3D Topology of the Magnetic Field in the Solar Corona

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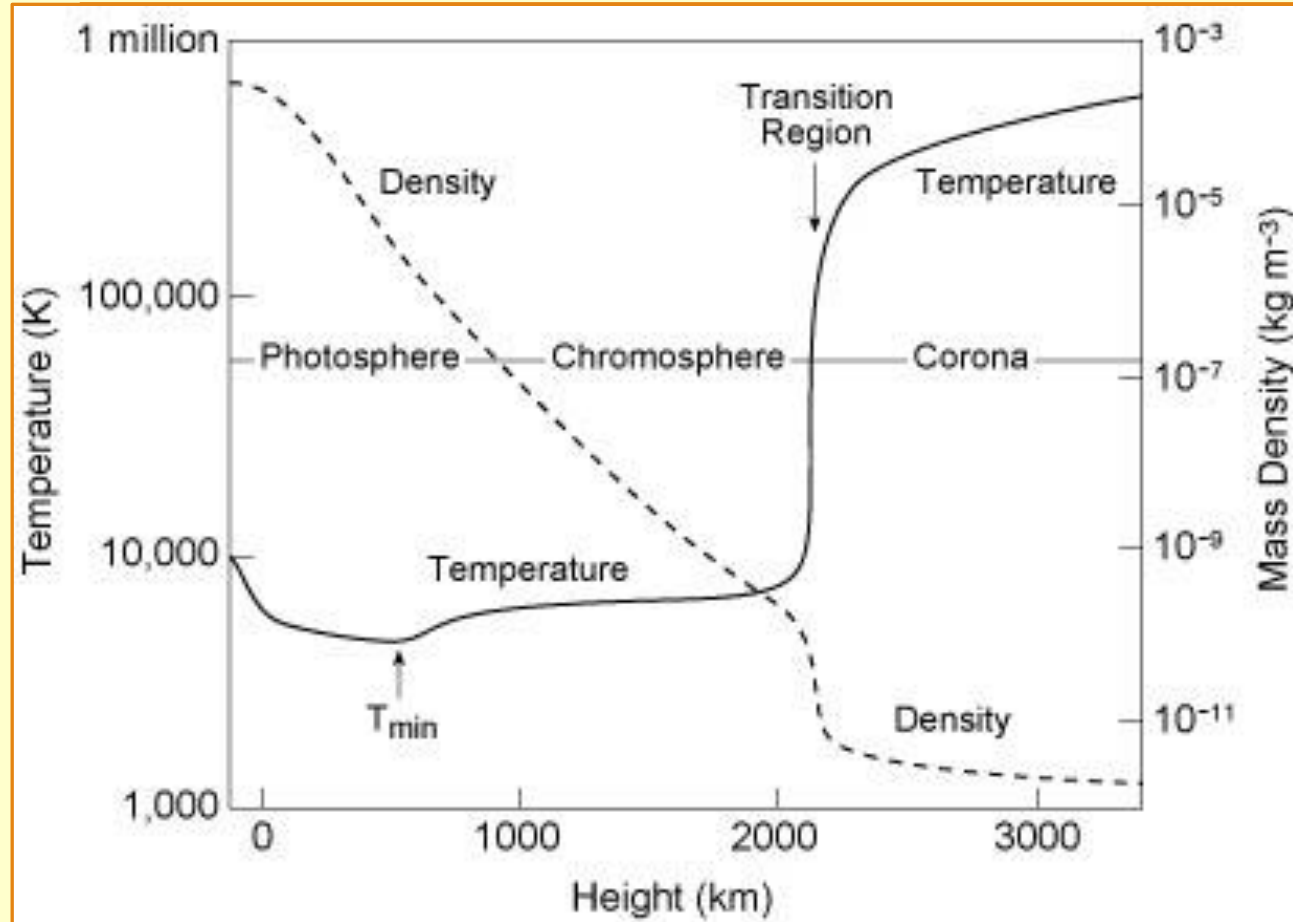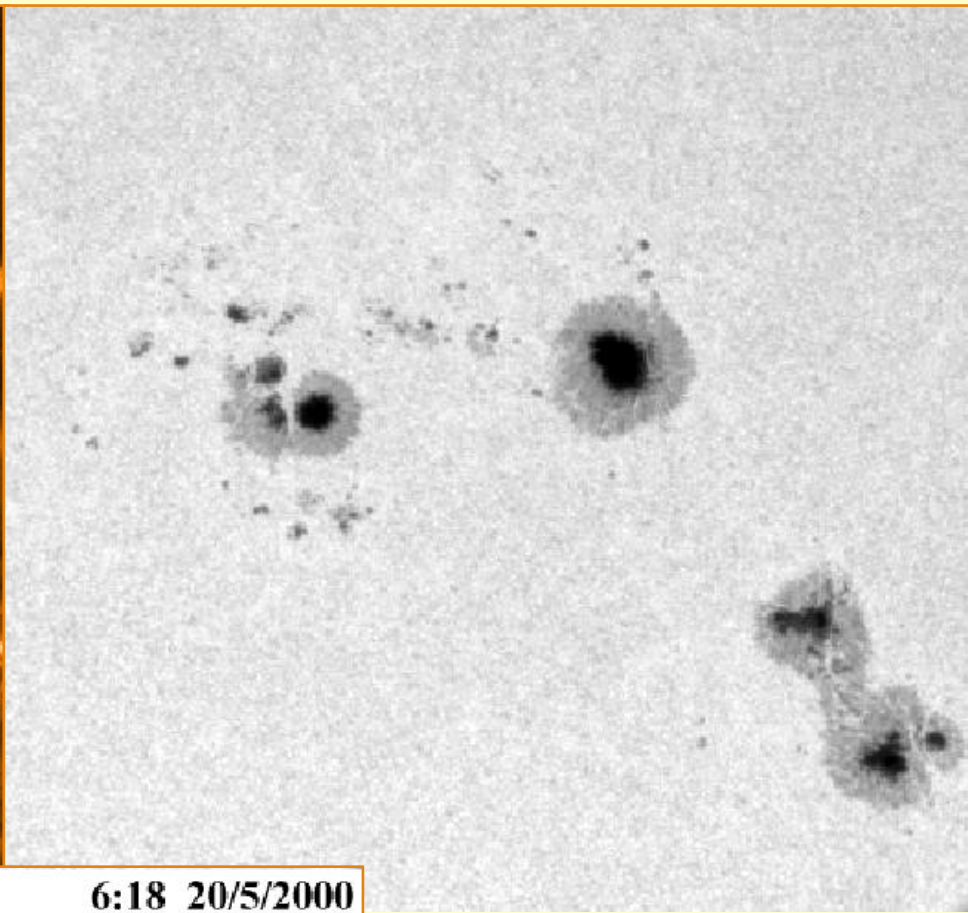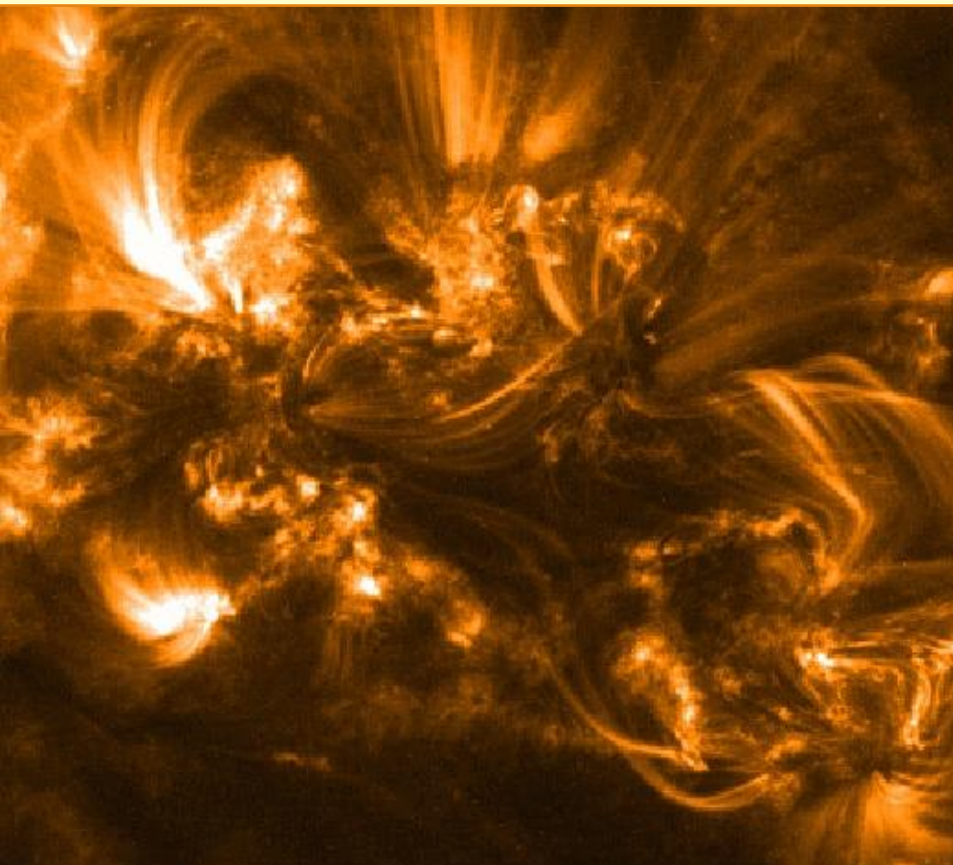
University of Central Lancashire

Overview

1. The Sun

2. Magnetic Topology

3. Open Separatrix Surface

4. Conclusion

Solar Structure

- Photosphere
  - 5,800k , 10^{-9}g/cm^3

- Chromosphere
  - 40,000k , 10^{-12}g/cm^3

- **Transition Region**
- Corona
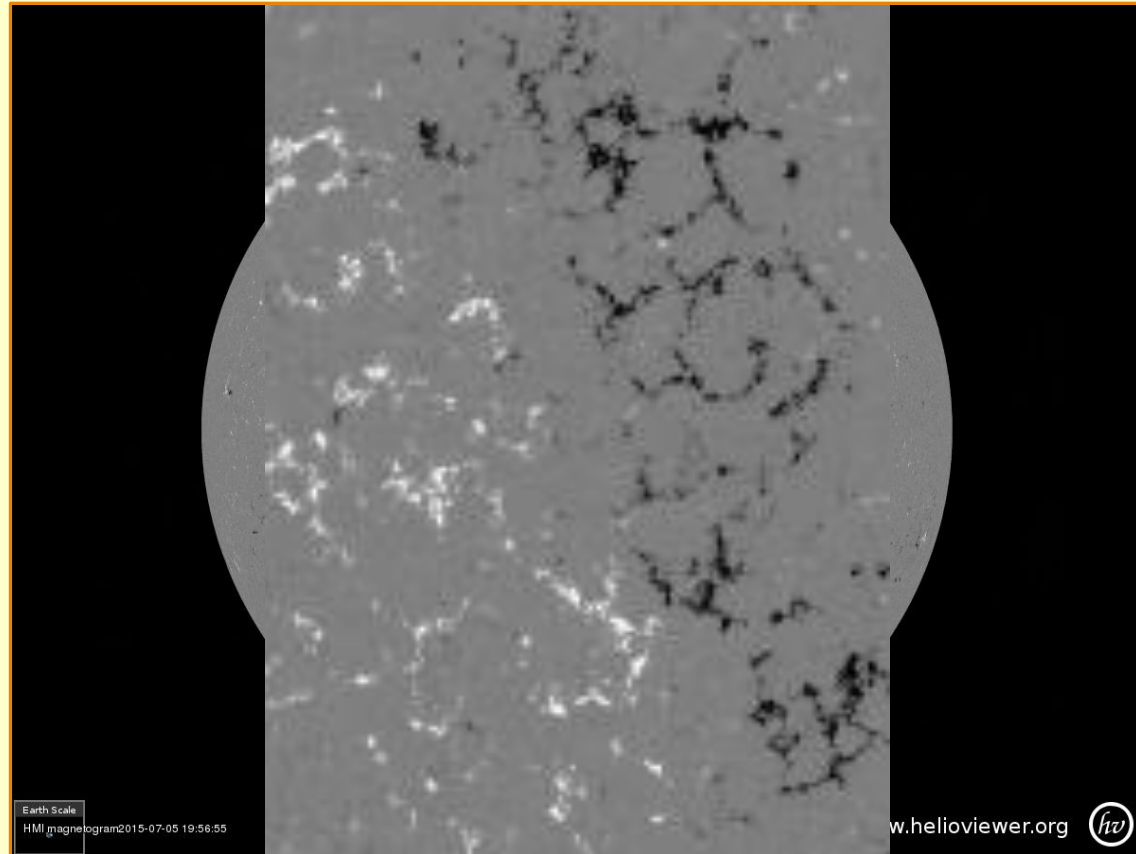 - 3,000,000k , 10^{-16}g/cm^3

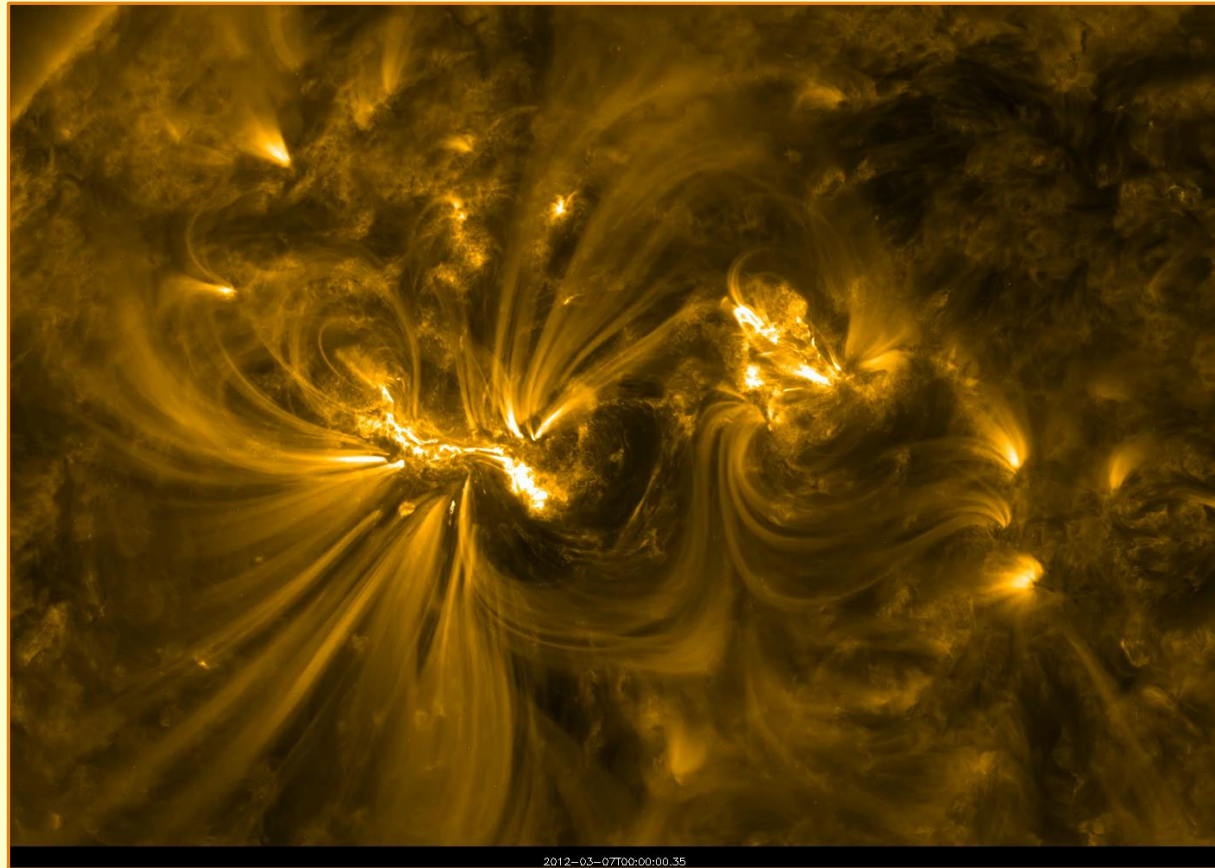TRACE: Fe IX & WL   6:18 20/5/2000

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

Earth Scale
HMI magnetogram 2015-07-05 19:56:55
w.helioviewer.org

Corona

- Two solar flares
  - X-5.4
  - X-1.2

- Post-flare, field lines change connectivity

2012-03-07T00:00:00.35

2D Reconnection

- Well understood

- Restricted, can only occur at X-Type null

- Two flux tubes reconnect
  - break at X-point
  - reform as two new flux tubes

- 2D properties don't transfer to 3D
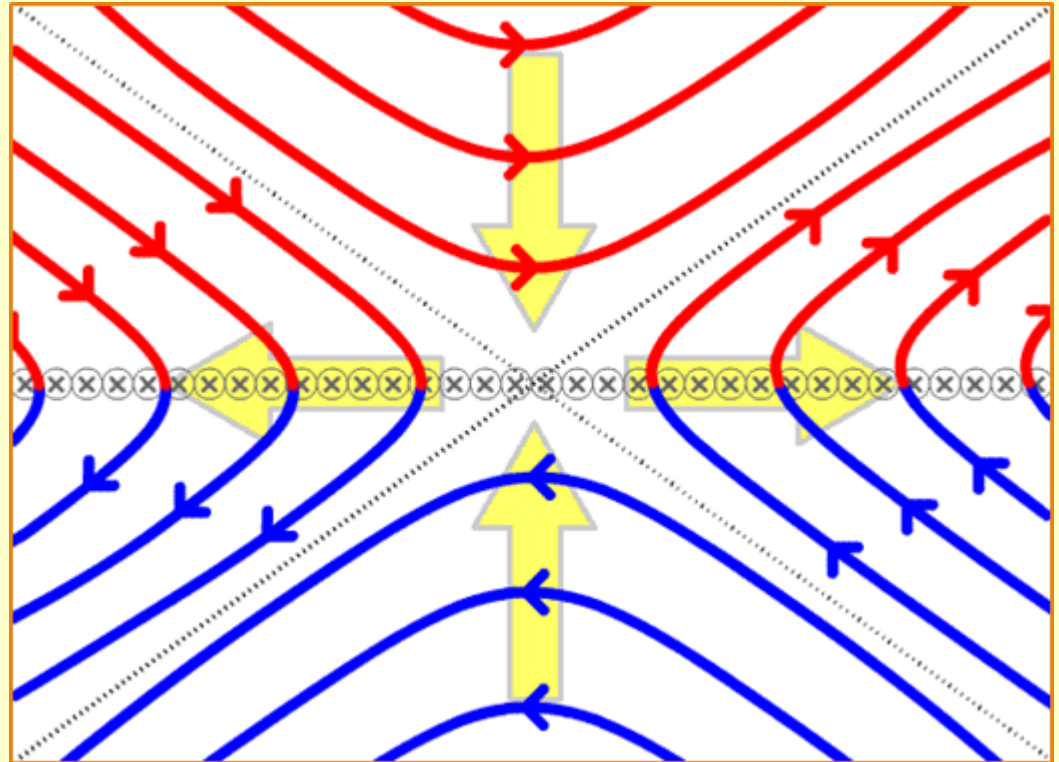
3D Reconnection

- 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
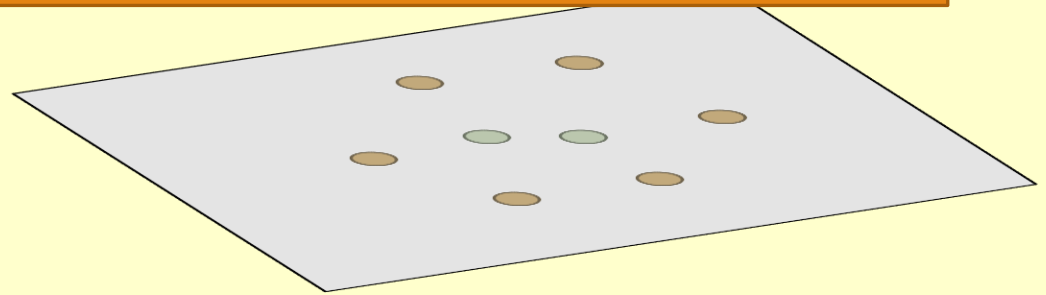 - Heat, light and particle acceleration

Magnetic Charge Topology

- Simplest, useful model

- Best model for structural simulations

Investigate and address differences between discrete and continuous source topologies
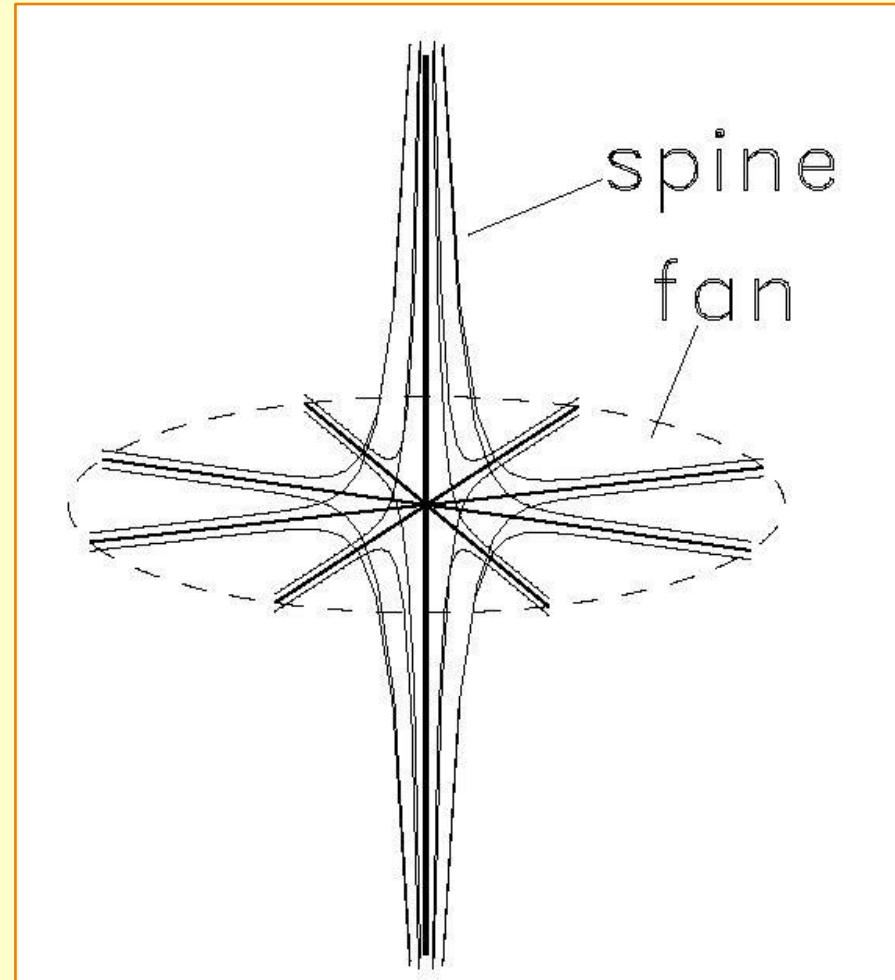
z=0 plane

- Scatter sources of flux on plane

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

# Magnetic Null Points

- We can define null points
  - Locations where
  $$B_x = B_y = B_z = 0$$
  - Anywhere in the volume

- Can define spine and fan field lines about a null

- Separatrix surfaces generated from these points

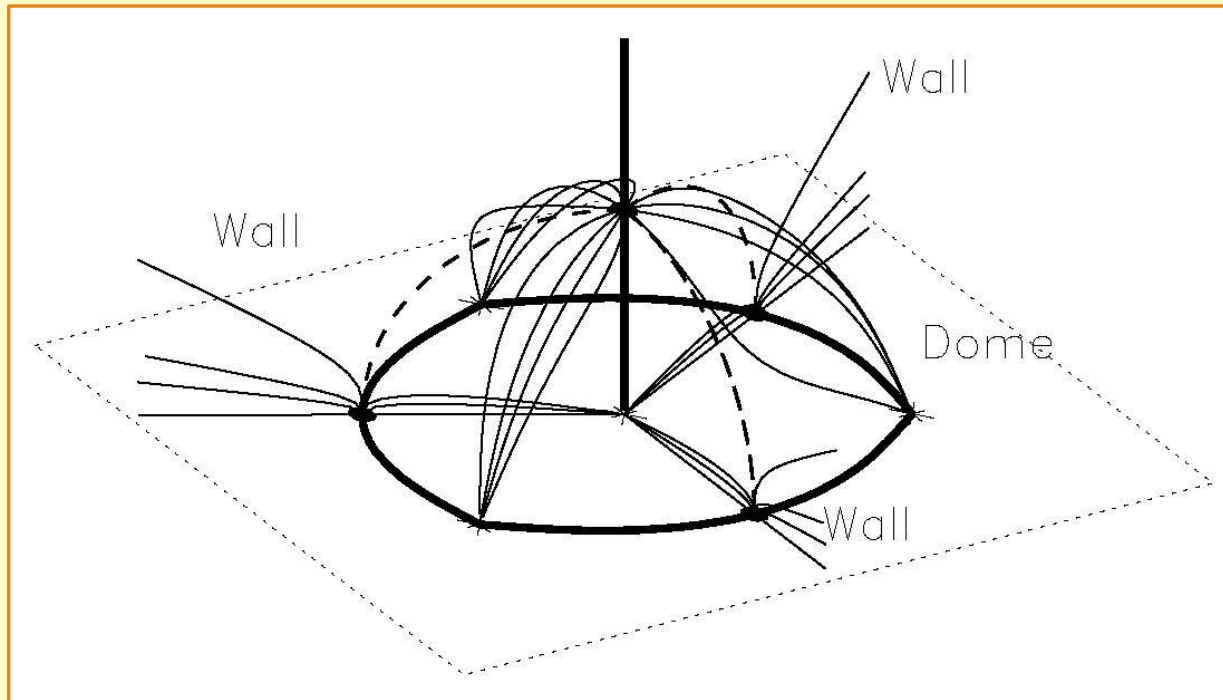- Intersections in surfaces form separator field lines

spine

fan

3 Source Cases

- Brown and Priest (1999)

- Various topological structures

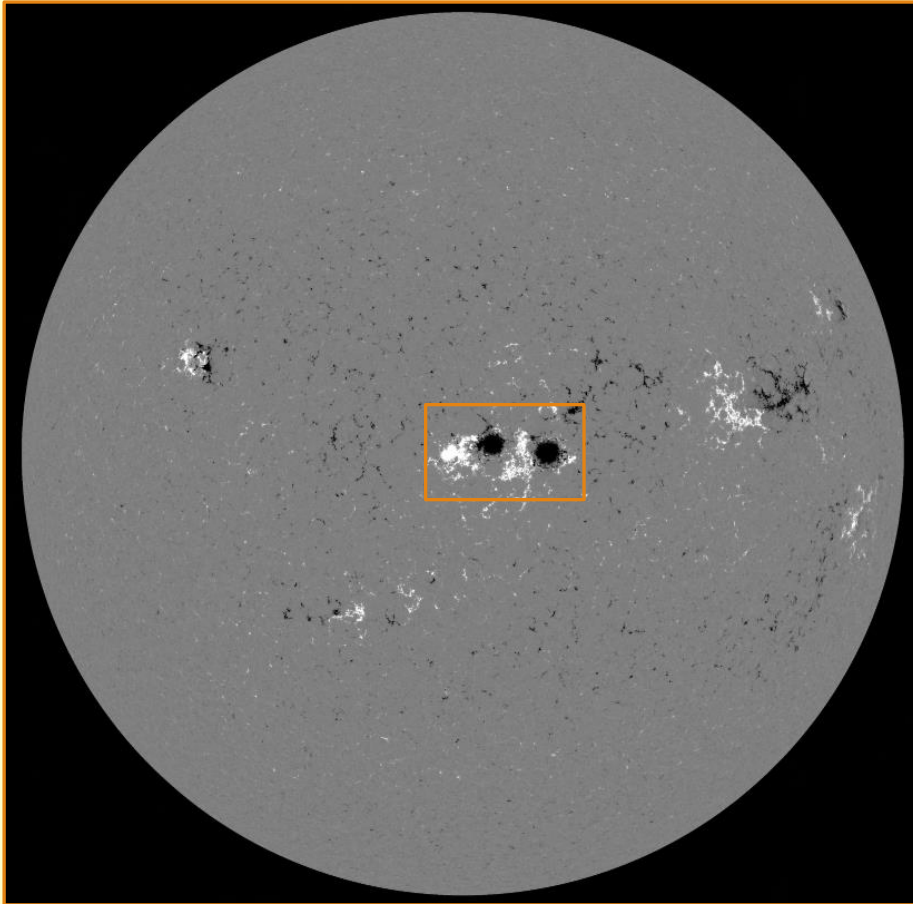- Building blocks for complex cases
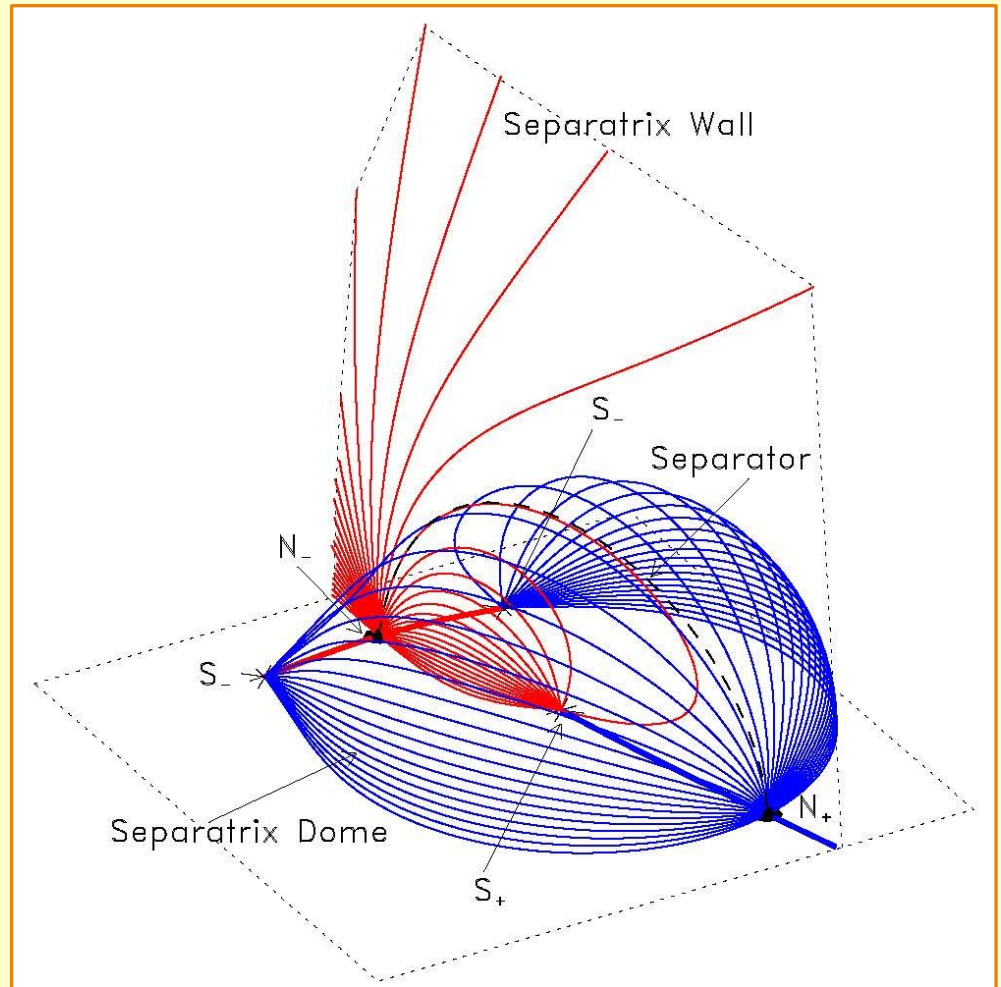
Coronal Nulls

- Null points not restricted to plane

- Flares occur in corona

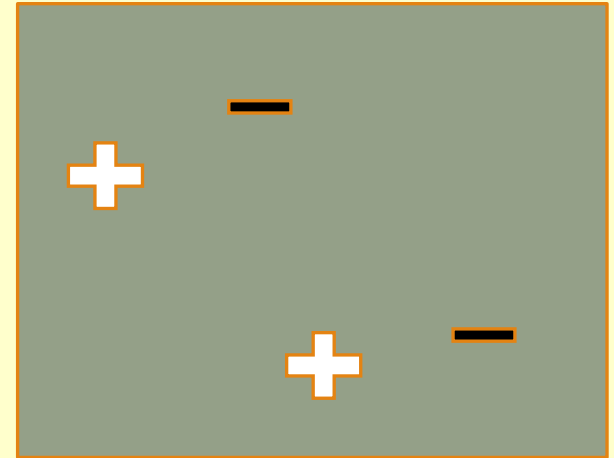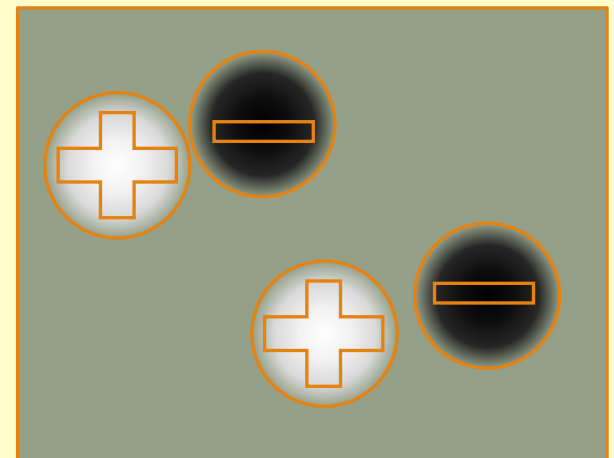- Hence want reconnection sites in corona

Source Types

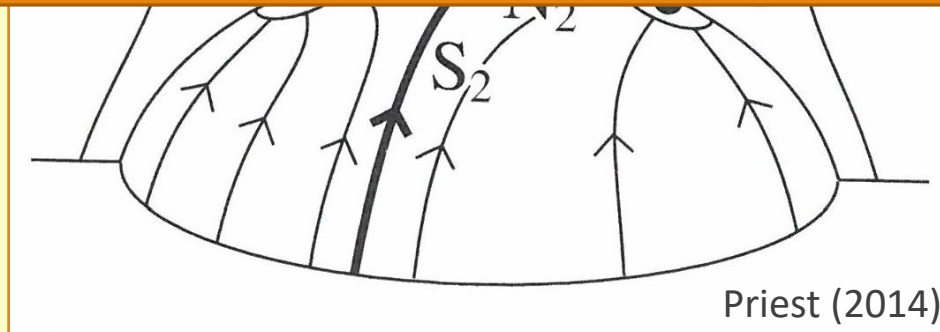

SDO/HMI – helioviewer.org

Discrete
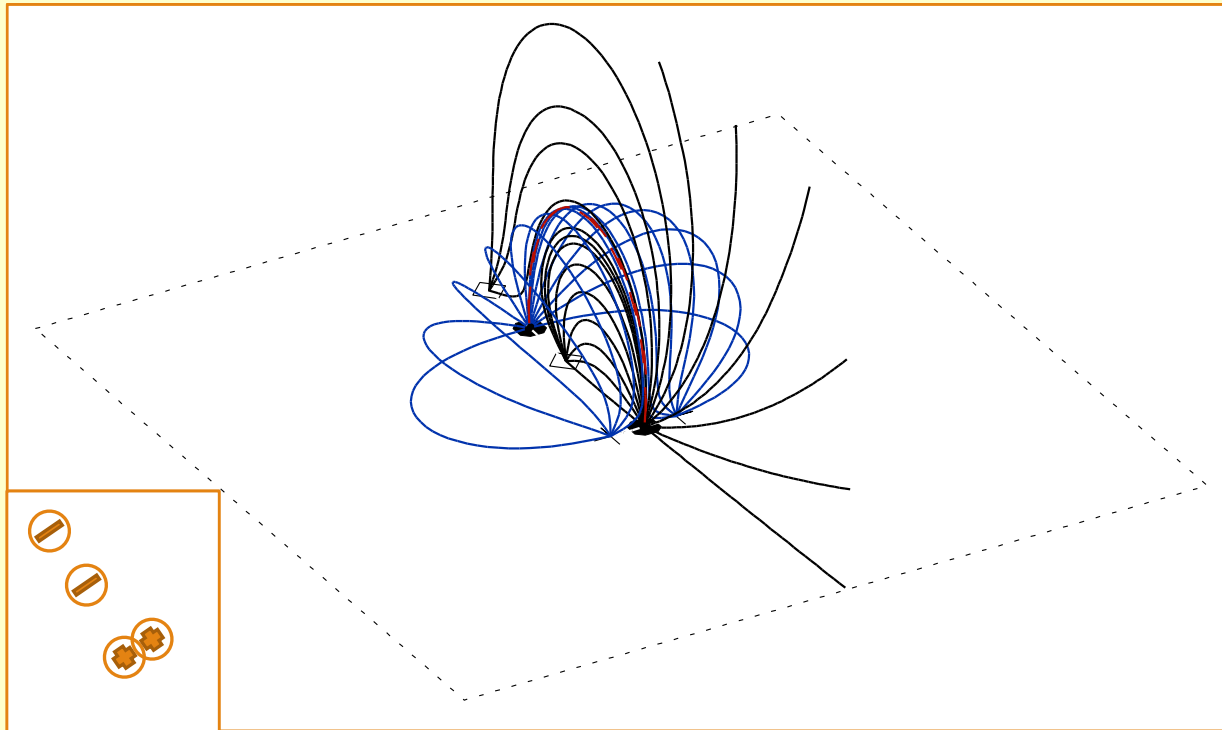

Continuous

An Open Separatrix Surface

Aims

- **Show that topology presented in Priest (2014) may not be complete picture**

- **Define additional features to get more complete picture of topology**
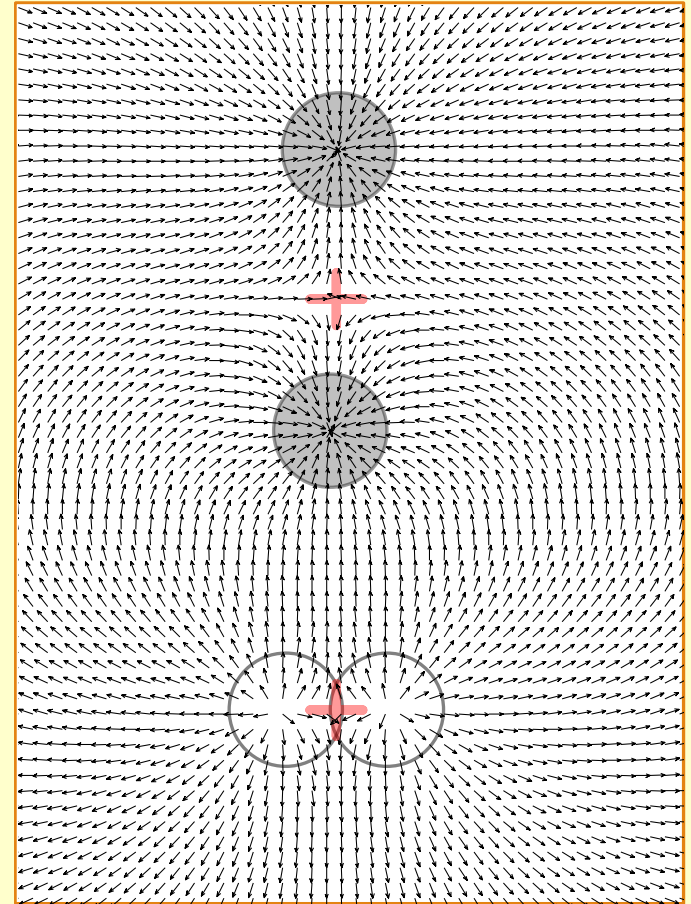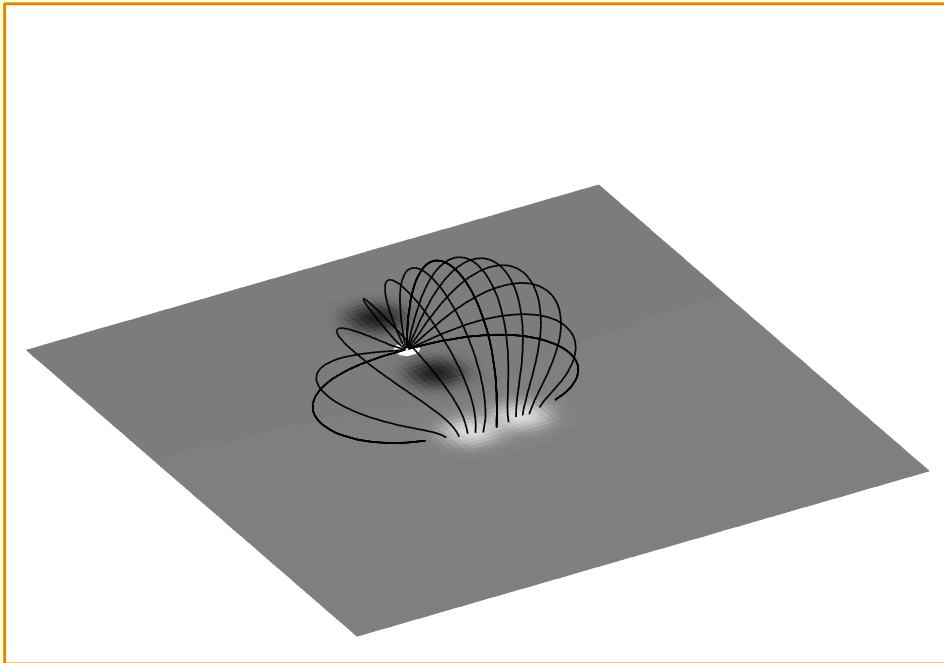
S_2 N_2

Priest (2014)

A Discrete Source Study

- Produce an intersected state topology with four sources

- Focus on effect moving pairs of sources close together has on topology

A Continuous Source Study

- A continuous source model of same configuration
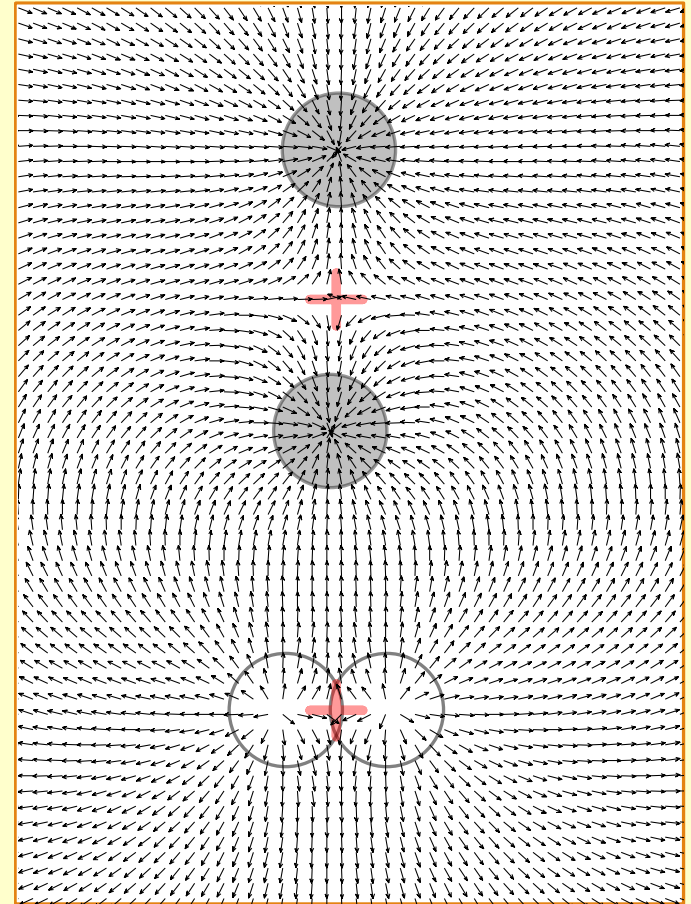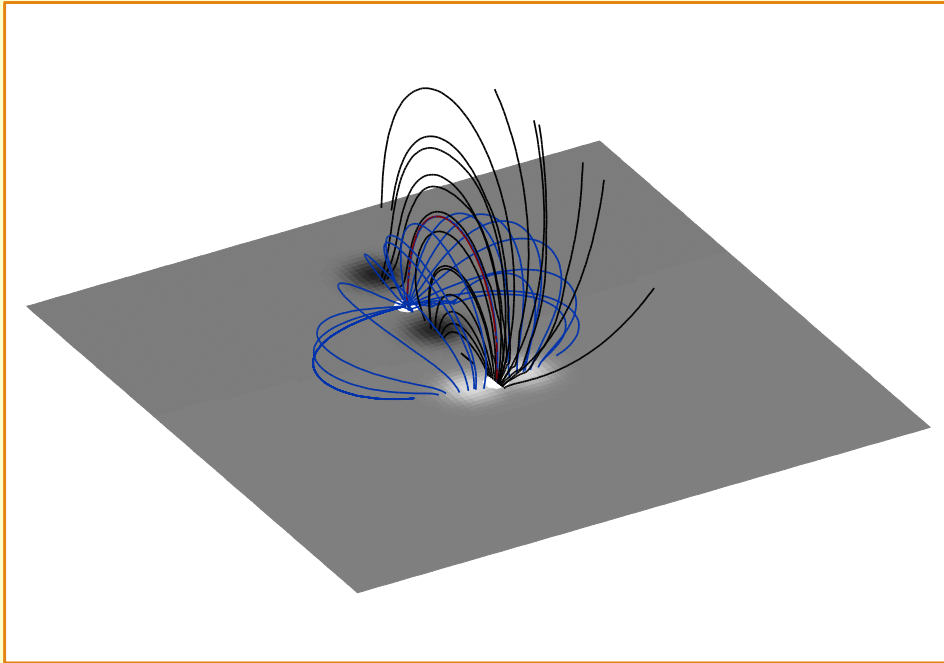
Null-Like Features

- We can define null-like points
  - Locations where
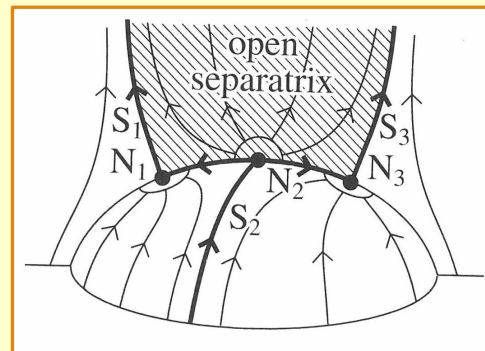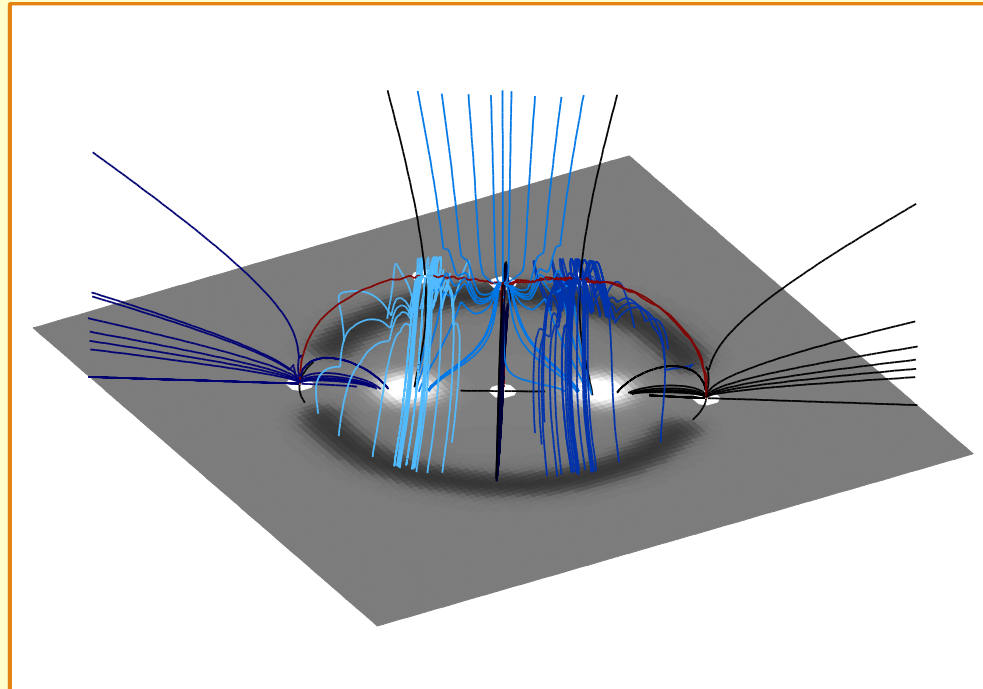 $$\boldsymbol{B}_x = \boldsymbol{B}_y = 0 \, , \boldsymbol{B}_z \neq 0$$
  - Only on z=0 plane
  - Forms an x-line structure

- Separatrix-like surfaces generated from these points

- Intersections in surfaces form separator-like field lines

A Complete Continuous Topology

- Null-like point preserves separatrix wall

An Open Separatrix Surface

Priest (2014)

Conclusions

Consideration of null-like points is required for a complete picture of a topology

- For Priest (2014) case, inclusion of null-like points suggests open separatrix may not be as open as previously thought