

3D reconstruction of a sigmoidal active region

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Abstract

A transient sigmoid was observed on 1 January 2009 by XRT on Hinode. Sigmoids are S-shaped structures found in the solar corona (mostly observed in X-ray images). It is known that active regions with sigmoidal morphology are more likely to be eruptive than non-sigmoidal regions. This is why it is important to know the morphology of such structures. Images of the cooler corona from EUVI on STEREO and EIT on SOHO show the loops that overlie the sigmoid for our event. We applied the triangulation method to these features in order to understand the three-dimensional configuration of the whole region. We used images of the sigmoid region observed from three viewpoints, each separated from each other by 45 degrees. We will present the difficulties in identifying the same features from the three different viewpoints, and also the advantages of multiple spacecraft observations in studying the complexity of such phenomena.

Introduction

Sigmoids are S-shaped structures found in the solar corona (or two “J” wrapping around each other...)

They are important sources of eruptions into the interplanetary space.

Types:

→ **transient sigmoids** (transient S-shaped brightenings immediately preceding CME eruptions) (*Rust and Kumar 1996*)

→ **long-lasting sigmoids** (display the S shape for many hours or even several days until their eventual eruption. Sometimes they become more clearly S-shaped in the last few hours before the eruption.) (*McKenzie and Canfield 2008*)

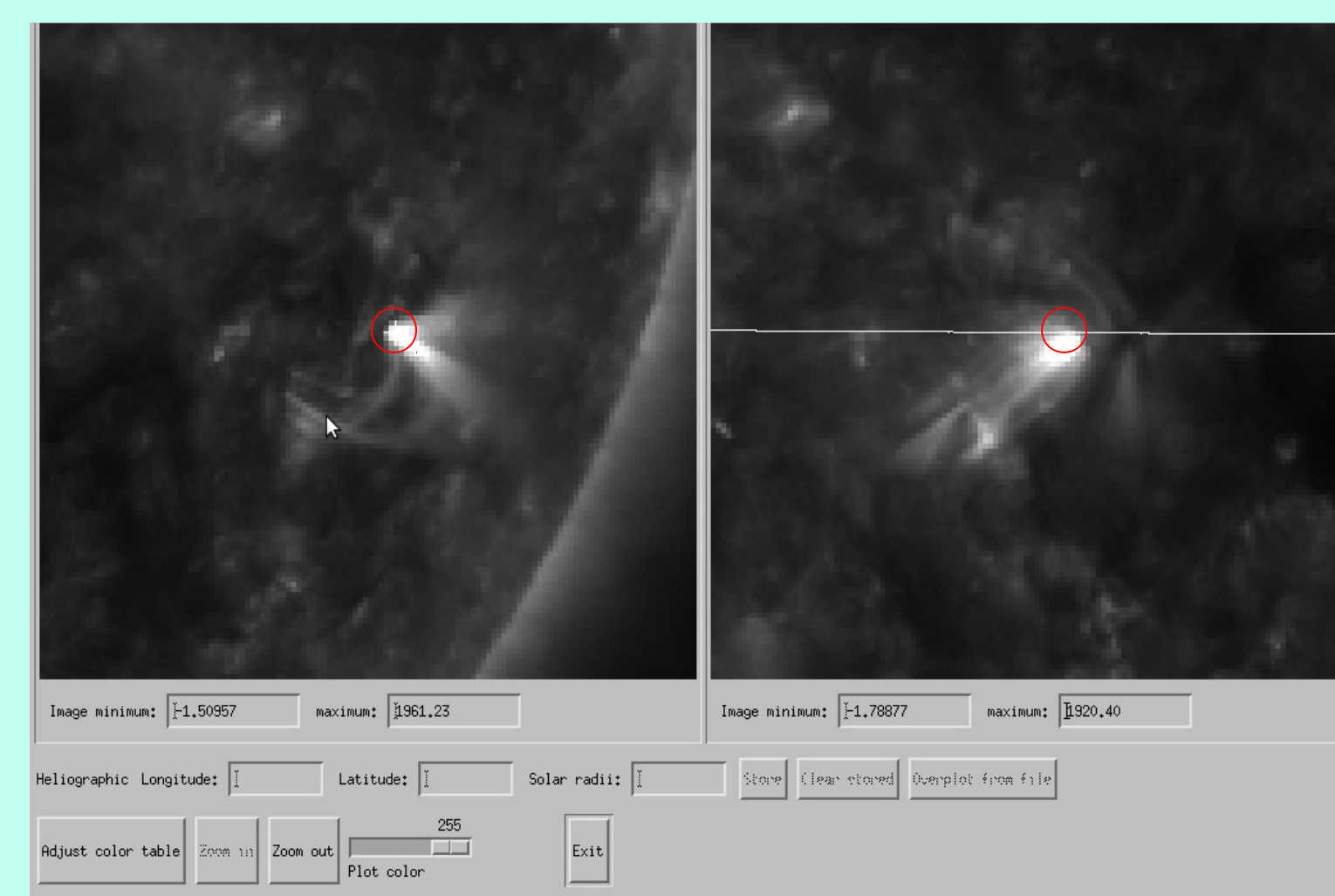
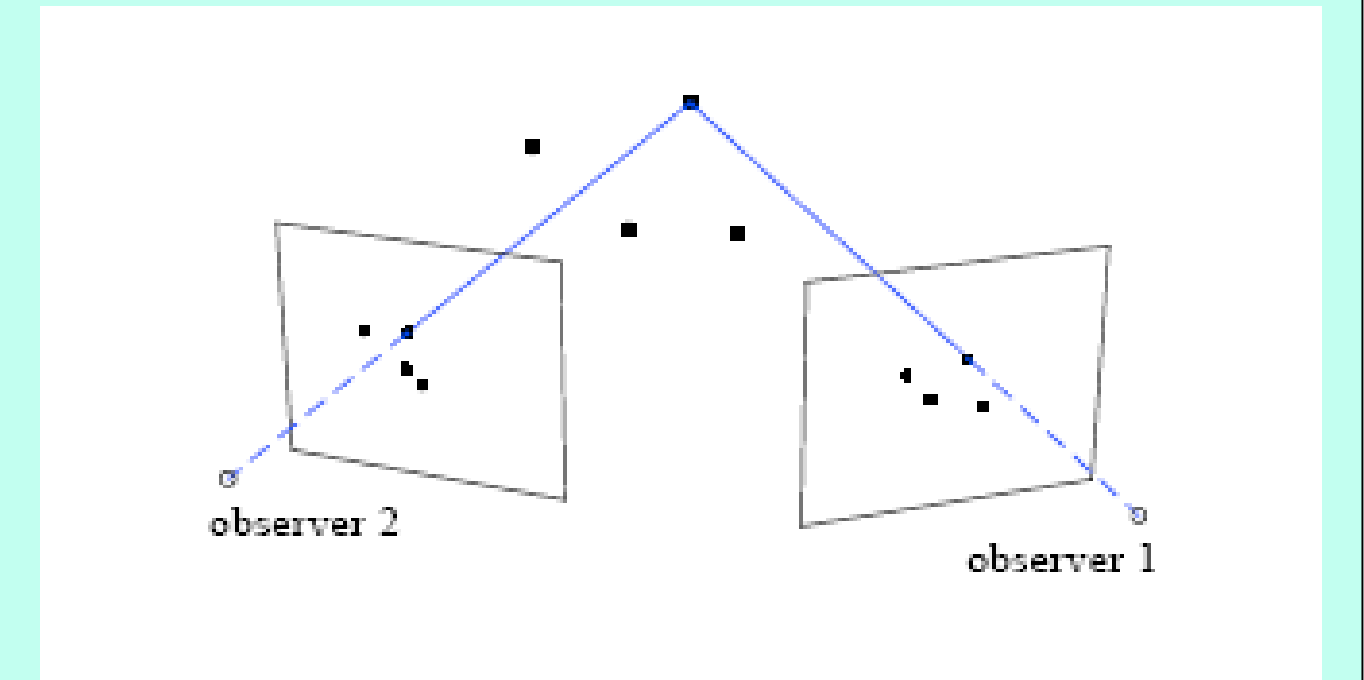
Models to explain sigmoids characteristic S shape

All models involve twisted magnetic flux-ropes

- **Kinking flux-rope model** (*Fan and Gibson 2004*)
- **Global 3-D Model of Magnetic Flux Emergence** (*Roussev et al. 2012*)

3D Reconstruction

- Identify the same feature in left and right images.
- Use triangulation to determine position in 3D.

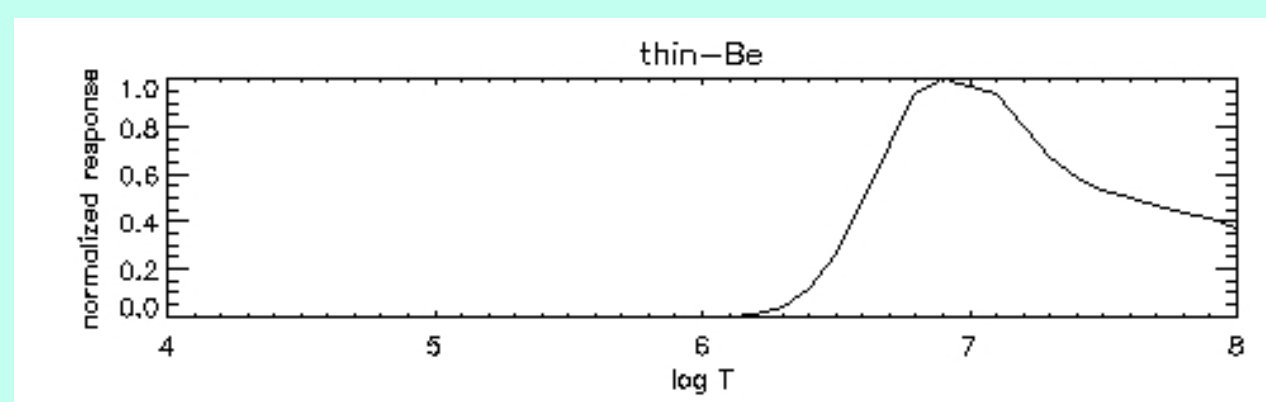
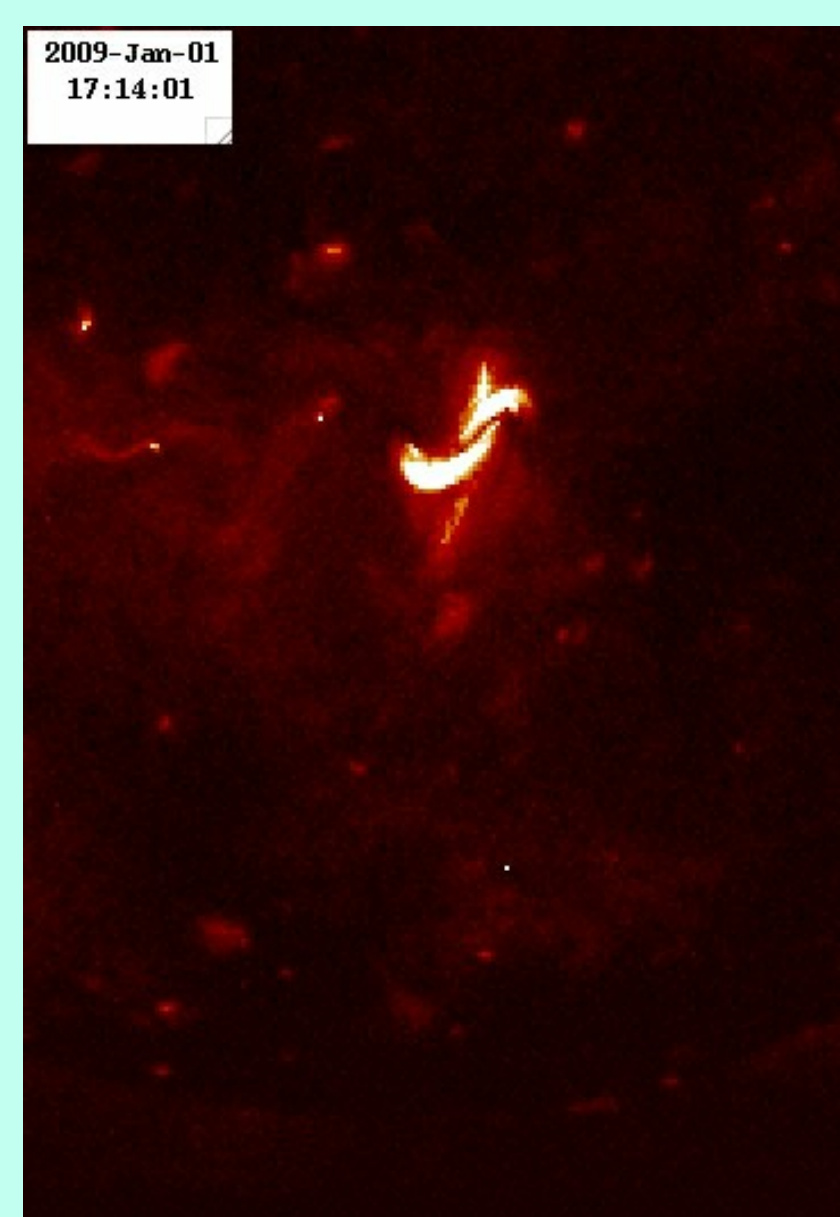


Schematic representation of the triangulation concept (*Inhester, 2006*)

Over sigmoid loops observed by EUVI 17.1 nm, 17:11 UT. Zoomed region. [See measure.pro](#) available in Solar Soft.

Sigmoid on 01.01.2009

Transient sigmoid observed by Hinode/XRT.
(<http://xrt.cfa.harvard.edu/xpow/20090101.html>)

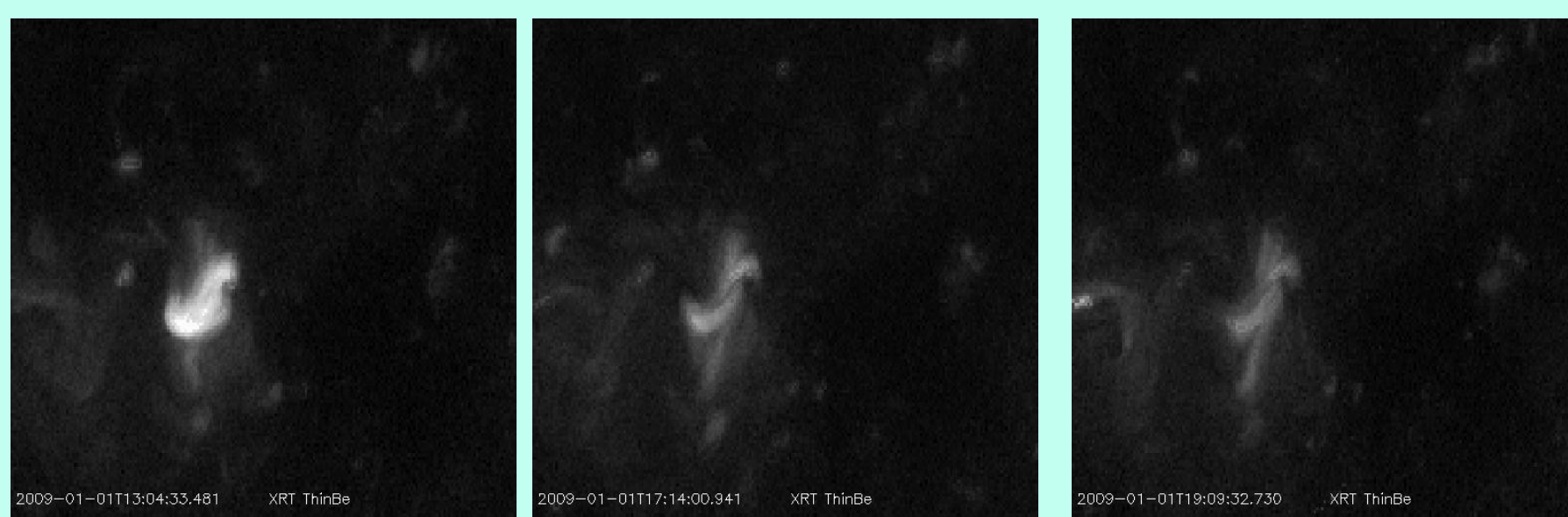


Sigmoid evolution:

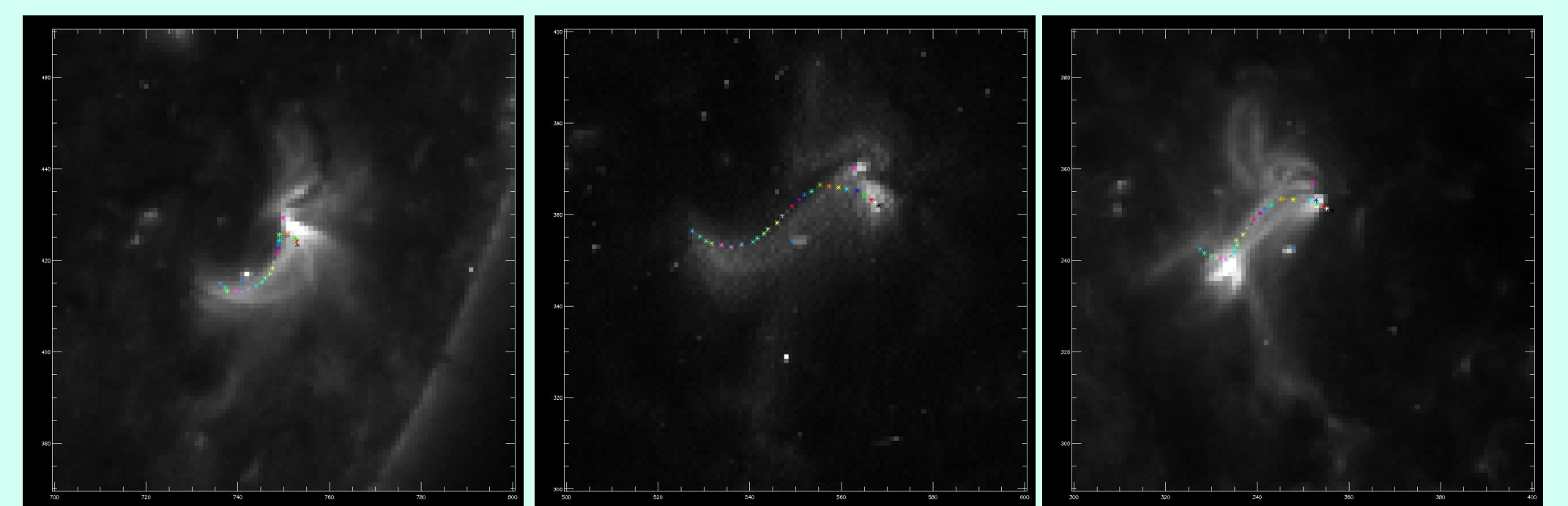
13:04 UT

17:14 UT

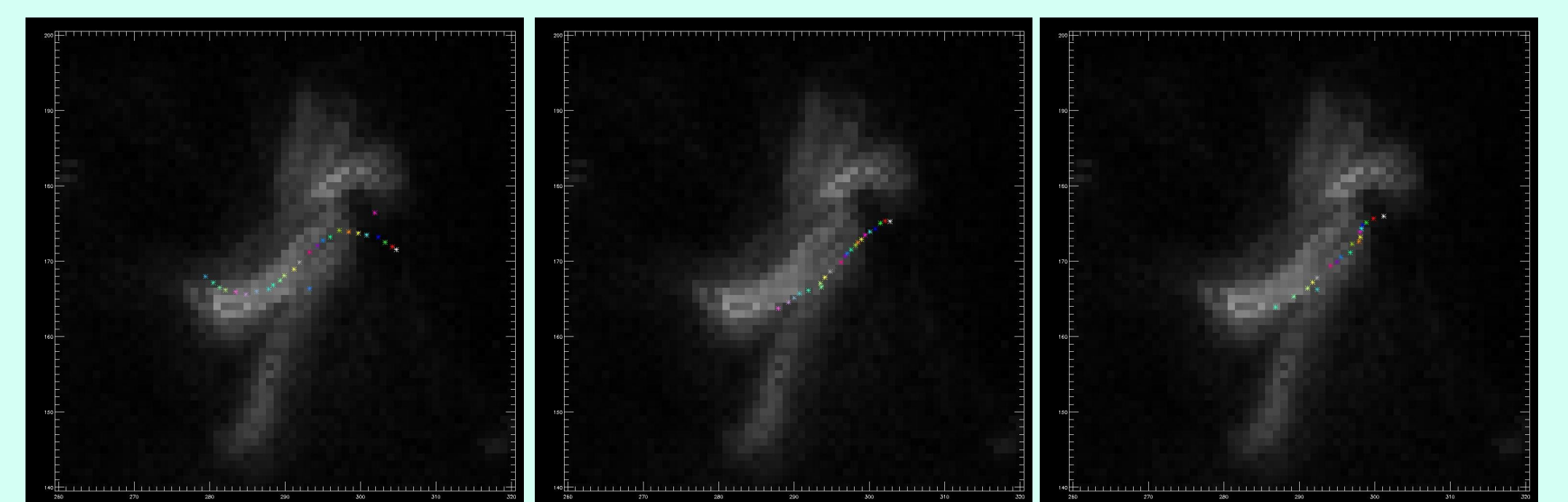
19:09 UT



Sigmoid – preliminary results



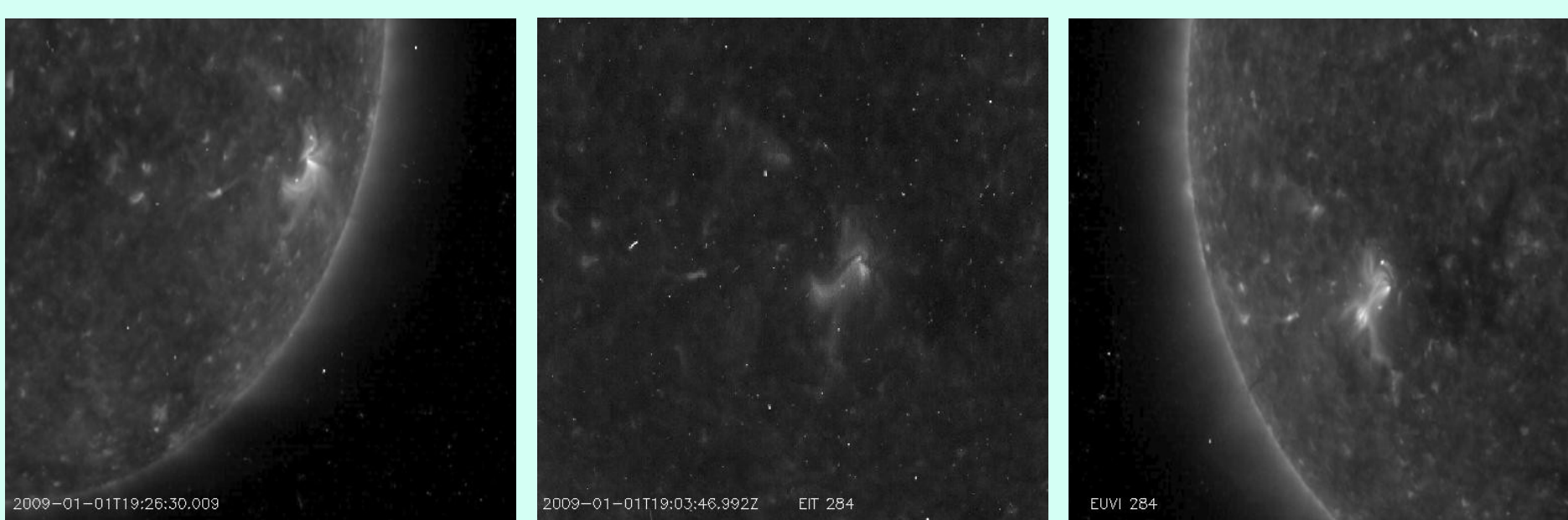
Reconstruction using EUVI-B and EIT 28.4 over-plotted on A (right), EIT (middle) and B (left) images



Reconstruction using EUVI-B and EIT 28.4 (left); EUVI-A and EIT (middle) and EUVI-A and -B over-plotted on XRT sigmoid.

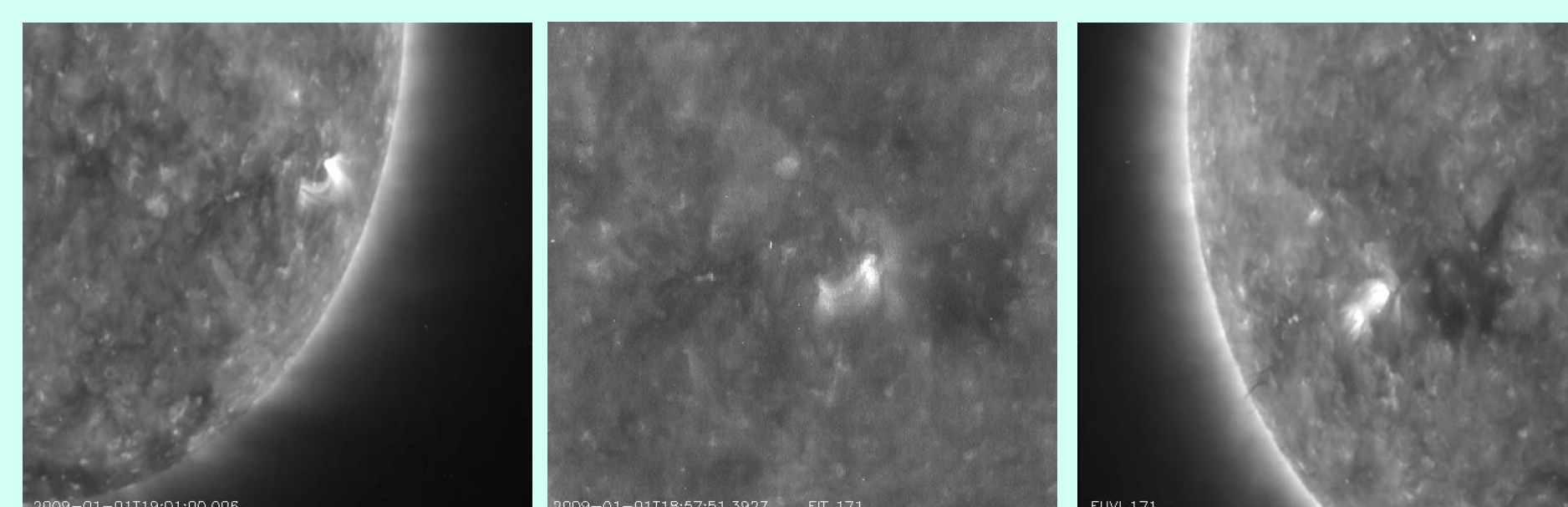
Sigmoid in 28.4 nm images (~ 19:00 UT)

STEREO/EUVI-B SOHO/EIT STEREO/ EUVI-A

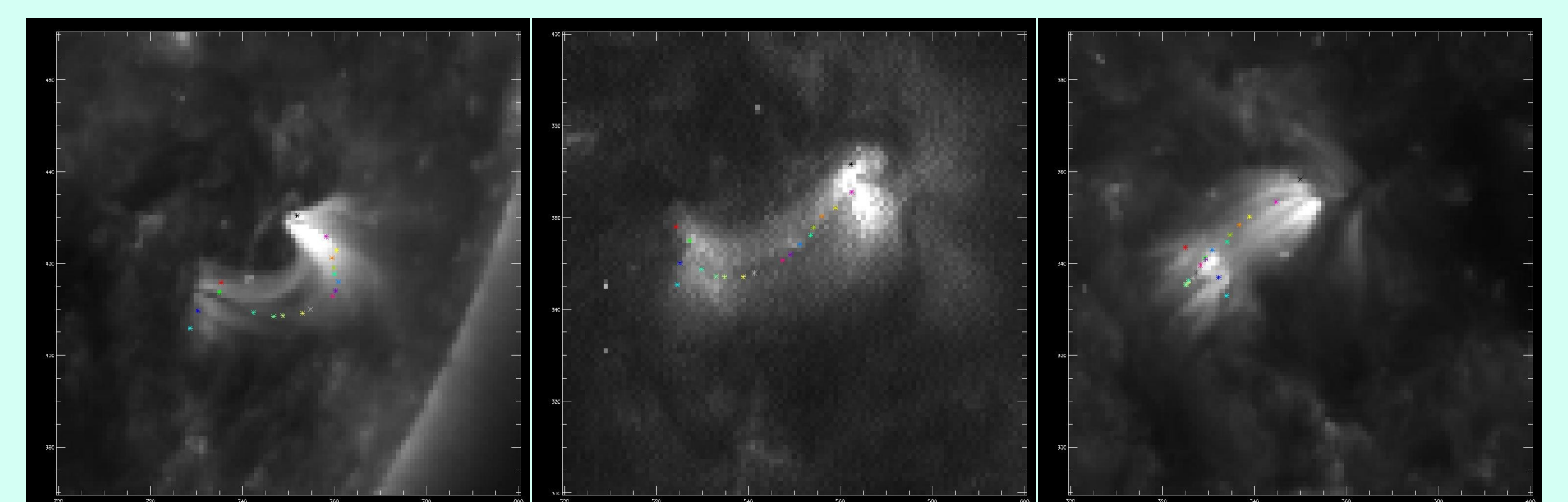


Over sigmoid loops in 17.1 nm images

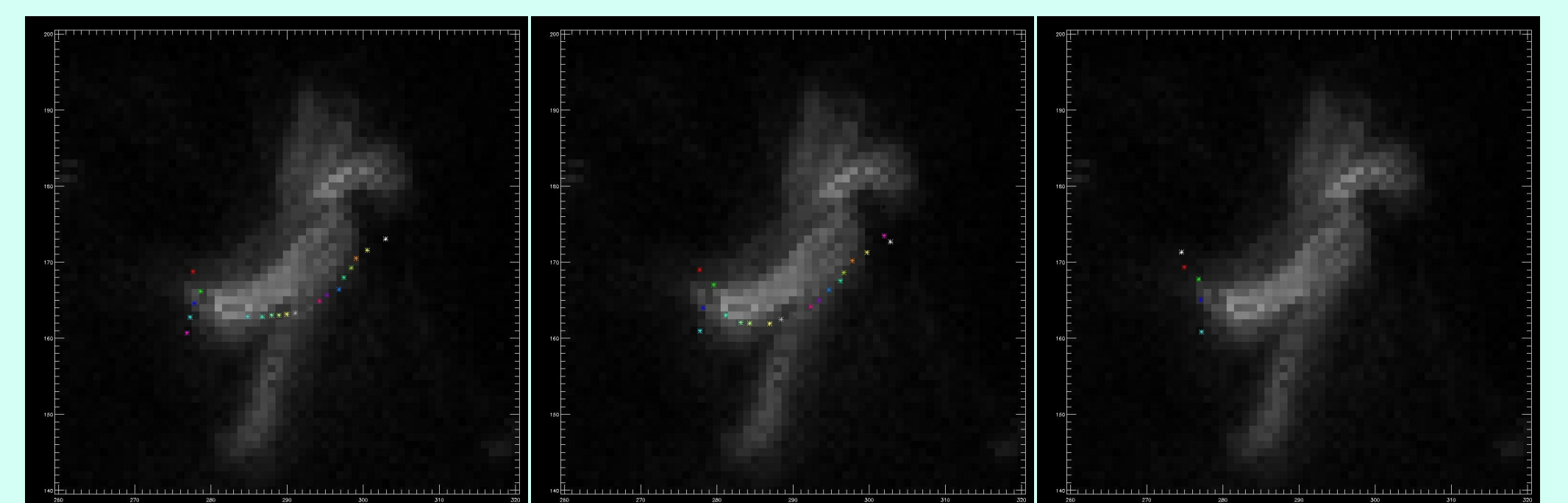
STEREO/EUVI-B SOHO/EIT STEREO/ EUVI-A



Over sigmoid loops – preliminary results



Reconstruction using EUVI-A and EIT 17.1 over-plotted on A (right), EIT (middle) and B (left) images.



Reconstruction using EUVI-B and EIT 17.1 (left); EUVI-A and EIT (middle) and EUVI-A and -B over-plotted on XRT sigmoid.

References:

- Fan, Y.; Gibson, S. E., ApJ 609, 1123, 2004.
- Inhester, B., eprint arXiv:astro-ph/0612649, 2006.
- McKenzie, D. E.; Canfield, R. C., A&A 481, L65, 2008.
- Roussev, Iliia I.; Galsgaard, Klaus; Downs, Cooper; Lugaz, Noé; Sokolov, Igor V.; Moise, Elena; Lin, Jun; Nature Physics 8, 845, 2012.
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Acknowledgements

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Summary and outlook

- The sigmoid has the appearance of 2 opposing J-like shapes wrapping around each other.
- The reconstruction using 28.4 nm images could fairly reproduced the lower part of the sigmoid. Not distinguished features could be identified for the upper part.
- The 28.4 and XRT images may show different plasma of the sigmoid.
- The over-sigmoid loops are not easily identified in the 3 spacecraft. The southern foot points could be identified and reconstructed.
- Improve the reconstruction by comparing with the extrapolated magnetic field lines and with the model output of Roussev et al. 2012.