I-LOFAR Observations of the 10 September 2017 X8.2 Solar Flare

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The Sun can produce large-scale energetic events such as solar flares and coronal mass ejections (CMEs), which are often associated with accelerated particles and emission at radio wavelengths. To date, the site of and mechanisms responsible for particle acceleration are not well known. Here, we investigate these phenomena using radio observations of the 10 September 2017 X8.2 solar flare at 10-240 MHz from the recently constructed Irish Low Frequency Array (I-LOFAR). We present I-LOFAR observations of radio bursts associated with the flare, CME and shock.

1. Flare and CME, using AIA and LASCO

- On 10 September 2017 Active Region (AR) 12673 produced an X8.2 flare.
- The flare was located on the western limb and was one of the largest of a series of flares produced by the AR.
- The flare was followed by a fast CME, first seen in LASCO at 16:09 UT.

10 September 2017 X8.2 Flare Details	
Active Region	12673
Location	S09W90
Start time	15:35 UT
Peak time	16:06 UT

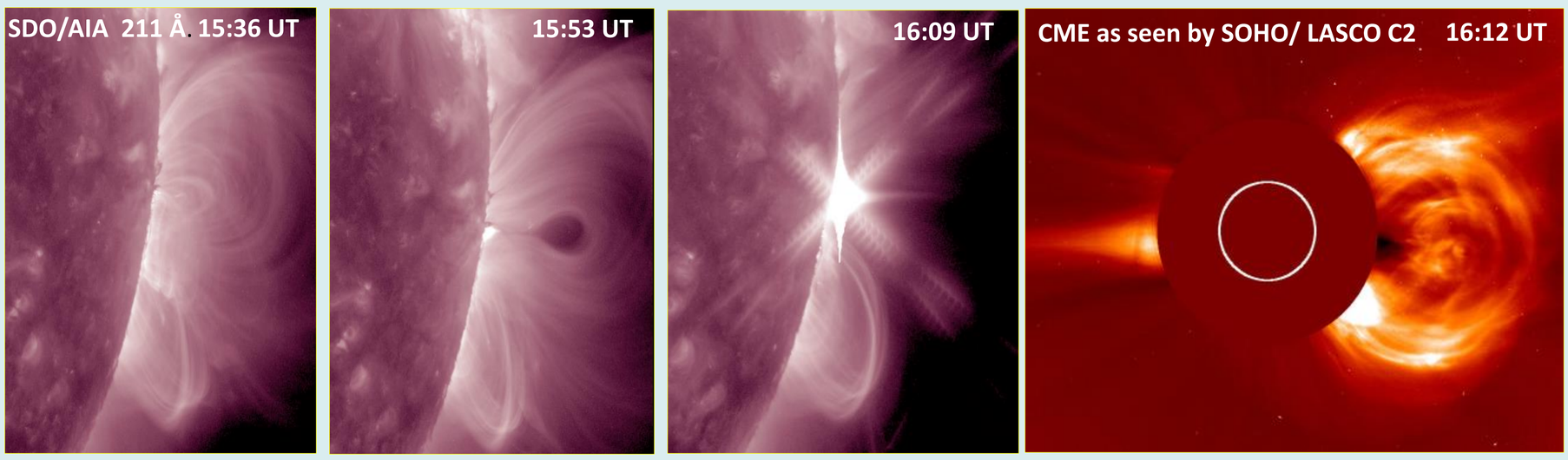

Figure 1 Flare and CME evolution as seen by evolution as seen by SDO and LASCO.

- The CME reached velocites of over 2000 km/s as seen by SOHO/LASCO.
- A Solar Particle Event (SPE) was detected by STEREO A at 16:25 UT and GOES 13/SEM/EPS at 16:45 UT.
- CME arrival detected at L1 by DSCOVR/PLASMAG at 19:26 UT.
- The CME was not particularly geoeffective as the Earth was only impacted by the flank of the CME.

2. I-LOFAR

- Constructed summer 2017.
- Located in Birr Castle, Ireland.

Figure 2 International LOFAR Telescope.

Frequency 10-90 & 120-240 MHz.
Sampling <1 sample per second.
Resolution 0.8-195 kHz.

Figure 3 I-LOFAR station in Birr.

3. Radio Dynamic Spectra from I-LOFAR

Mode 357
Multi-mode observing with I- LOFAR at 10-240 MHz [3]. A blend of modes 3, 5 and 7 was used to produce dynamic spectrum spanning 10-90 and 110- 240 MHz.

Mode	Array	MHz
3	LBA	10-90
5	HBA	110-190
7	HBA	210-240

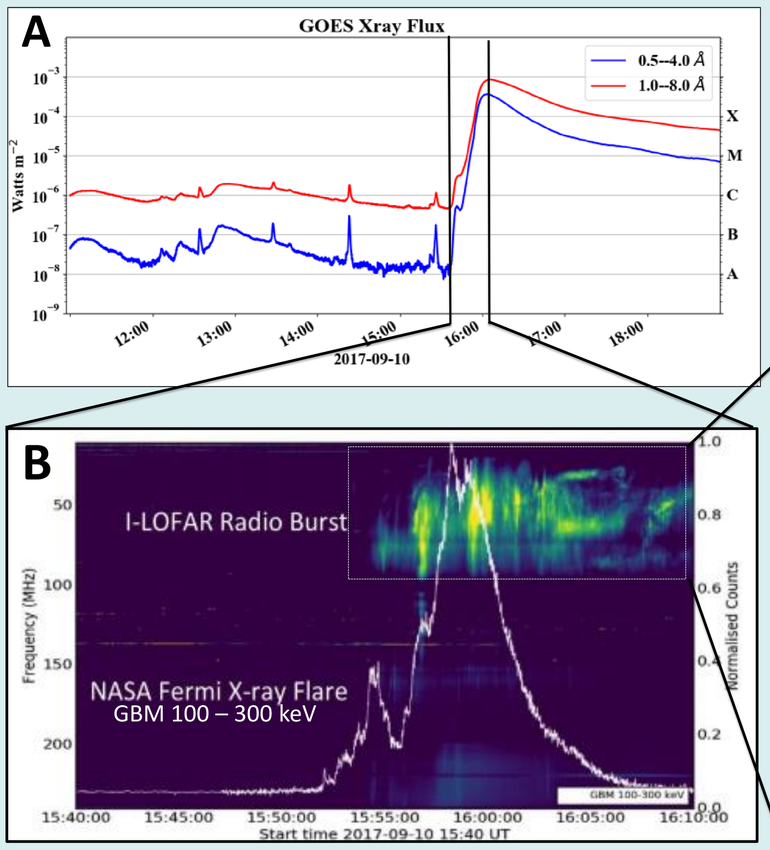

Figure 4 A. GOES X-ray Flux showing the 10 September 2017 X-class flare. **B.** I-LOFAR dynamic spectrum at frequencies of 10-240 MHz overlaid with normalised counts measured by the Fermi Gamma-ray Space Telescope. **C.** Zoom-in of the dynamic spectrum at 18-88 MHz. Multiple radio burst signatures of shocks and electron beams were observed to occur at flare maximum [2].

4. Conclusion and future work

- I-LOFAR observed a number of radio bursts at high spectral resolution.
- I-LOFAR observations were coordinated with tied-array beam observations with the full LOFAR core.
- Tied array beam observations will allow us to find location of radio bursts [4].
- High-temporal resolution LOFAR core observations will also help with the identification of the structures in the I-LOFAR dynamic spectrum.
- Intend to study sites of particle acceleration and make comparison to solar eruptive models.

References

[1] Van Harlem et al., A&A, 556, A2, 2013.
[2] Morosan, D. E., A&A 568, A67, 2014.
[3] McKay-Bukowski, Making Observations with Mode-357, 2013
[4] Morosan, D. E., A&A, in prep, 2017.

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