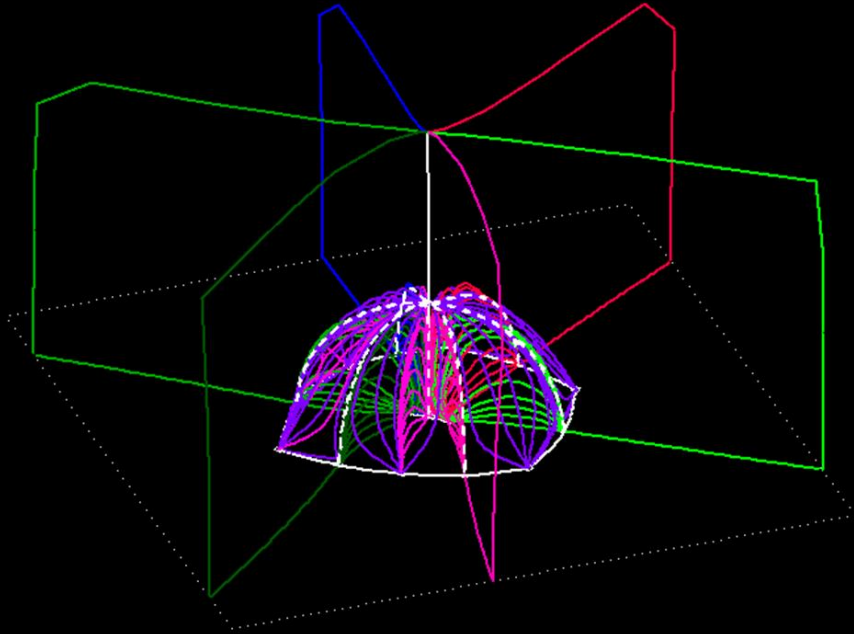


Model

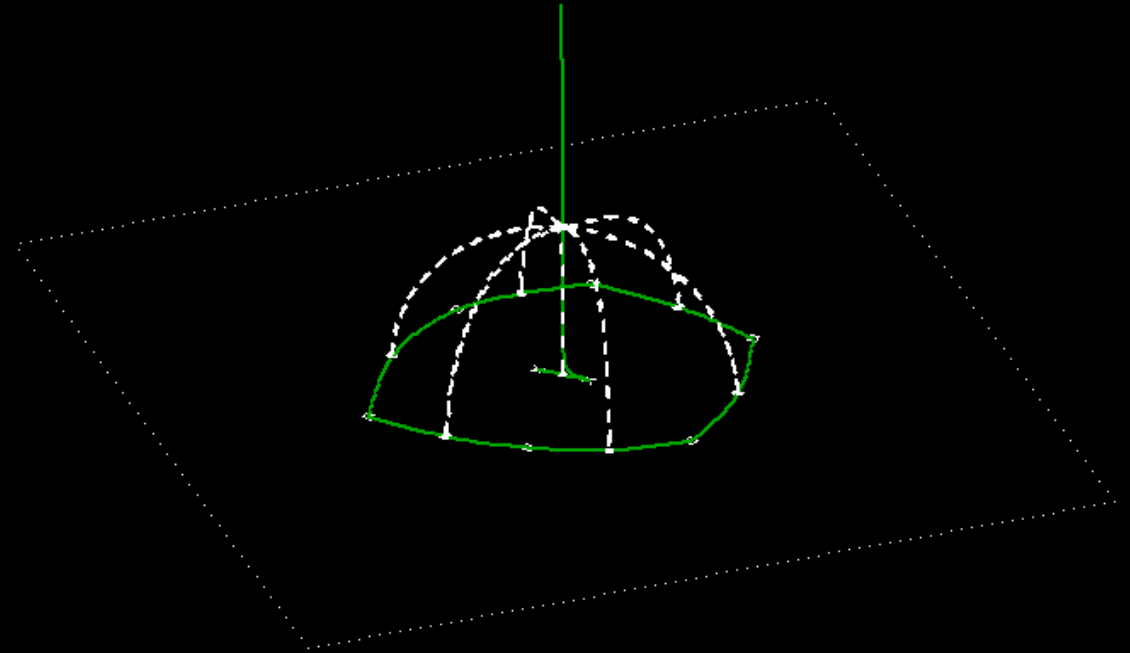
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# 8 Source Topology



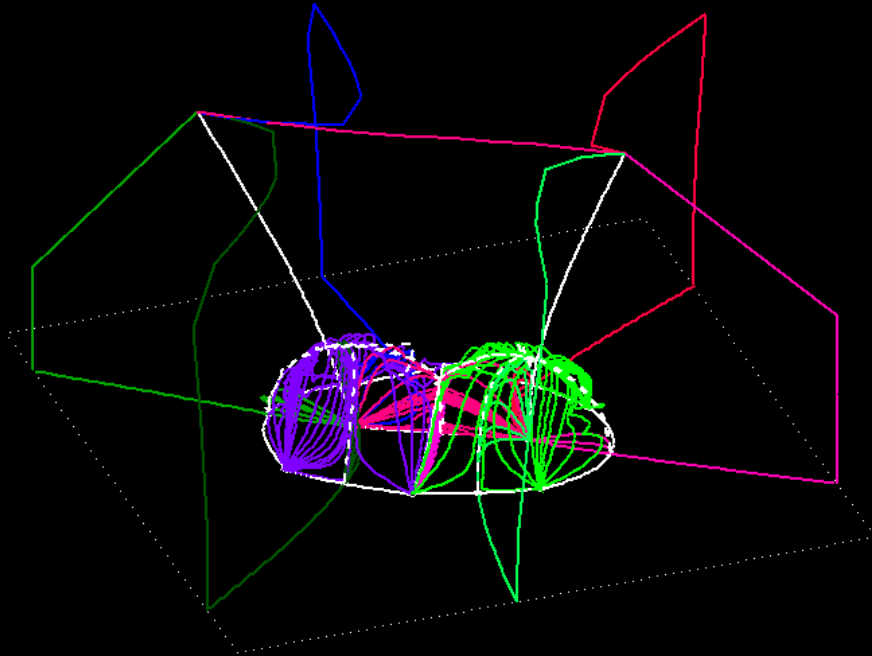
- Seven separatrix walls
- One coronal null point
- One coronal dome
- 8 internal regions of connectivity



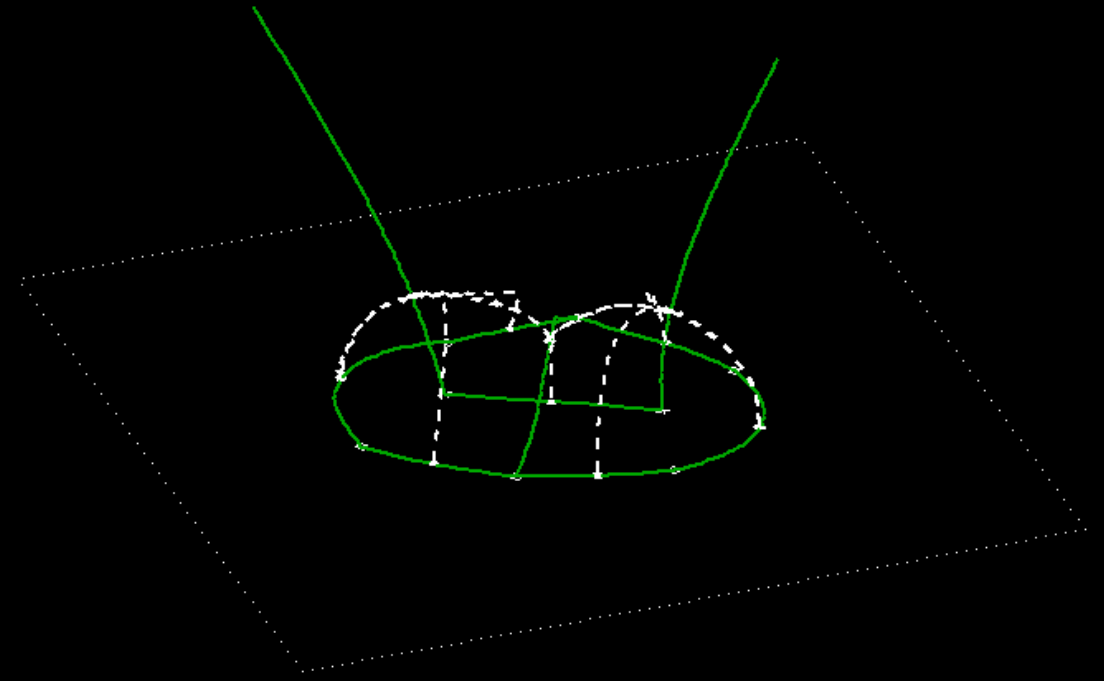
- Seven separators



# Turning Point Bifurcation

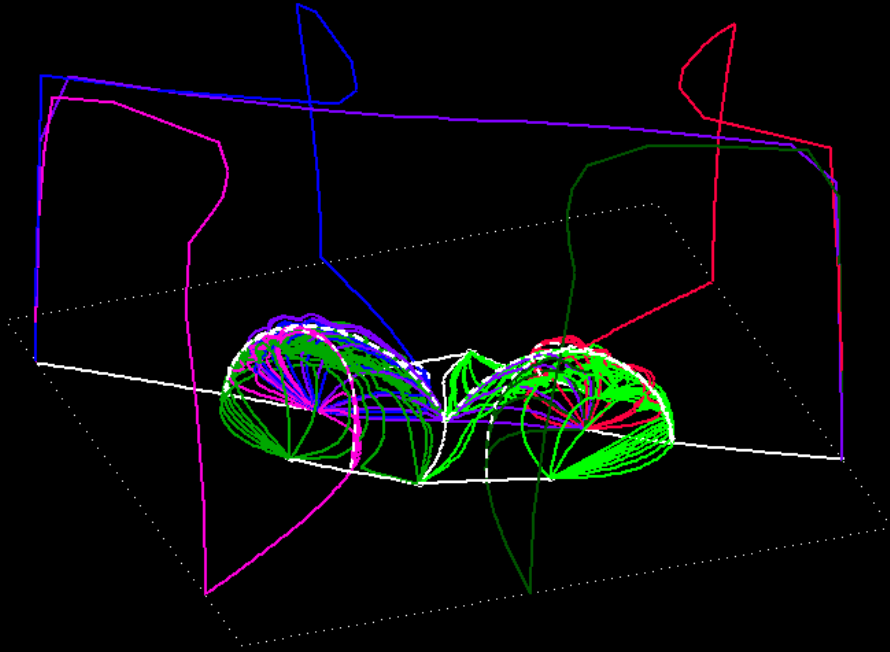


- Seven separatrix walls
- Three coronal null points
- Two coronal domes
- 8 internal regions of connectivity

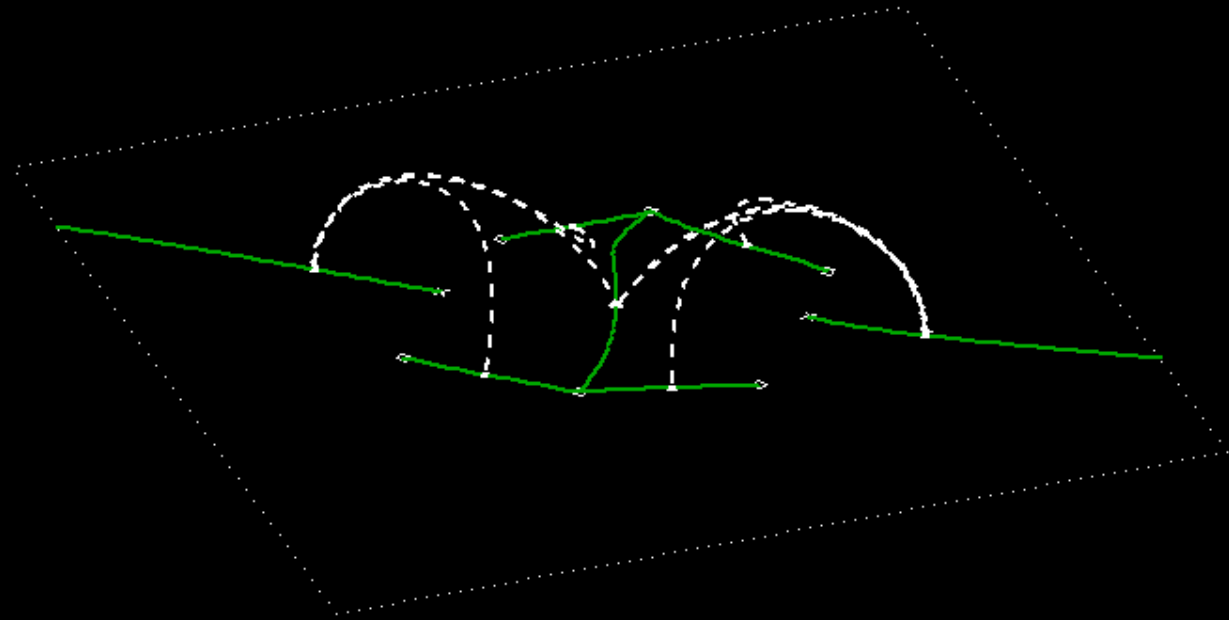


- Nine separators

# Pitchfork Bifurcation



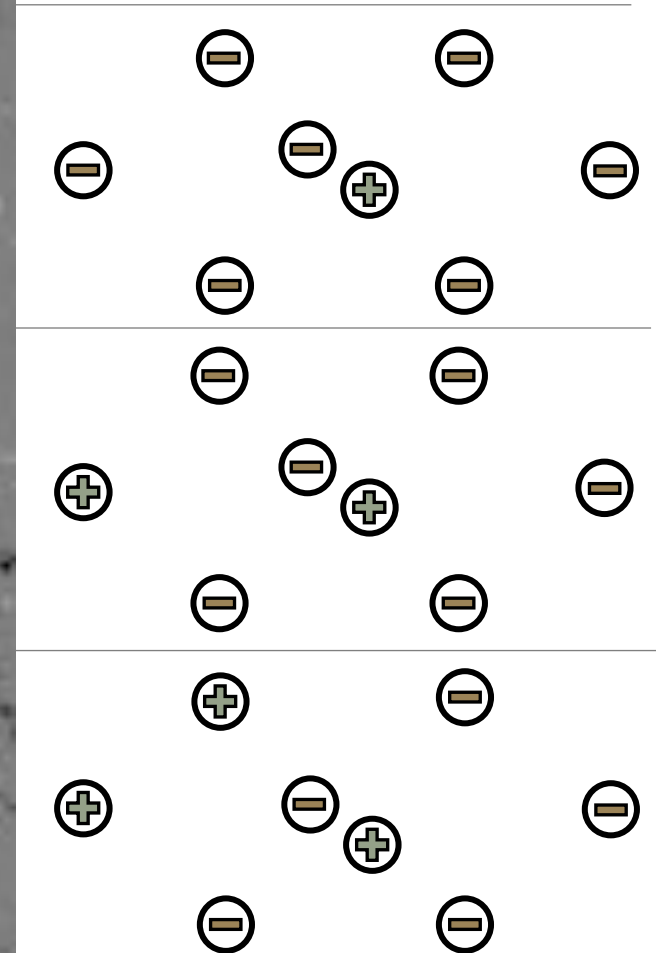
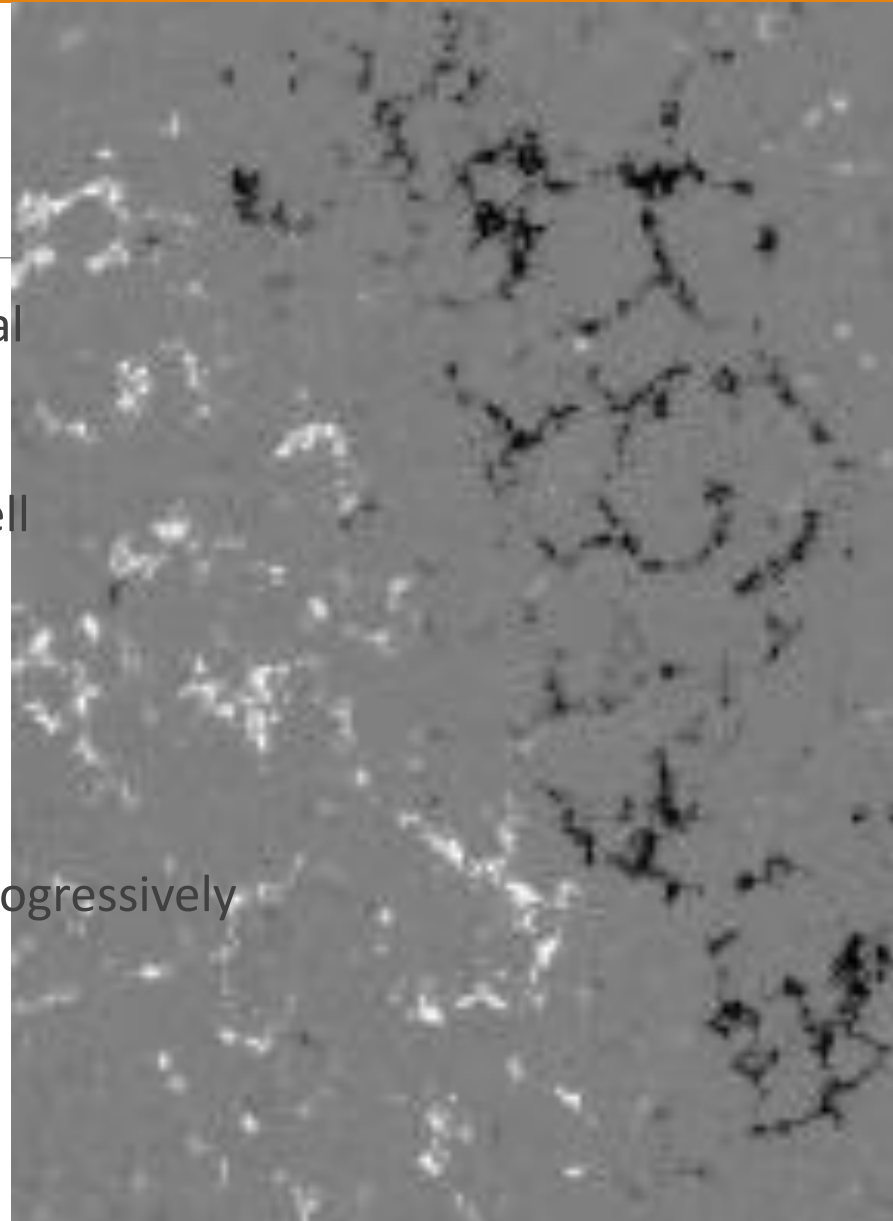
- Five separatrix walls
- No coronal null points
- Two domes
- 8 internal regions of connectivity



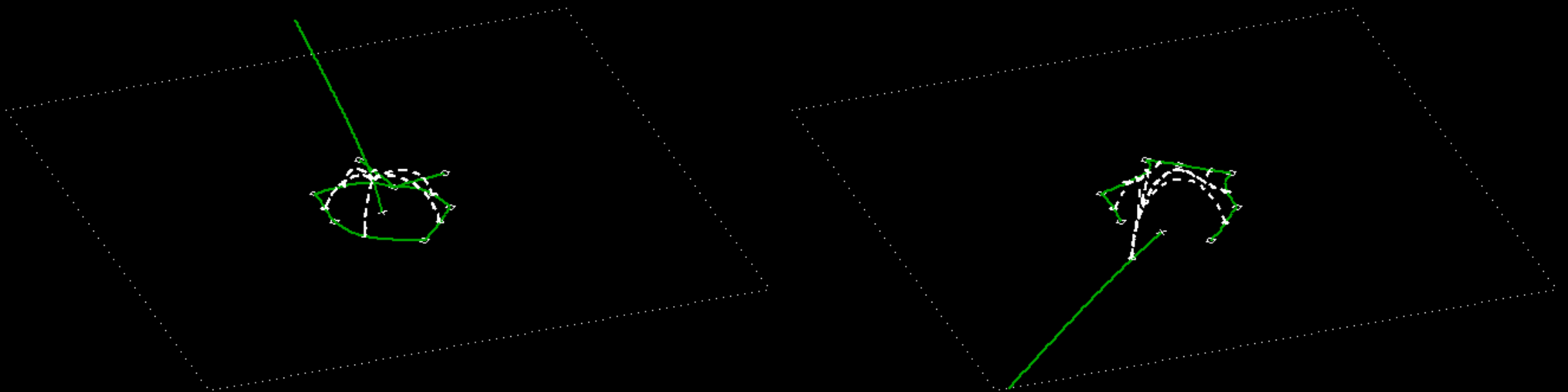
- Six separators

# Emerging a

- Previous case was artificial
- Simulate more realistic cell
- Emerge a bipole
- Vary boundary sources progressively



# Emerging a Bipole



# Future Work

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- Begin simulations using continuous sources
- Draw comparisons between the point source simulations and continuous source simulations
  - Do we see similar behaviour between the two types
  - Do point source simulations approximate continuous source simulations well
- Observational work creating continuous source simulations based on magnetogram images