SO/PHI data request form
(Cruise phase + first science orbit; SO/PHI-Team internal version)

Flux rope formation (new proposal)

Valori G. [1], David Orozco[2]

Affiliations(s)

[1] MPS

[2] IAA

Science case

Flux ropes are helical magnetic field structures that can support material against gravity. They are understood to constitute the core field that, loosing stability against the surrounding field, are ejected to form solar eruptions, carrying their load of material with them. The advances in theoretical interpretation of this mechanism has put forward a characteristic transition point during the process of formation of flux ropes where the helical structure is initially connected to the photosphere (the so-called bald patch -BP- configuration, with inverse crossing of the transverse component at polarity inversion line) to a fully detached flux rope (with an hyperbolic flux tube -HFT- separating it from the photosphere and a direct crossing of the transverse component at the PIL). Such a transition was indeed confirmed, albeit only indirectly, using photospheric vector magnetograms and head-on views of reconnection events as inferred from EUV observations. On the other hand, numerical modeling of such complex phenomena often relies on force-free extrapolations that rarely contain well-detached flux ropes, except for very few cases (see e.g. James et al ApJ 855L, 2018). Also, the head-on view of EUV events is always prone to uncertainties about the real height of the observed events, making often difficult to associate them to specific field line rearrangements in the 3D structure of the forming flux rope.

The unique opportunity offered by PHI and Solar Orbiter is to allow numerical modeling of an AR using high resolution PHI vector magnetograms and, at the same time, to combine EUI with the Earth view (eg from AIA) to provide a stereoscopic reconstruction of the emission height associated to reconnection events. We propose to exploit such an opportunity to study the formation of flux ropes in active regions, with particular emphasis on the BP-to-HFT transition and the associated formation of sigmoidal EUV structures that are formed by flux cancellation at the PIL. The topology of the forming flux rope, and the BP and HFT characterization in particular, would be obtained employing the quasi-separatrix layers method applied to a series of nonlinear force-free extrapolations. In the fortunate case that an eruption would occur during the observation time, this study can be easily extended to address mechanism behind the (eventual) slow rise phase preceding the eruption, and whether that is related to the HFT phase of the flux rope, and ultimately the instability reconnection mechanism triggering the eruption.

While the PHI cadence is not crucial, the observation should happen during the transition phase. The following data request is based on the assumption of such a lucky coincidence.

Requirements / data	
Type of solar feature	Active region
HRT or FDT	HRT
Physical parameters needed (available: B_LOS, vector B, v_LOS, I_c, raw data)	Vector B
Total length of observation	3 days
Cadence (maximum 1 dataset/min)	1 hour
Pointing needs	Active region
Orbit needs (spatial resolution/co-rotation/angle to Earth/angle to other spacecraft)	Angle to Earth: 40-60deg (for EUI/AIA sterescopy)
Total number of datasets:	84
Full frame 2k x 2k or partial frame 1kx1k, 0.5kx0.5:	Full frame
Full resolution or 2x2, 4x4 binned data	Full resolution
noise level (default 10-3):	Default
Co-observations with other instruments:	EUI/HRT at highest possible cadence compatibly with full period of observation
Special requests	None