A Comprehensive Overview of the 2011 June 7 Solar Storm

TRINITY COLLEGE DUBLIN

D. Shaun Bloomfield[1], E. Carley[1], P. T. Gallagher[1], P. A. Higgins[1], D. M. Long[1,2], S. A. Maloney[1,3], S. A. Murray[1], A. O'Flannagain[1], D. Pérez-Suárez[1,4], D. Ryan[1], P. Zucca[1]

[1] Trinity College Dublin, Ireland; [2] UCL/Mullard Space Science Laboratory, UK; [3] Skytek, Ireland; [4] Finnish Meteorological Institute, Finland.

Location of planets and *STEREO*-A/B. Parker spirals from 400 km/s solar wind; red curves mark active region boundaries.

Summary

Eruptive event from NOAA region 11226 (S22W53) consisting of:

- soft X-ray (SXR) flare (M2.5),
- hard X-ray (HXR) ribbon motion,
- EUV wave (< 500 km/s),
- filament lift off (500-800 km/s),
- CME (900-1500 km/s),
- Type II, III, and IV radio bursts

1 – Event Onset

- SXR flux rise (06:16 UT)
- Type II start (06:26 UT)
- HXR flux peak (06:26 UT)
- HXR foot-point maximum speed (45 km/s, 06:26 UT)
- Type III start (06:26 UT)
- Temperature peak (12 MK, 06:29 UT)
- Type IV start (06:33 UT)
- SXR flux peak (06:41 UT)
- Emission measure peak (2×10^{49} cm^{-3}, 06:45 UT)

Evolution of (a) SXRs, (b) temperature, (c) emission measure, (d) HXRs, (e) microwave, and (f) radio flux.

2 – Filament & CME

- Eruption is directed towards the Sun-Earth line, as seen from both *STEREO* perspectives

Eruption viewed from *STEREO*-B (left), Sun-Earth line (middle), and *STEREO*-A (right). Slits in the AIA image show areas used to make distance-time plots.

Filament distance-time evolution with 3 phases: static phase (< 06:10 UT), slow rise phase (~06:10–06:20 UT), and fast rise phase (> 06:20 UT).

- Filament rise starts slow (10–25 km/s) then accelerates (400–800 km/s)
- Motion faster in northwest foot point – destabilization by prior B-class flare?
- CME achieves 900–1500 km/s

CME height-time evolution in the *STEREO*-A plane-of-sky (POS) and radially de-projected (D-P). Overlaid are constant velocity fits.

(a–b) Example UV ribbons and SXR/HXR contours. Evolution of UV/HXR foot-point (c–d) locations, (e–f) speeds, and (g) contextual SXR/HXR light curves.

3 – Post-eruption Effects

- Electron speed from Type III forward edge (0.22*c*) matches arrival time
- Two possible CME shocks between *STEREO*-A plane-of-sky and mean solar wind ballistic estimates

Predicted electron arrival at L1 (shaded area), propagated along 400–450 km/s Parker spirals.

Predicted CME arrival at L1 shown by shaded areas for radially de-projected CME speed (CME D-P), *STEREO*-A plane-of-sky CME speed (CME POS), and mean solar wind speed (SW).

Dynamic radio spectra from RSTO and *STEREO*-A/B. Labels indicate the Type II, III, and IV bursts and herringbones originating from 50 MHz during the Type III burst.

This work was supported by funding from the European Community Seventh Framework Programme (including a Marie Curie Intra-European Fellowship and the HELIO e-Infrastructure grant), the ESA PRODEX programme, the Irish Research Council for Science, Engineering and Technology, and the AXA Research Fund. The authors are grateful to H. Meszarosova for providing access to the Ondrejov dynamic spectra.