A Generalised Flux Function for 3D Reconnection

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with

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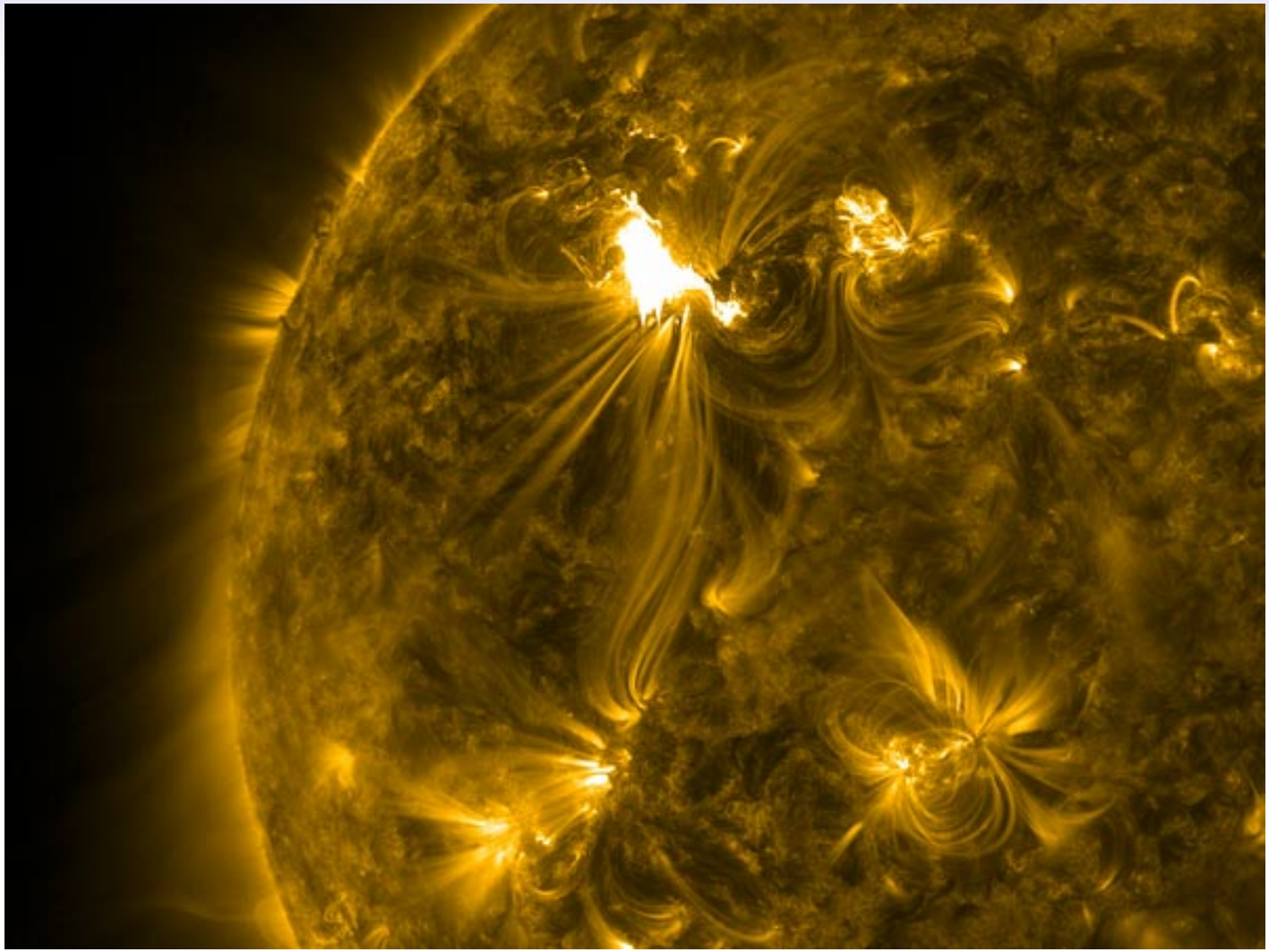
RAS National Astronomy Meeting 2012, Manchester

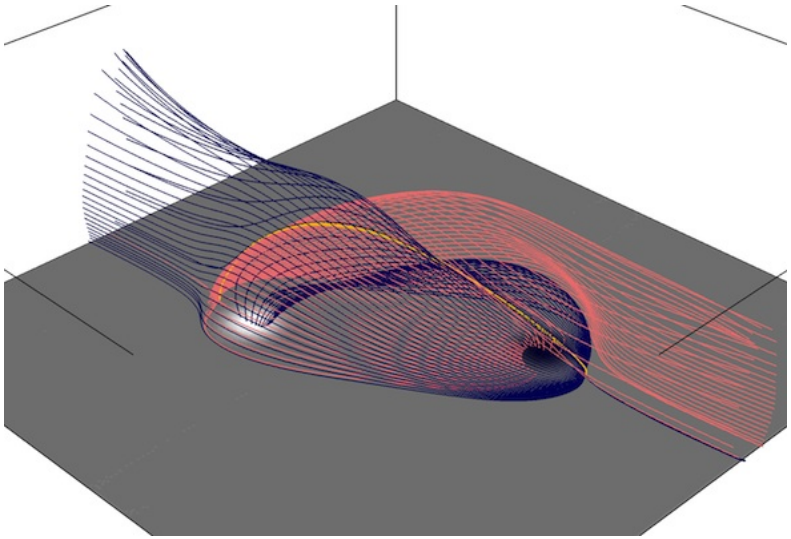


SDO/AIA, 6th March 2012

Magnetic reconnection: the change of connectivity of magnetic field lines in a non-ideal plasma. **Can occur anywhere in 3D**

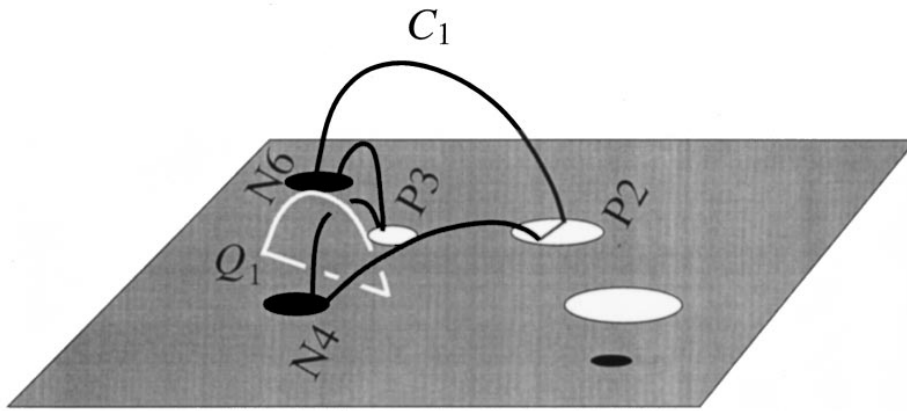
Magnetic field partitions

3D magnetic skeleton



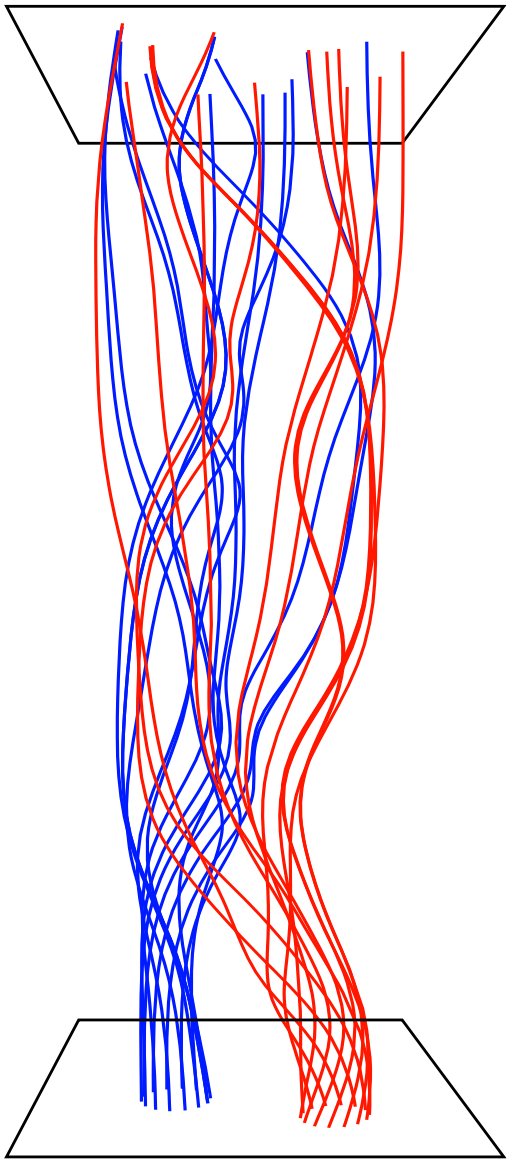
Parnell, Haynes & Galsgaard, 2010

Boundary connectivity

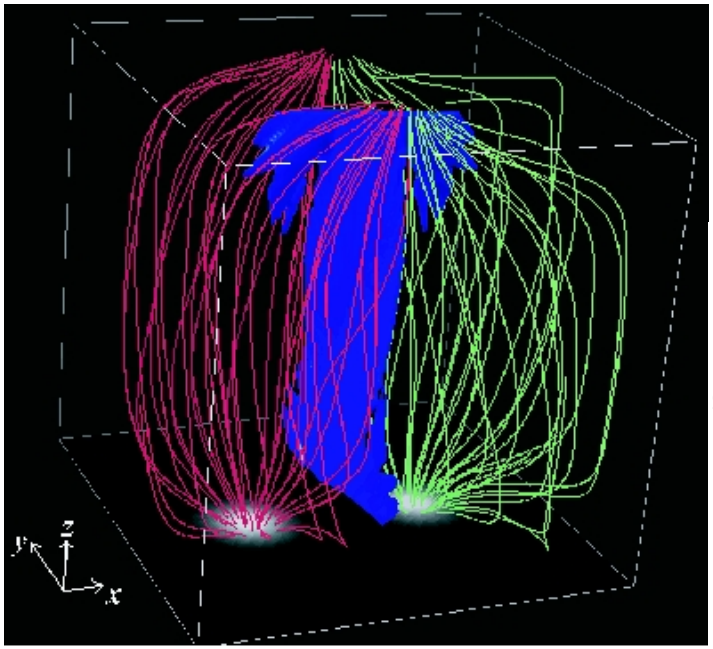


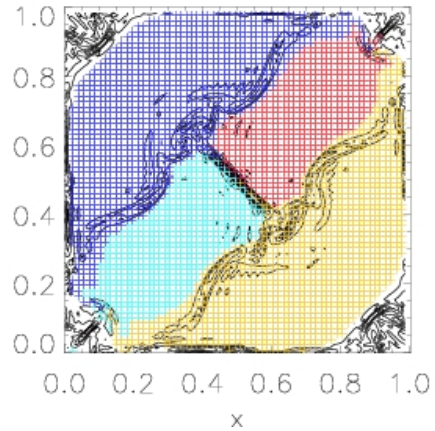
Longcope, 2001

How to partition a flux tube?



Sometimes by boundary connectivity (toroidal fluxes):





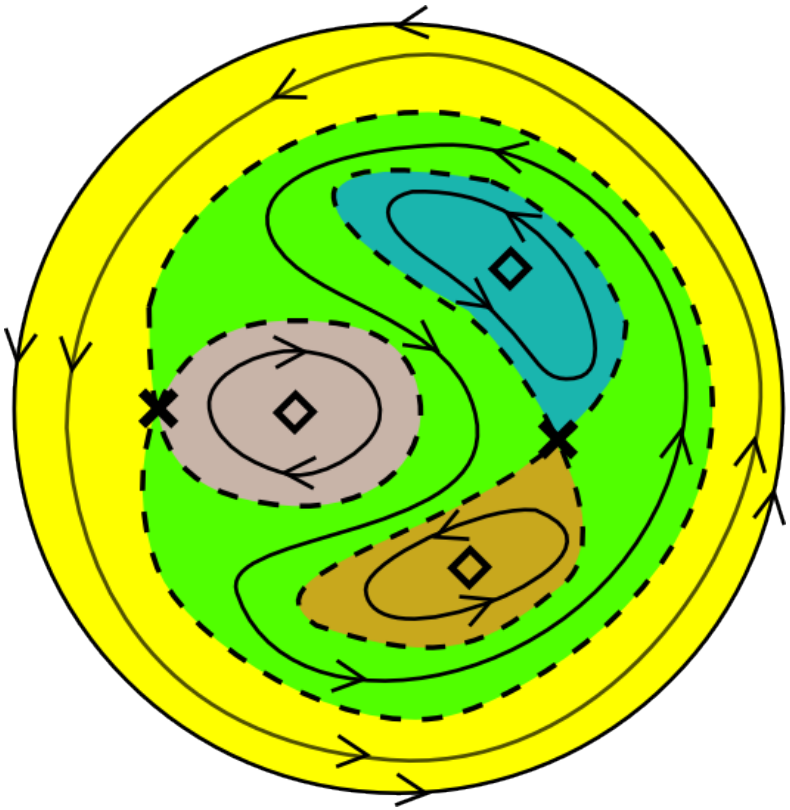
Wilmot-Smith & De Moortel, 2007

What about poloidal (horizontal) fluxes?

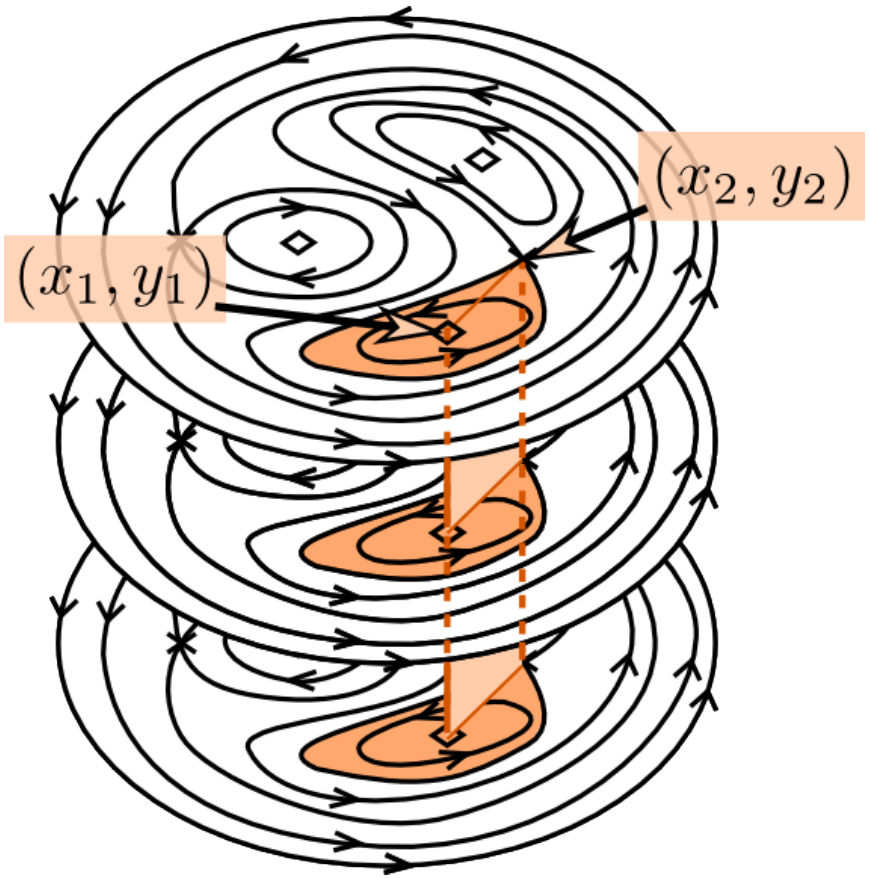
2D reconnection

Poloidal flux, e.g.

$$\Phi = \int \mathbf{B} \cdot d\mathbf{a} = \oint \mathbf{A} \cdot d\mathbf{l}$$
$$= A(x_1, y_1) - A(x_2, y_2)$$

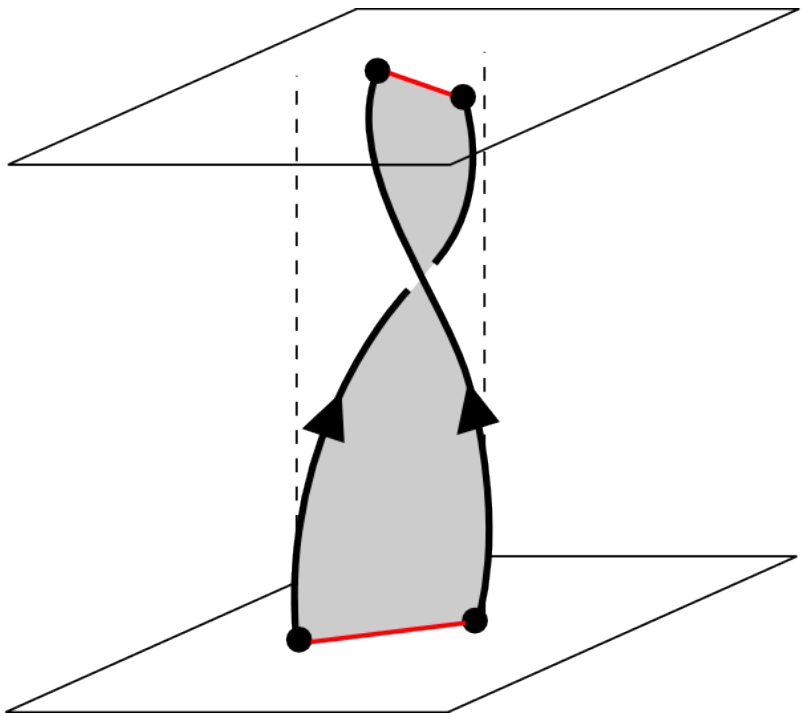


$$\mathbf{B}(x, y) = \nabla \times \left[A(x, y) \mathbf{e}_z \right]$$



Generalised flux function

$$\mathcal{A}(x,y) = \int_{(x,y)}^{\mathbf{F}_1(x,y)} \mathbf{A} \cdot d\mathbf{l}$$



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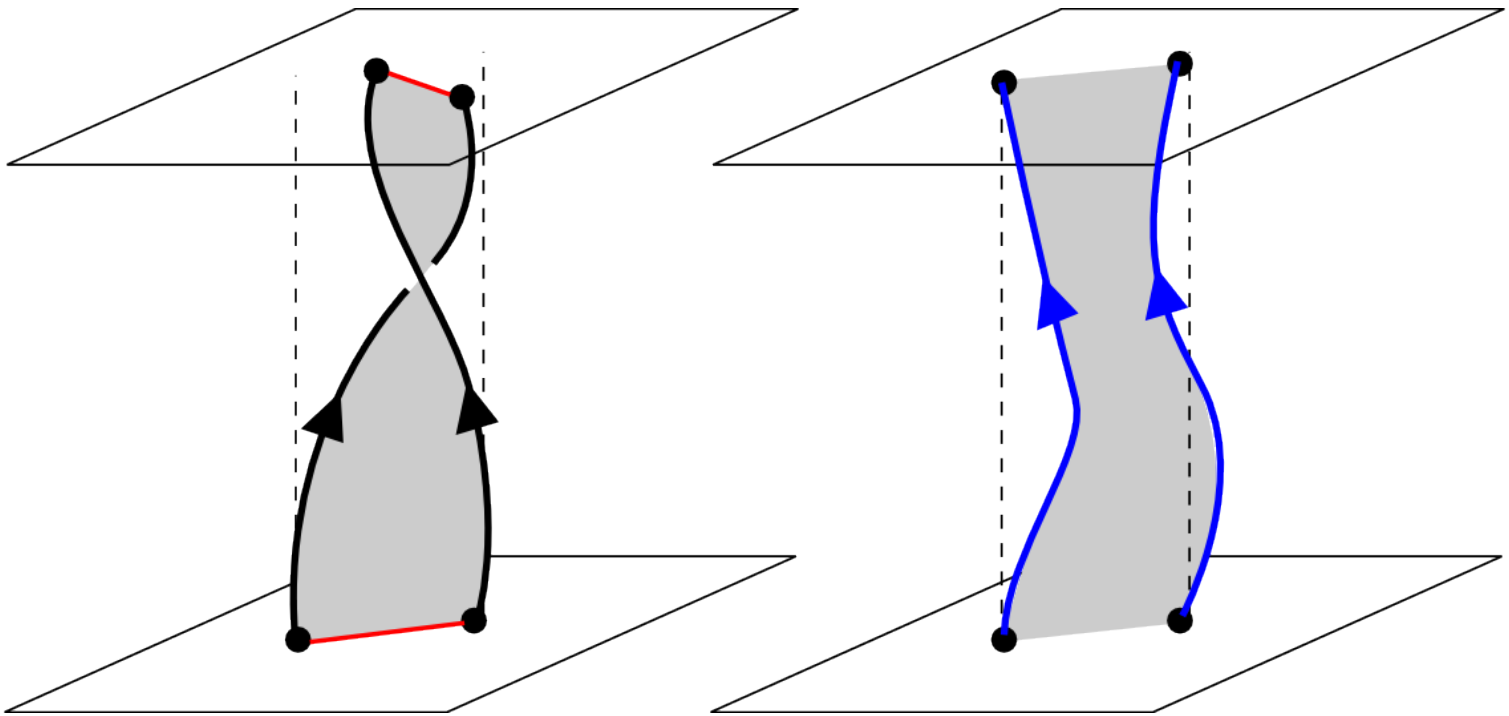

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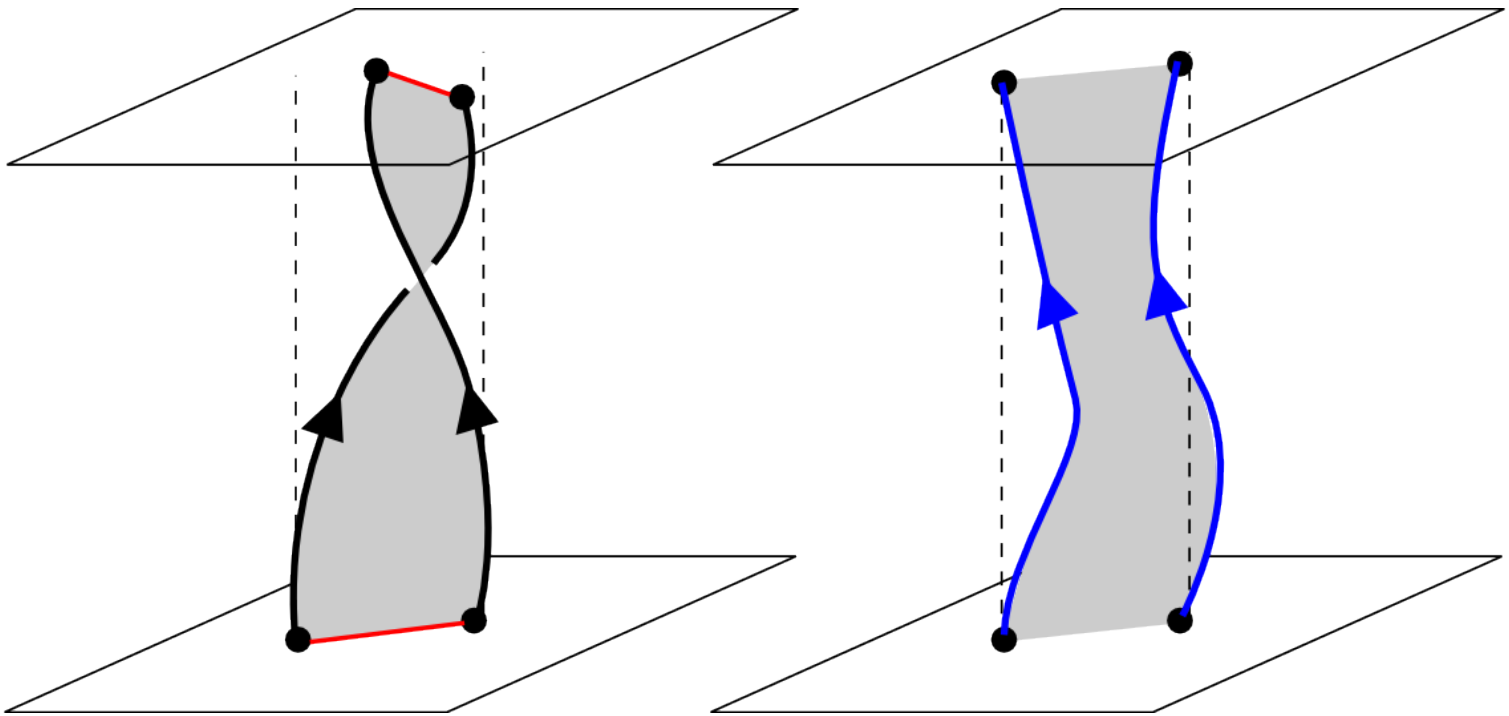
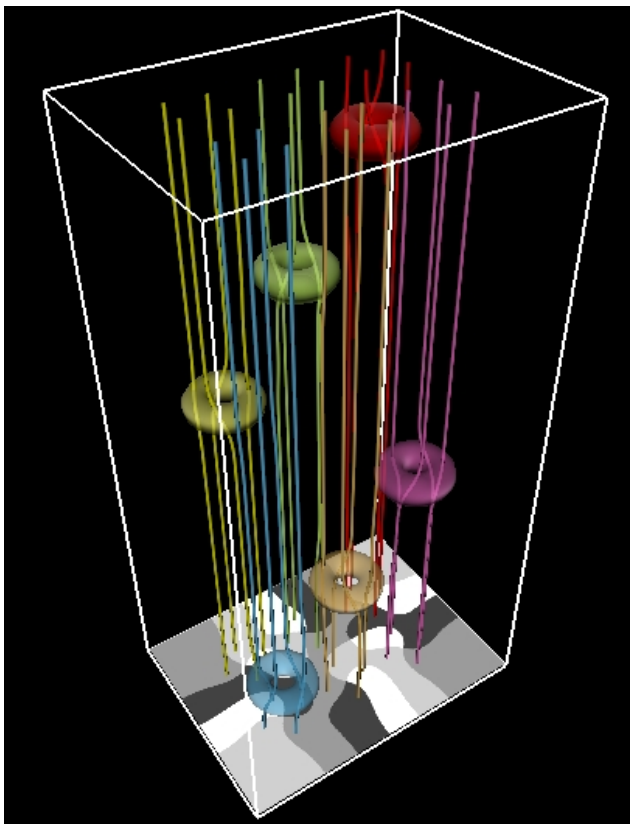


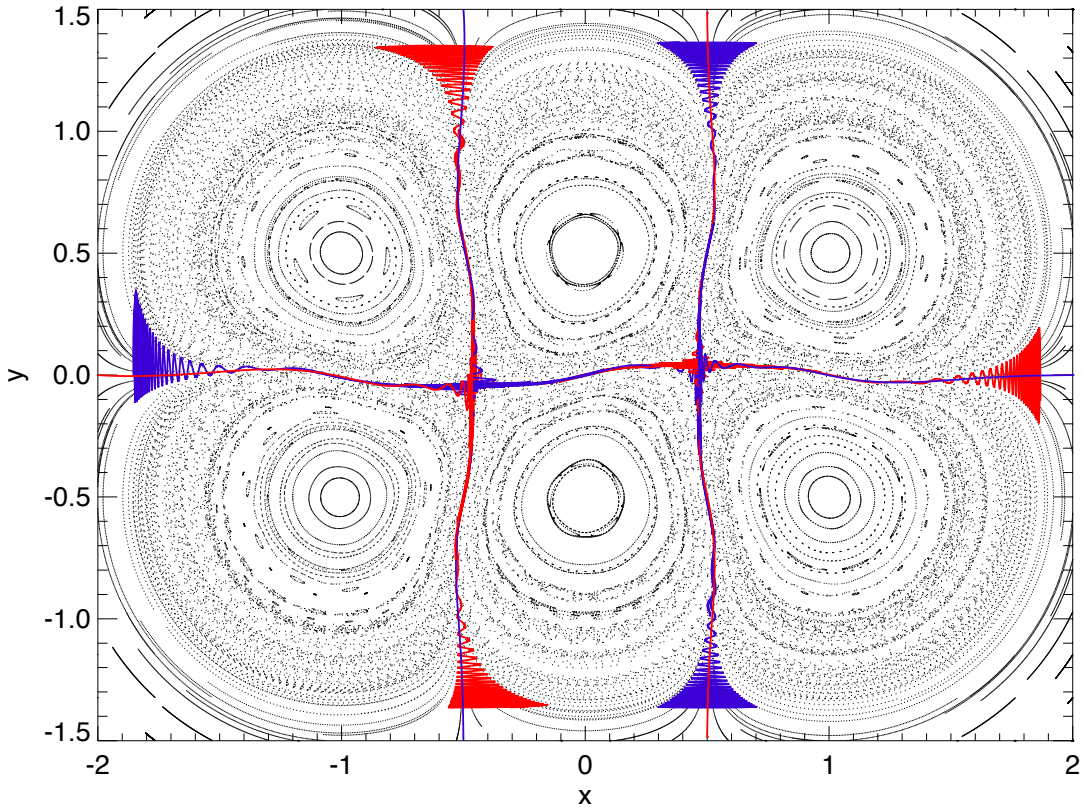
Gauge transformation $\mathbf{A} \to \mathbf{A} + \nabla\psi$ gives

$$\mathcal{A}(x,y) \to \mathcal{A}(x,y) + \psi\Big|_{(x,y)}^{\mathbf{F}_1(x,y)}.$$

Example

Flux tube with six twist regions:





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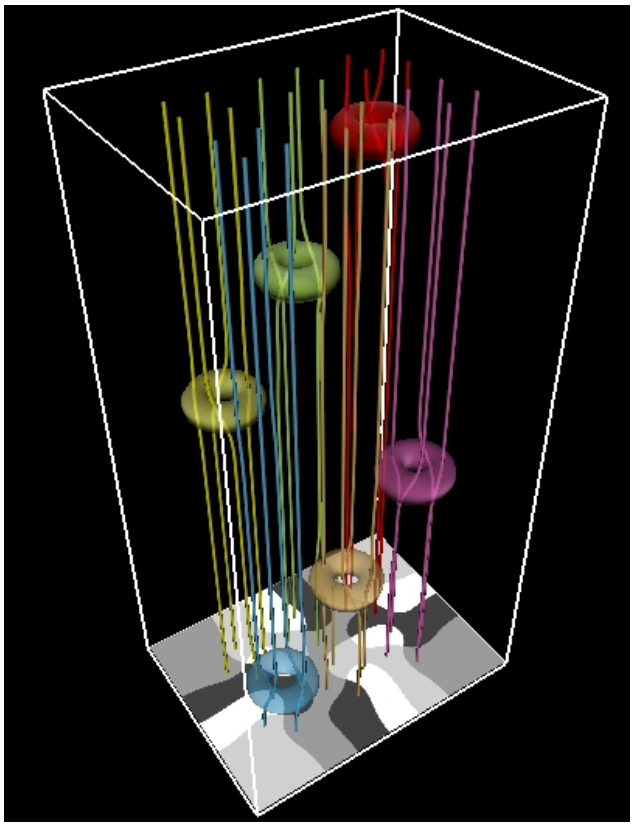

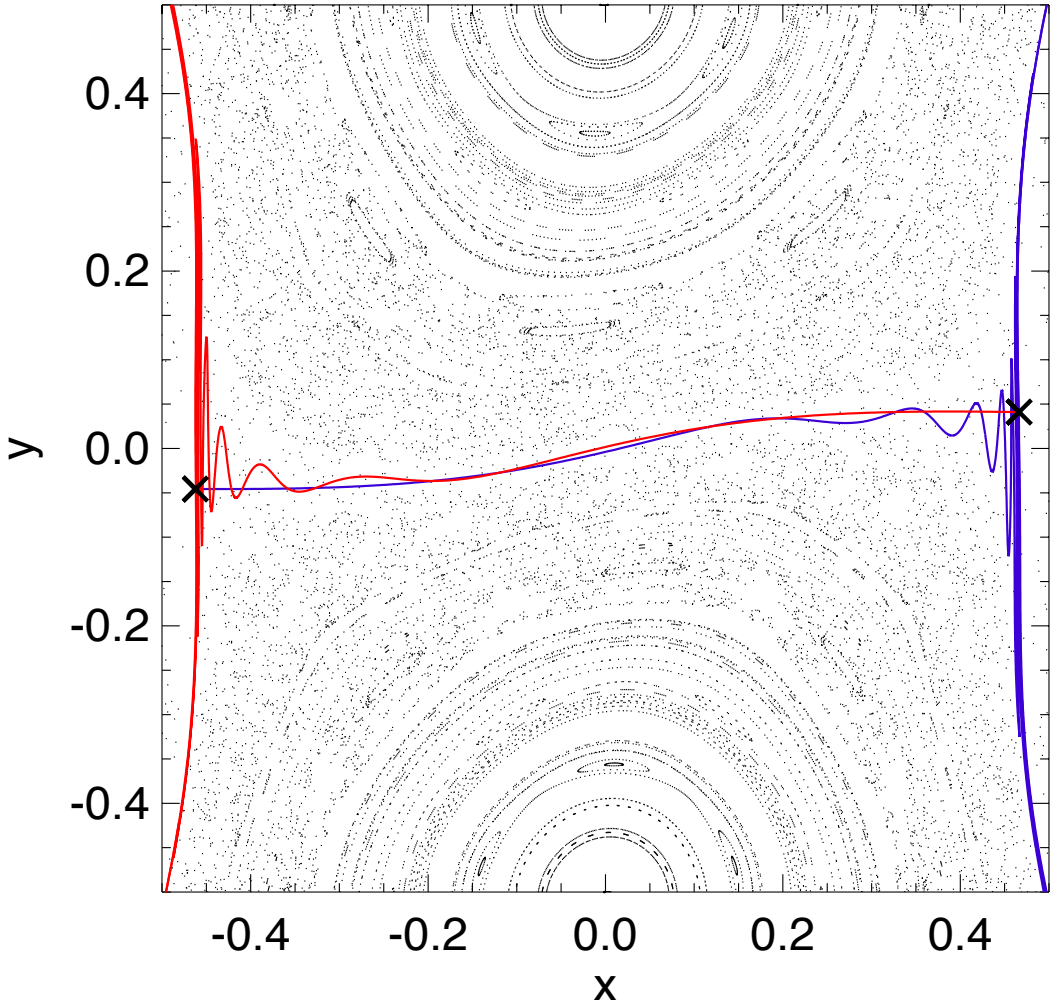

(Un)stable manifolds used method of Krauskopf & Osinga (1998).

Conclusion

- Partition of poloidal fluxes in a non-zero flux tube.
- Measured by generalised flux function $\mathcal{A}(x, y)$ at periodic points.
- Well-defined measure of global reconnection.
- Partition could be refined using higher period orbits.

Further details

- Yeates & Hornig, *Phys Plasmas* **18**, 102118 (2011).

`http://www.maths.dur.ac.uk/~bmjg46/`

APPENDICES

Non-periodic flux tubes