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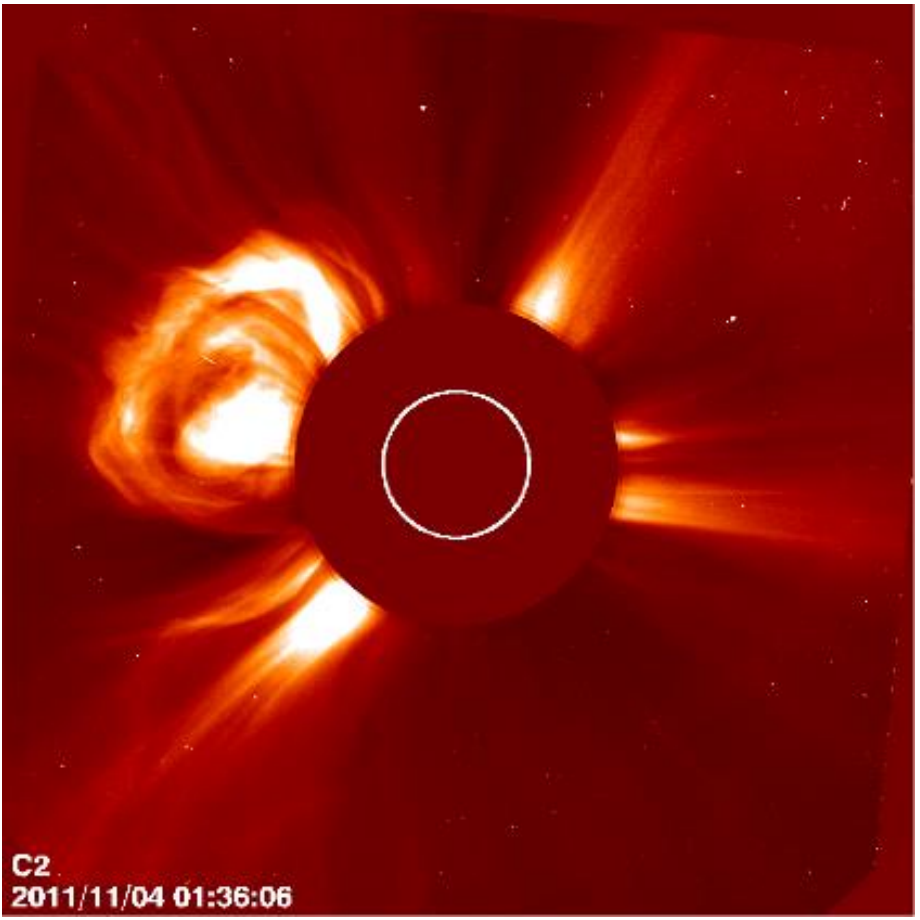

The radial evolution of a magnetic cloud

Solar Orbiter summer school, L'Aquila

22/09/2014

Simon Good

Supervisor: Robert J. Forsyth

Imperial College London

Presentation outline

1. My PhD topic
2. The November 2011 event
3. Magnetic field and plasma data
4. Overlapped magnetic field data
5. Key findings
6. Summary

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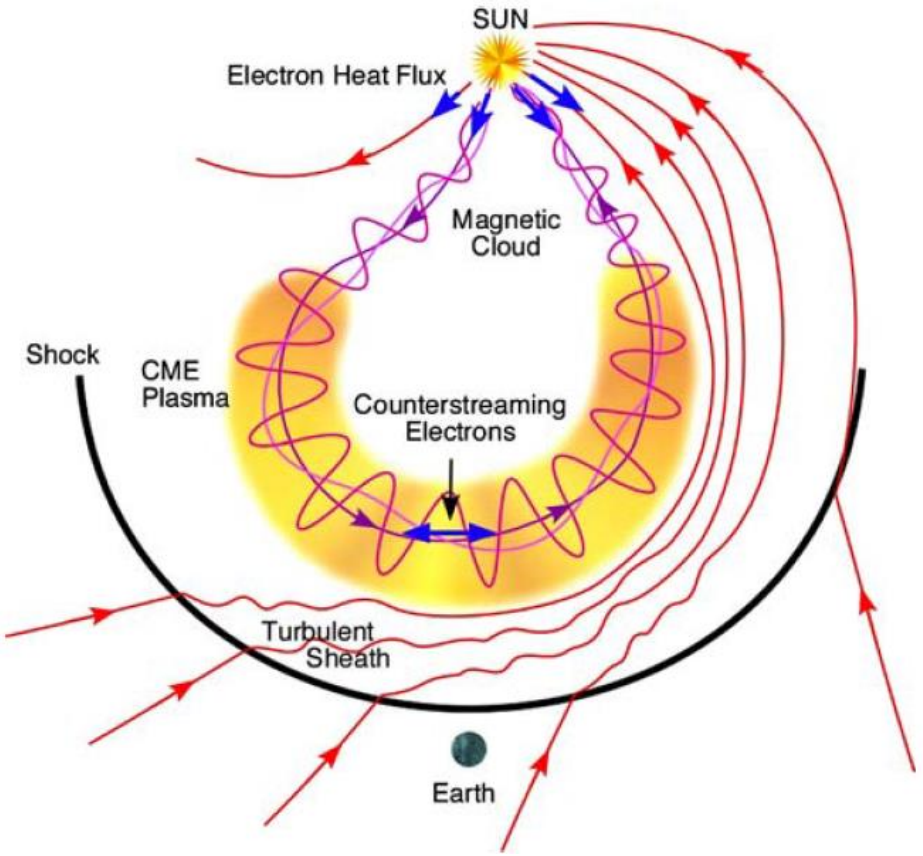
My PhD topic

- CMEs are discrete, large scale eruptions of magnetic field and plasma from the Sun

→ How do CMEs evolve during propagation?

→ How do CME-solar wind interactions affect CME kinematics, dynamics and morphology?



Zurbuchen and Richardson (2005)

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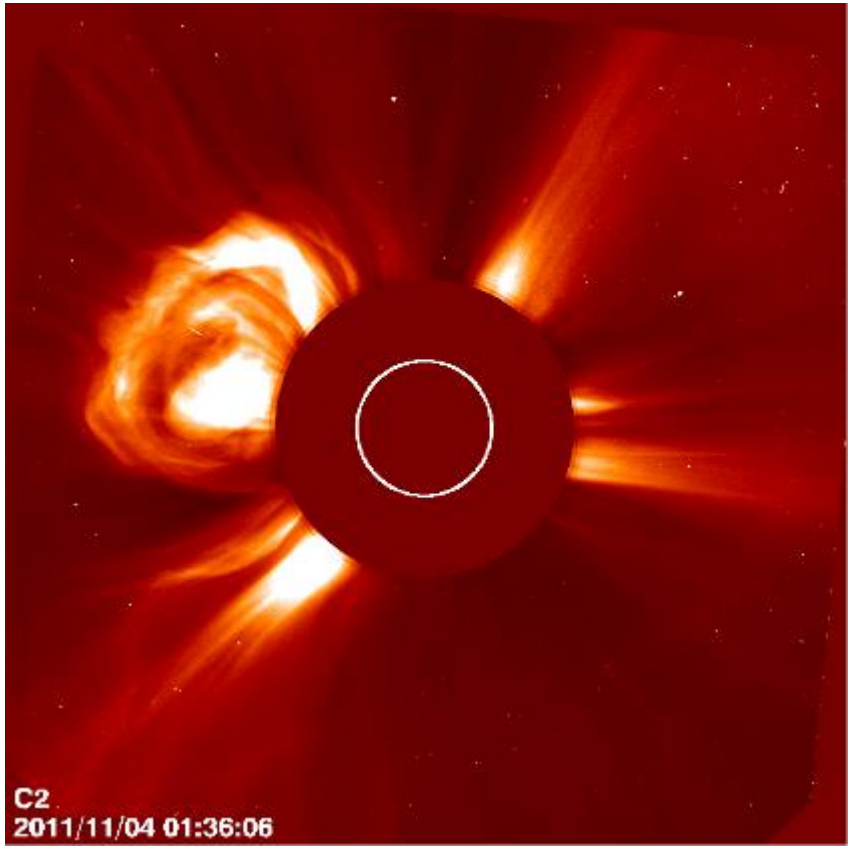
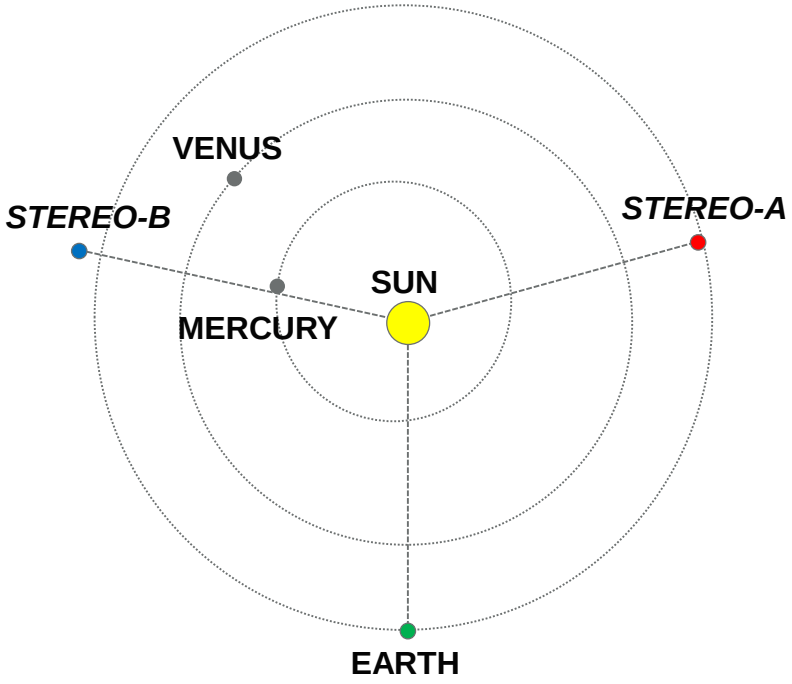
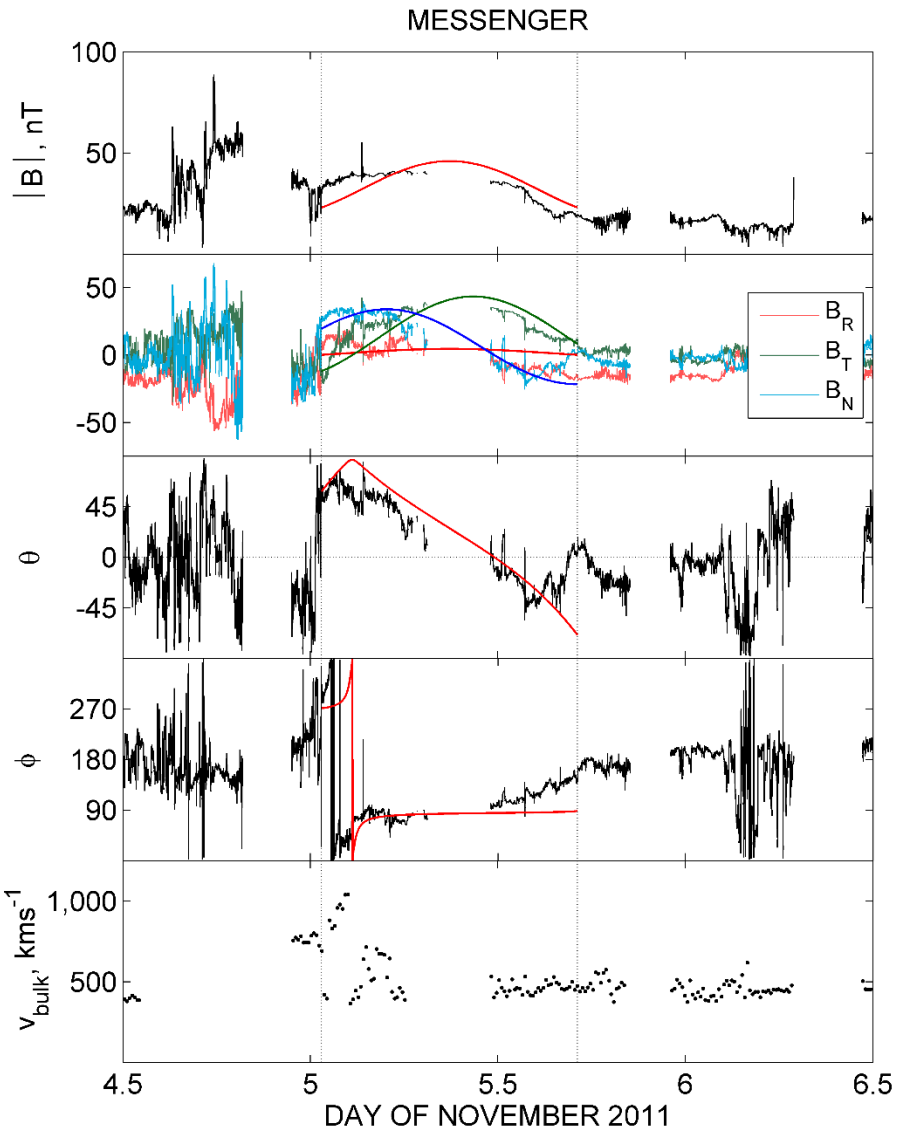
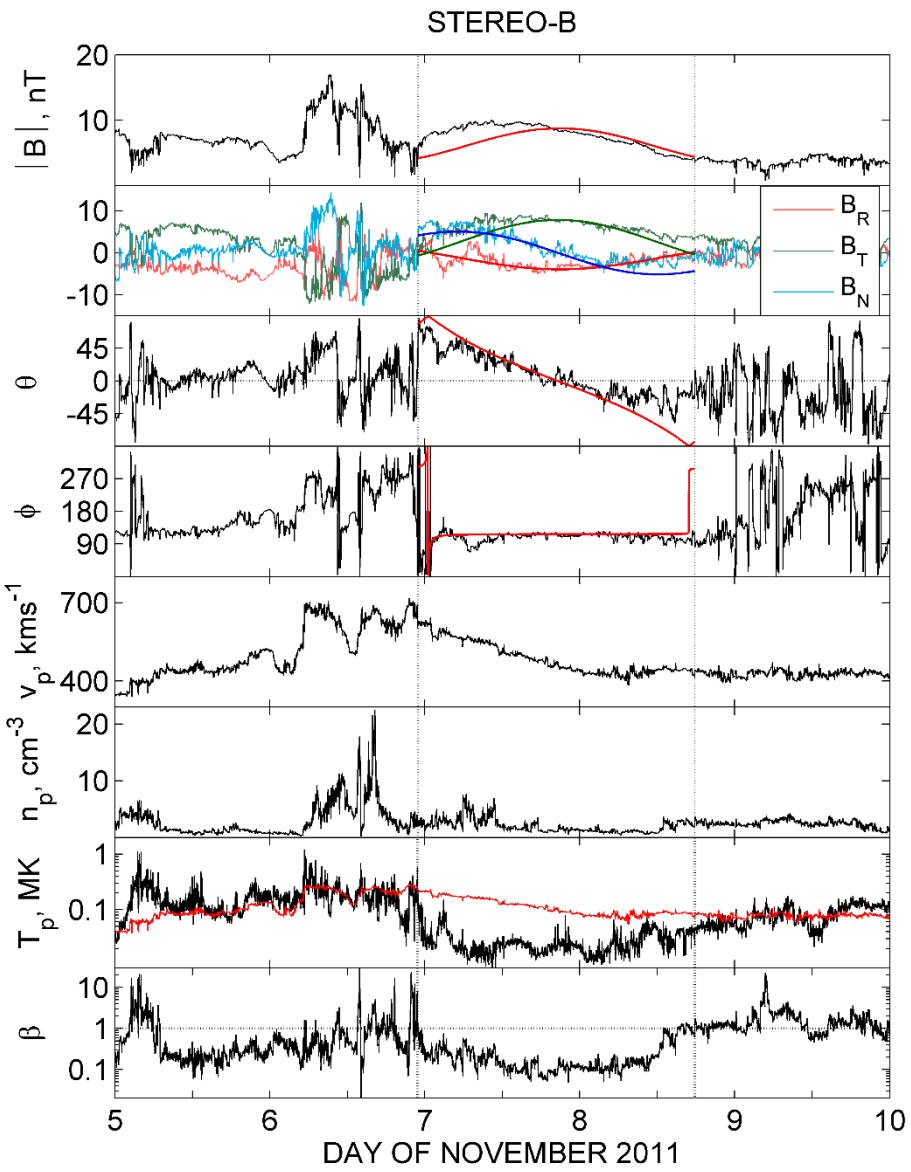
The November 2011 event



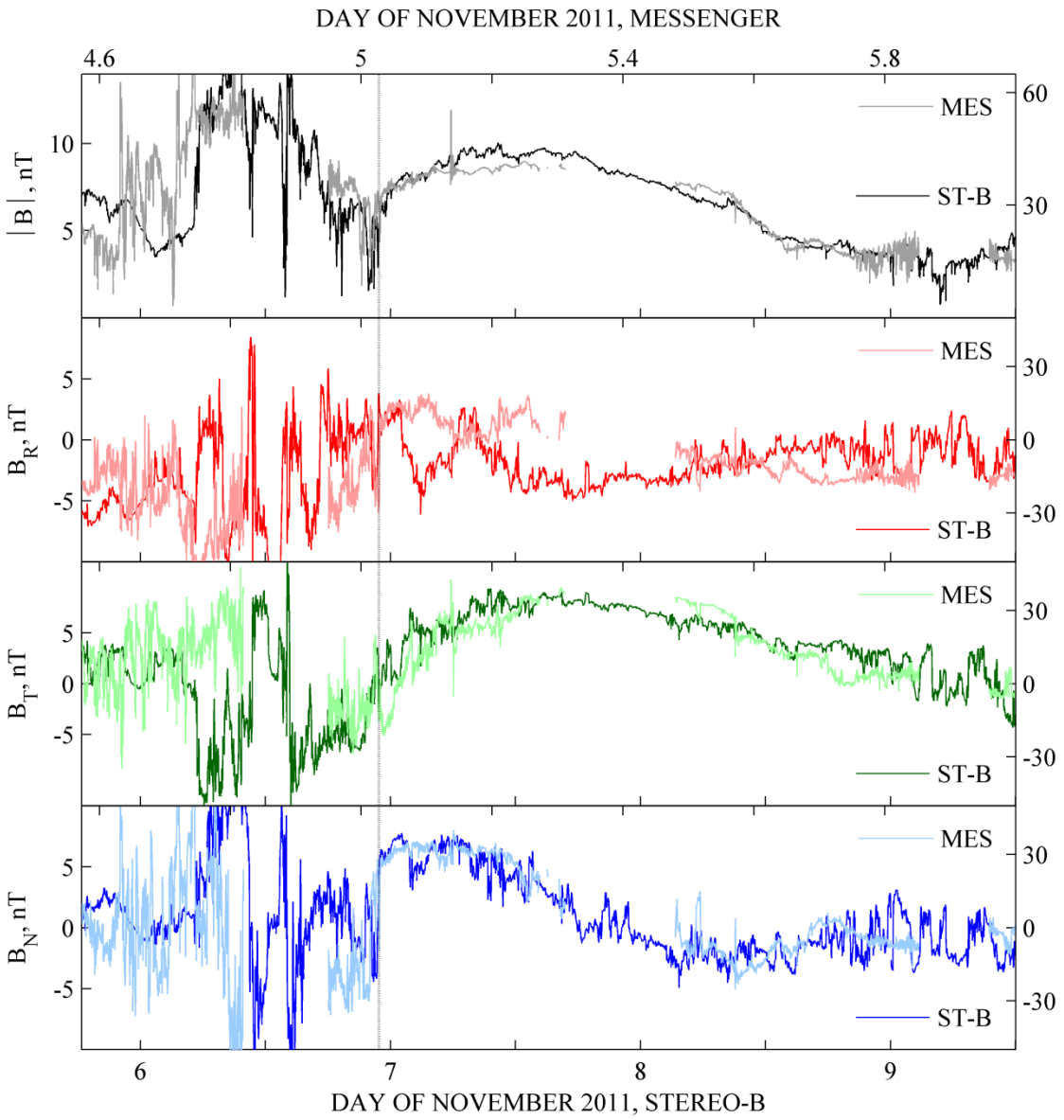


November 2011 event - in situ data





Overlapped B-field data



- Very good correlation between B-field magnitude, B_T and B_N component
- Weaker correlation in the B_R component
- Approximately self-similar radial expansion

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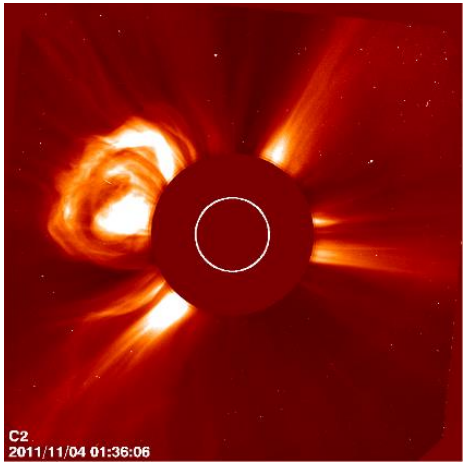
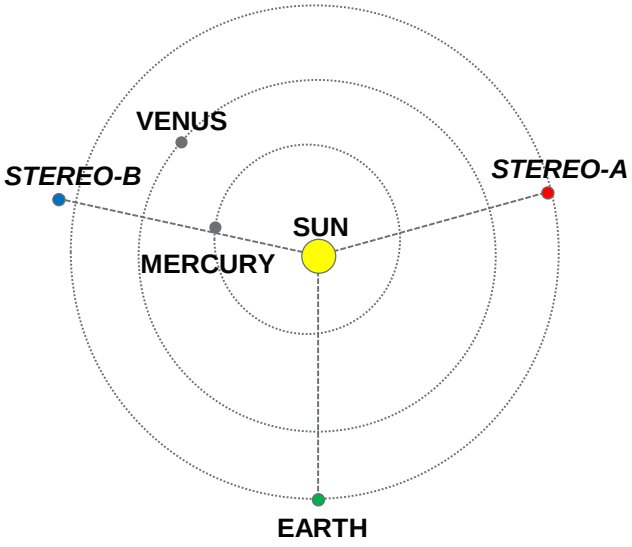
Key findings





	MESSENGER	STEREO-B
Distance of s/c from Sun, AU	0.44	1.09
Sheath arrival time	2011 Nov 4 15:09 UT	2011 Nov 6 05:09 UT
Flux rope arrival time	2011 Nov 5 00:43 UT	2011 Nov 6 22:56 UT
Flux rope end time	2011 Nov 5 17:05 UT	2011 Nov 8 17:49 UT
Leading edge speed, km/s	~ 700	618
Trailing edge speed, km/s	~ 450	440
Rope handedness (force-free)	-1 (left handed)	-1 (left handed)
Impact parameter (force-free)	0.02	0.01
Rope axis orientation (force-free)	$\theta_R = 26°$, $\varphi_R = 84°$	$\theta_R = -4°$, $\varphi_R = 117°$
Axis B-field strength, nT (force-free)	46.0	8.8
$S = v_{Bmax} \cdot t$, AU	0.22	0.56
Flux rope cylinder diameter, AU	0.22	0.50
Magnetic flux, nT AU^2	1.69	1.69

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Summary

- Magnetic clouds are a magnetically structured and coherent subset of CMEs observed in situ
- I have shown an example of a magnetic cloud observed at two radially aligned spacecraft, at different heliocentric distances; such radial observation allows the purely radial evolution of the cloud to be ascertained
- There is evidence to suggest that the magnetic cloud expanded, rotated and conserved its magnetic flux
- I am currently analysing a number of other such radially observed CMEs and hope to draw some general conclusions from this wider analysis

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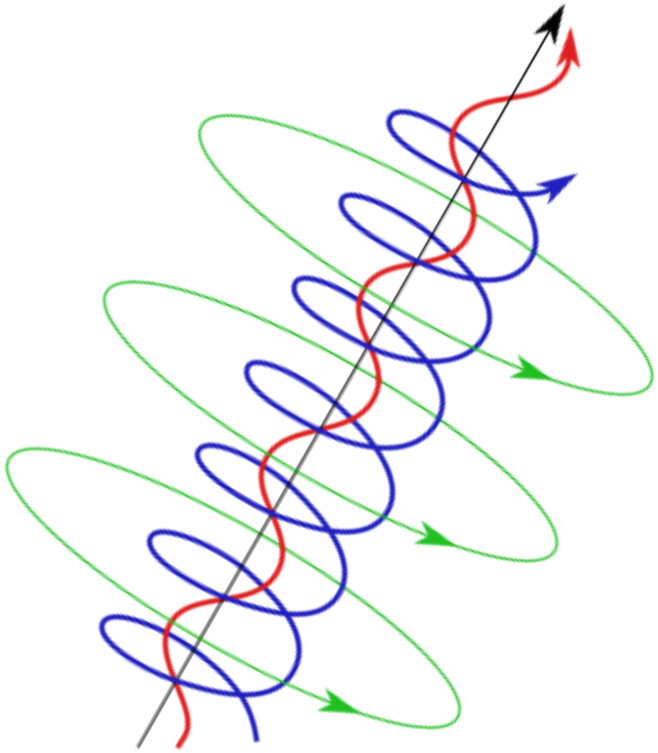
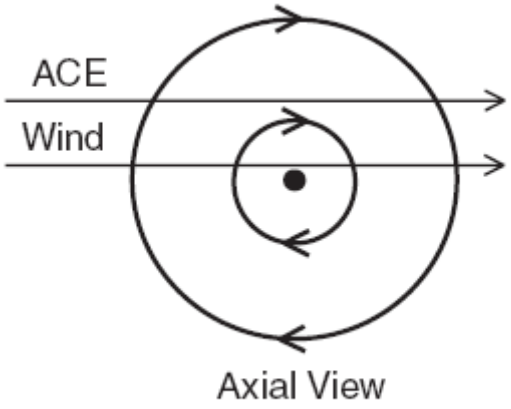
Flux ropes; flux rope model



- Set of nested, helical field lines wound around a central axis
- Common space plasma structures
- Can we estimate global parameters (e.g., axis orientation) from a single spacecraft crossing?

$$\nabla^2 B = -\alpha^2 B \quad \rightarrow \quad \begin{aligned} B_A &= B_0 J_0(\alpha R) \\ B_T &= H B_0 J_1(\alpha R) \\ B_R &= 0 \end{aligned}$$



Burlaga, 1988