

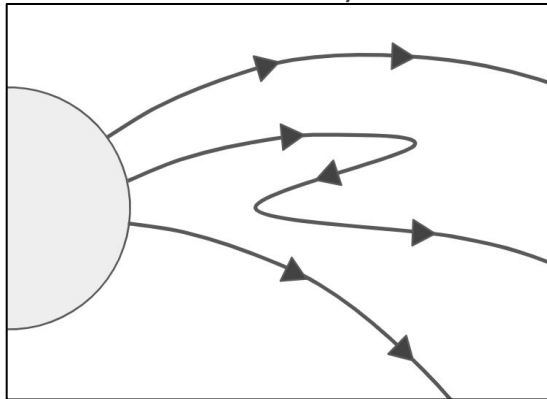
Radial Evolution of Inverted Heliospheric Magnetic Field Between 0.3 and 1 AU

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Introduction: Inversions

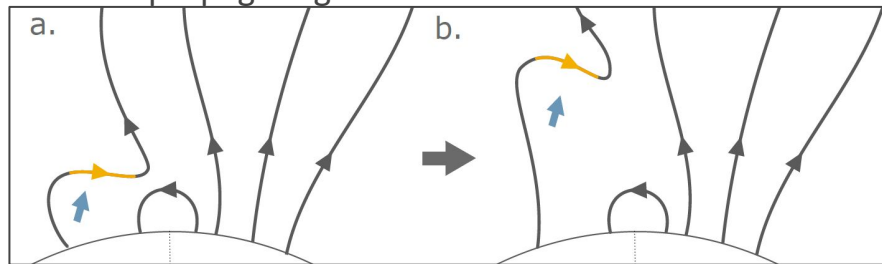
Schematic of inversion/reversal



Heliospheric magnetic field (HMF) can locally fold back on itself: 'inversions'/'reversals'

PSP sees numerous reversals which are Alfvénic + outward propagating, possibly caused by coronal jets ('switchbacks': Bale *et al.* 2019; Kasper *et al.* 2019)

Outward propagating switchback



But inversions also found at 1 AU and beyond (Kahler *et al.* 1996; Balogh *et al.* 1999)

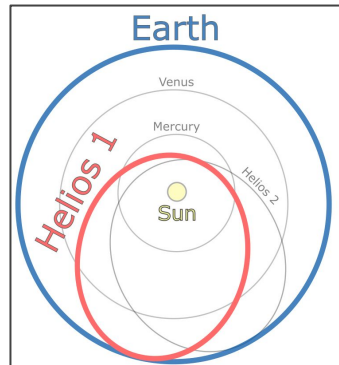
Q:

Are all inversions formed at the Sun and decaying?

or is there an *in situ* driving process for these inversions?

Helios: Inverted Flux Occurrence

Helios orbit

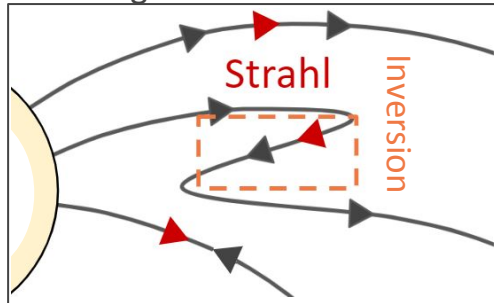


Adapted:
<http://helios-data.ssl.be.keley.edu/about/>

Helios 1 measurements of solar wind 0.3-1 AU, 1974-1981.

Get solar wind + field samples on 40 s cadence.

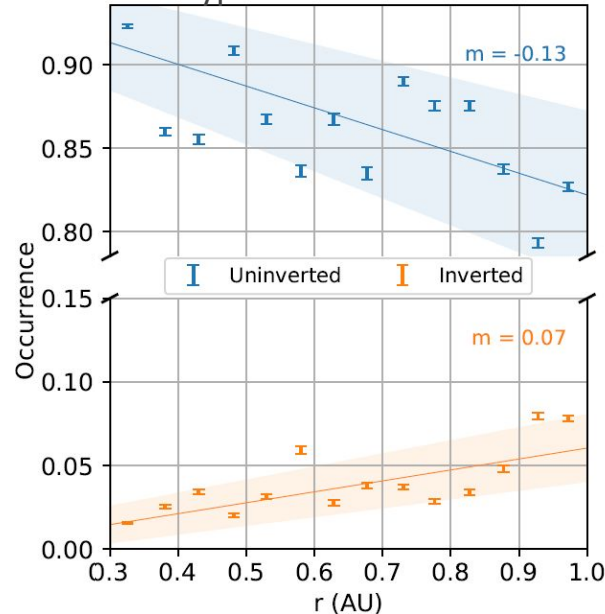
Strahl signature of inversions



Identify inverted HMF samples using 220 eV **strahl electron direction** and HMF polarity relative to Parker spiral.

Compute **fraction of inverted samples** as function of distance r .

HMF type vs. r



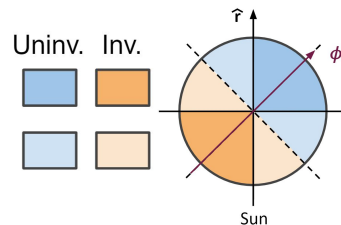
Inverted HMF occurrence increases with radial distance.

Suggests driving of inversions.

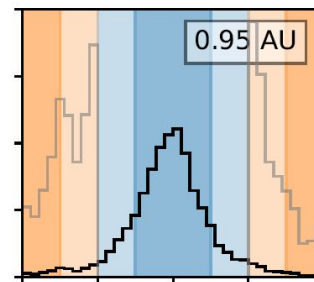
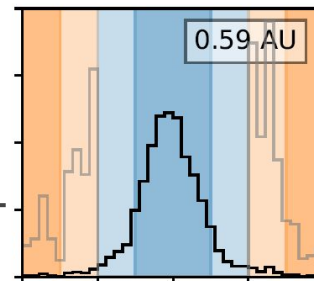
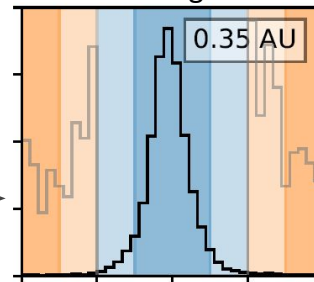
Field Deflection Angle

Q: What driving processes cause inversion occurrence to grow with r ?

Histograms of $\Delta\phi_p$: angle from Parker spiral (use magnetic sector **verified by strahl**).



Deflection angle



r

↓

No strong **+/- bias** in inversion direction:

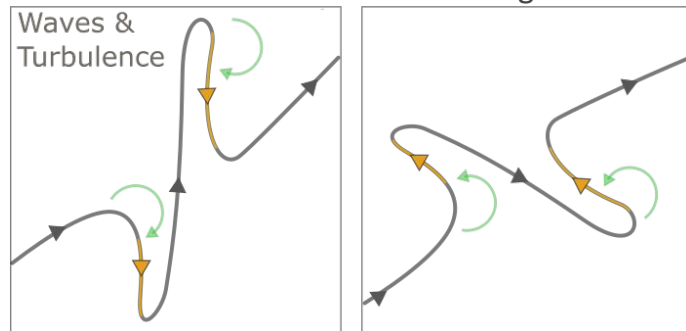


Waves/turbulence are primary driver?

$\Delta\phi_p$ continuous over $\pm 90^\circ$:

Same process causing generic deflections and full inversions of the field.

Schematic of Fluctuations Generating Inversions



Waves can invert field in **either direction**. Expect velocity field structures (large shears/ejecta) to invert field only clockwise (see **bonus page**).

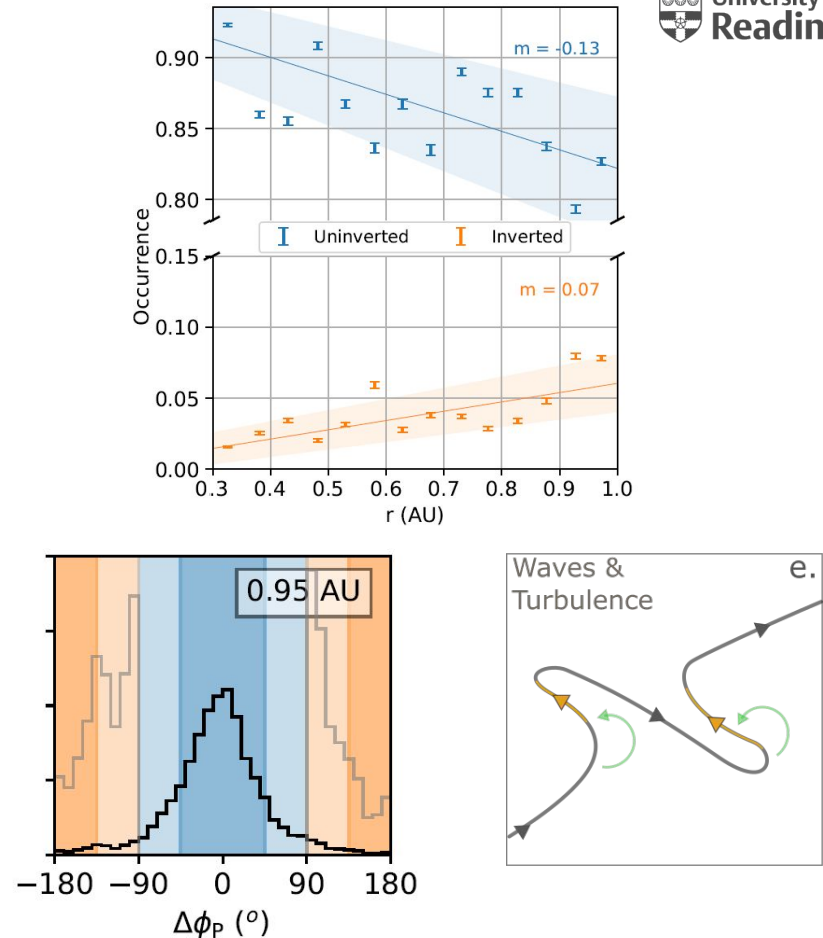
Summary

The occurrence of inverted fields increases with distance from the Sun.

Inversions from 0.3 to 1 AU are primarily driven *in situ* rather than formed at the Sun.

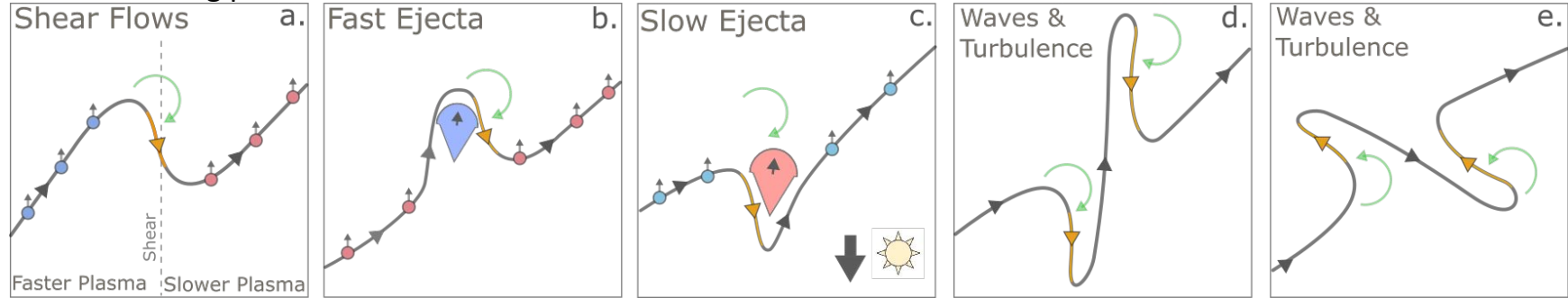
Waves or turbulent fluctuations may be dominant because of symmetry of inversion direction.

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Bonus Page: Driving Schematics

Possible driving processes for inversions



Summary of possible processes which could drive inversions into the field.

- a. **Velocity shears** threaded by a magnetic flux tube act to align field with the shear → can invert field if goes **clockwise** from Parker spiral direction.
- b. and c. **Ejecta** (e.g., CME or blob) drapes background field over it, inverts field in some manner as shear - **only clockwise**.
- d. and e. **Waves/turbulent fluctuations** distort field, and potentially invert it **in either direction**.

Note shears+turbulence could also invert field (Landi *et al.* 2005, 2006)

References

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