[poster id 151] WG2: Interplanetary

Small flux ropes and associated global structures identified from multi-point observations with PSP, STEREO-A and Wind

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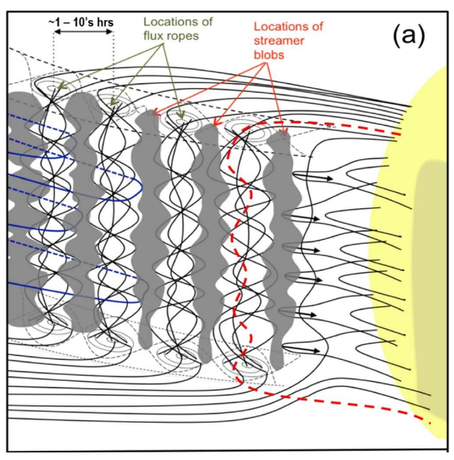
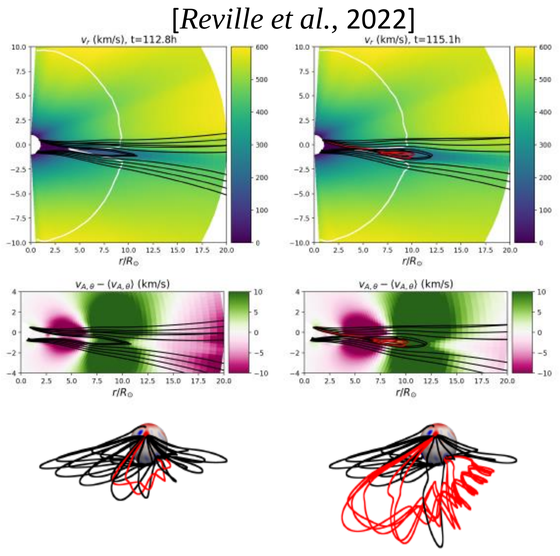
Background & Motivation

- Interplanetry magnetic flux rope is one of the structures of the interplanetary magnetic field (IMF) in the solar wind.
- Small-scale magnetic flux ropes (SMFRs) are frequently observed at 1AU than magnetic clouds (MCs), and their origin is still under debate.
- The similarity of properties with MCs and other evidence suggest that they may be **generated in the Sun**.
- In contrast, some SMFRs may be **generated in the interplanetary space** which is different from large-scale FRs. The main ideas are based on three factors, that is **reconnection of the outer layers, sector boundary (practically HCS)**, and **self-generation from solar wind turbulence.**
- Some models in the previous studies already suggest that the reconnection within HCS generates a series of FRs.
- We investigate heliospheric propagation of FRs (particularly embedded between successive blobs) during the SC minimum phase with PSP observations accompanied by ~1au observations away with ~70 ° in longitude.

[*Sanchez-Diaz et al.*, 2019; *Lavraud et al.*, 2020]

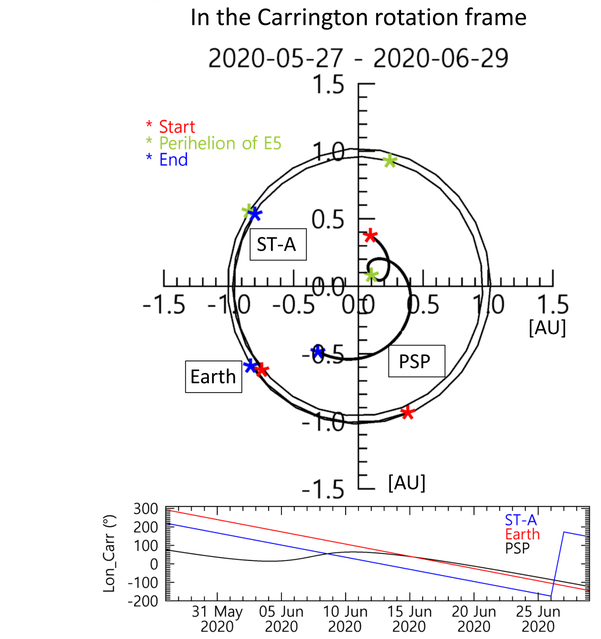


[*Reville et al.*, 2022]



Overview

(a) Angular separation of s/c

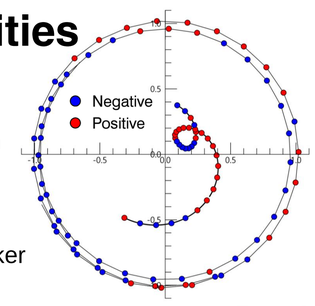


- A specific interval: 27 May, 2020 – 29 June, 2020 (~ one Carrington rotation)
- After the perihelion of PSP (7 June 08:23), PSP meets STEREO-A & Wind in similar longitude.

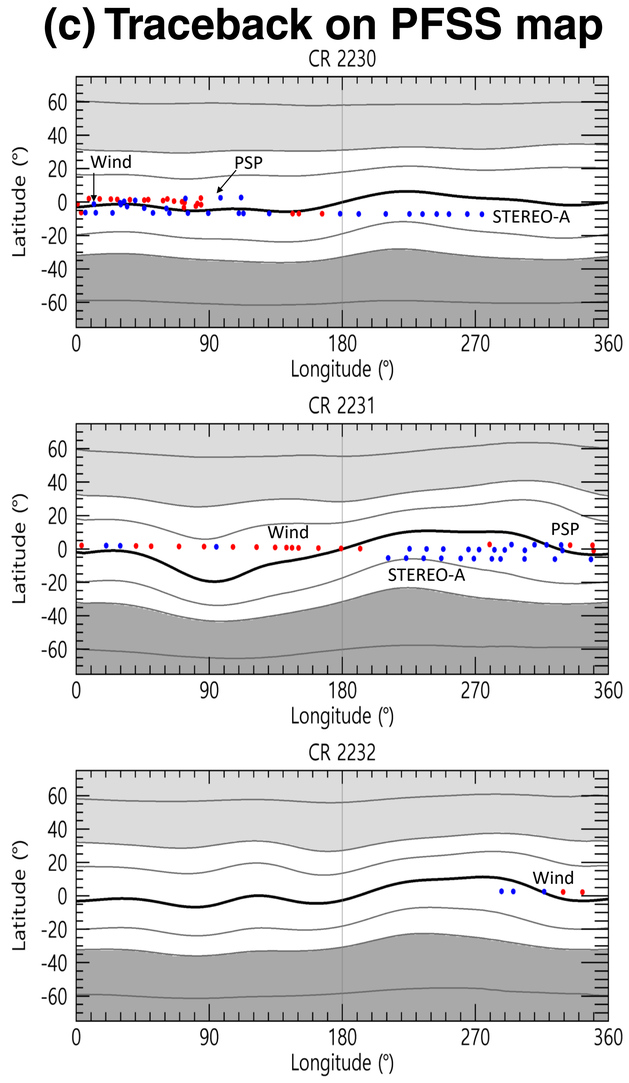
(b) IMF polarities

- Daily polarities of IMF
- s/c orbits projected on equatorial plane

➔ Polarities at similar longitude (or along Parker spiral) seem different.



(c) Traceback on PFSS map

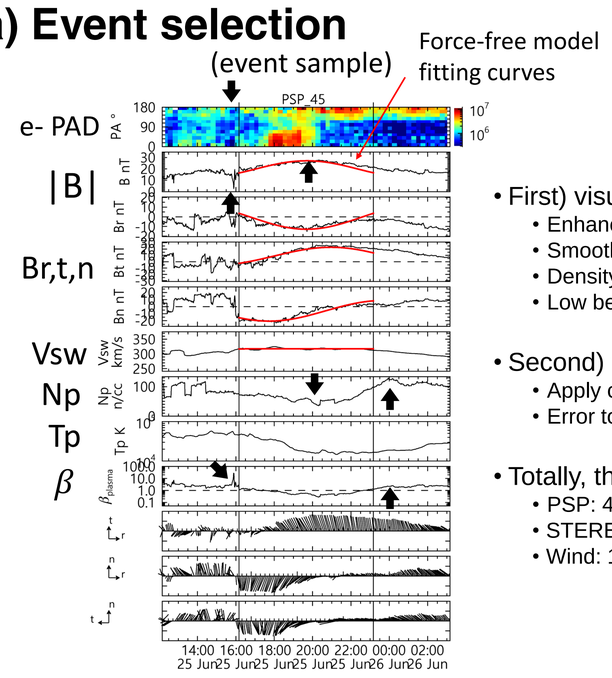


- Daily IMF polarities on PFSS map (source surface = 2.5Rs) using constant speed model.
- Mostly aligned to the neutral line (black thick line).

➔ It comes clear that observed IMF polarities by three s/c are different from each other below and above HCS.

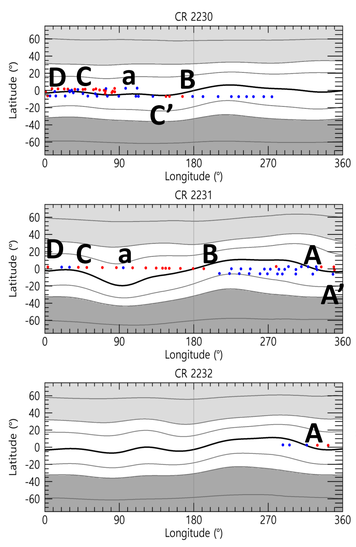
Results

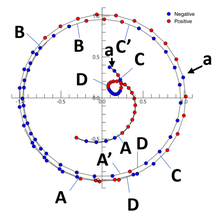
(a) Event selection



- First) visual inspection
  - Enhanced B
  - Smoothly rotation of B components
  - Density drop
  - Low beta
- Second) force-free model
  - Apply cylindrical model
  - Error tolerance: Erms < 0.35
- Totally, the number of SMFRs
  - PSP: 45 (out of 51)
  - STEREO-A: 26 (out of 38)
  - Wind: 10 (out of 16)

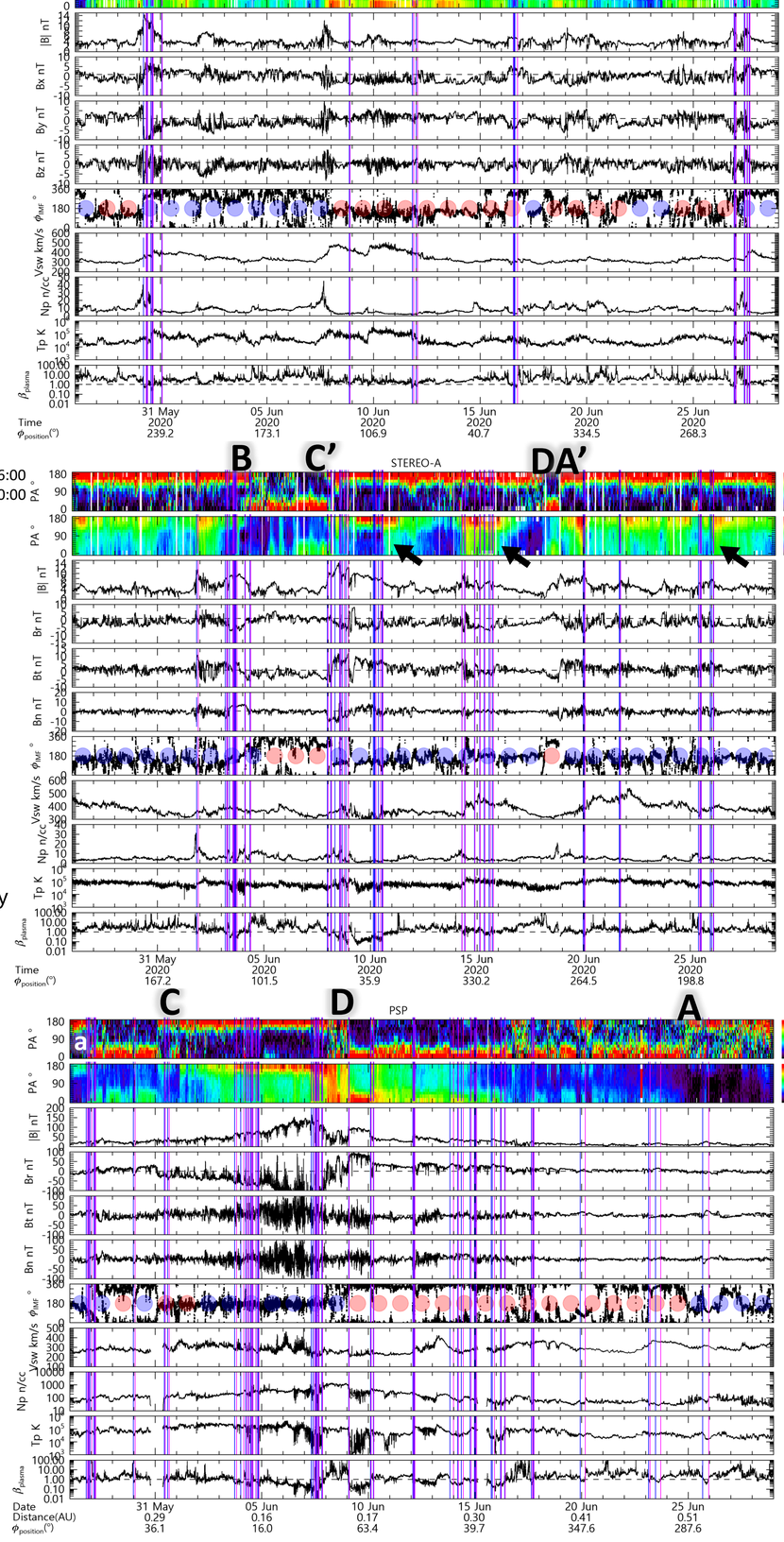
(b) Sector boundaries and HCSs





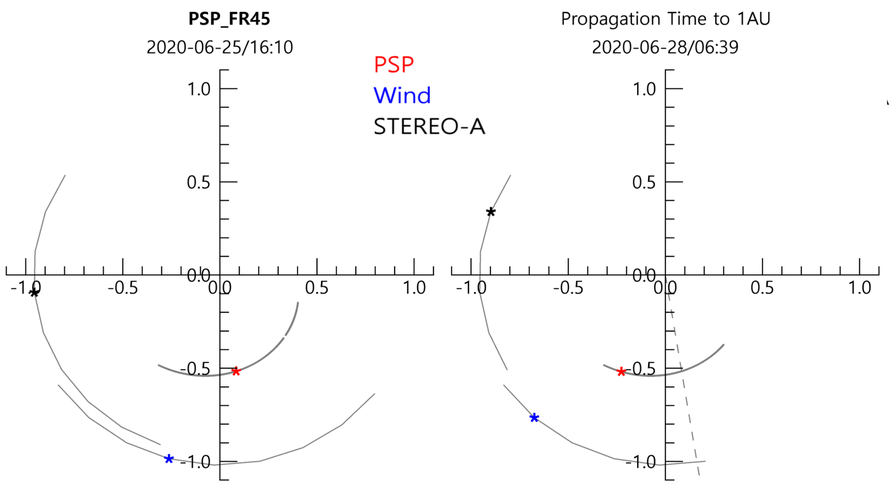
*** A to D: Sector Boundaries**
- **A-B: Toward**
- **B-C: Away**
- **C-D: Toward**
- **D-A: Away**

*** a:** partial sector (**Toward**) within sector **B-C**
- Wind: 2020-06-16 06:00 ~ 2020-06-17 06:00
- PSP: 2020-05-27 00:00 ~ 2020-05-27 20:00



1. **Sector boundaries A to D**
   : Based on neutral lines of the PFSS map, we mark all sector boundaries, **A** to **D**, and compare them with in-situ data.
2. **Sensitivity of observations of sector structure**
   : The latitudinal position of s/c aligned at the equatorial plane
   → The sector structure observed by either Wind or ST-A sensitively differs as affected HCS during SC minimum phase.
3. **Flux ropes near sector boundaries**
   : SMFRs(blue to magenta) embedded in dense plasma mostly occur near sector boundary.
   → Even If s/c does not pass the sector boundary directly, many of FRs are identified where close to the HCS (enhanced halo electrons, black arrows).
4. **Near tilted sector boundaries (A & B)**
   : The generation of FRs is repeatedly observed with a time difference of ~3 days between ST-A & Wind.
5. **Partial sector 'a'**
   : Not shown in this PFSS map (SS=2.5 Rs)
   → The reduced source surface should be applied at specific longitude around 90° for not only PSP but also 1AU (Wind).
6. **A transient event?**
   : Only one event (8 June) is detected at the same time at ST-A & Wind.

(c) Propagation time for transients (on-going)



- As an on-going work, we calculate propagation time for each SMFR from PSP to 1AU.
- Left) Start time of an SMFR observed by PSP and positions of s/c (lines: ± 5days).
- Right) radial direction of event (dashed line) and positions of s/c at arrival time.

Discussion & Conclusion

- Applying a force-free model, we identify SMFRs from multi-points observation.
- Because of structure of HCS during the minimum phase, three s/c have the opportunity to detect FRs generated nearby HCS.
- In this work, we suggest that most of SMFRs generate in the vicinity of co-rotating structures like sector boundary and HCS and propagate with the ambient solar wind.
- In future work, we find some cases observed near the Sun and 1AU and compare their properties.