High-resolution UV observations of small-scale energy release events in the solar atmosphere

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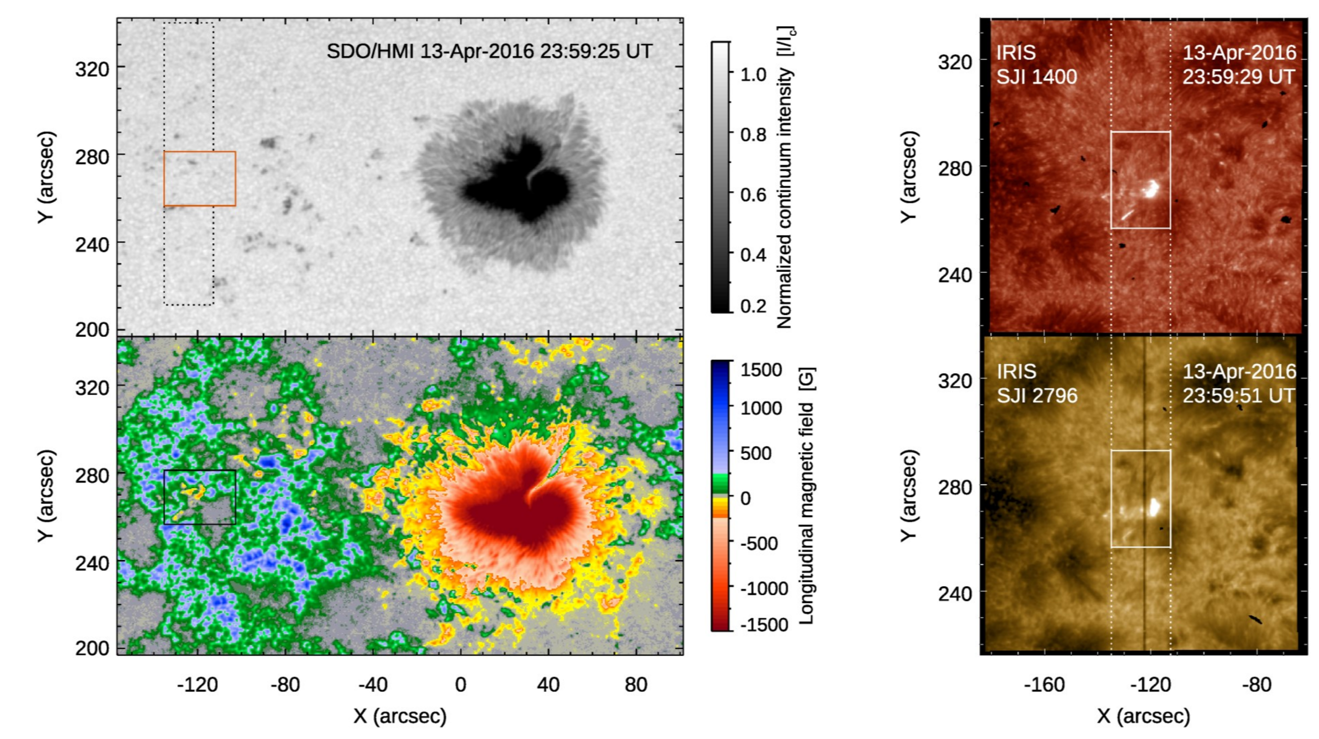
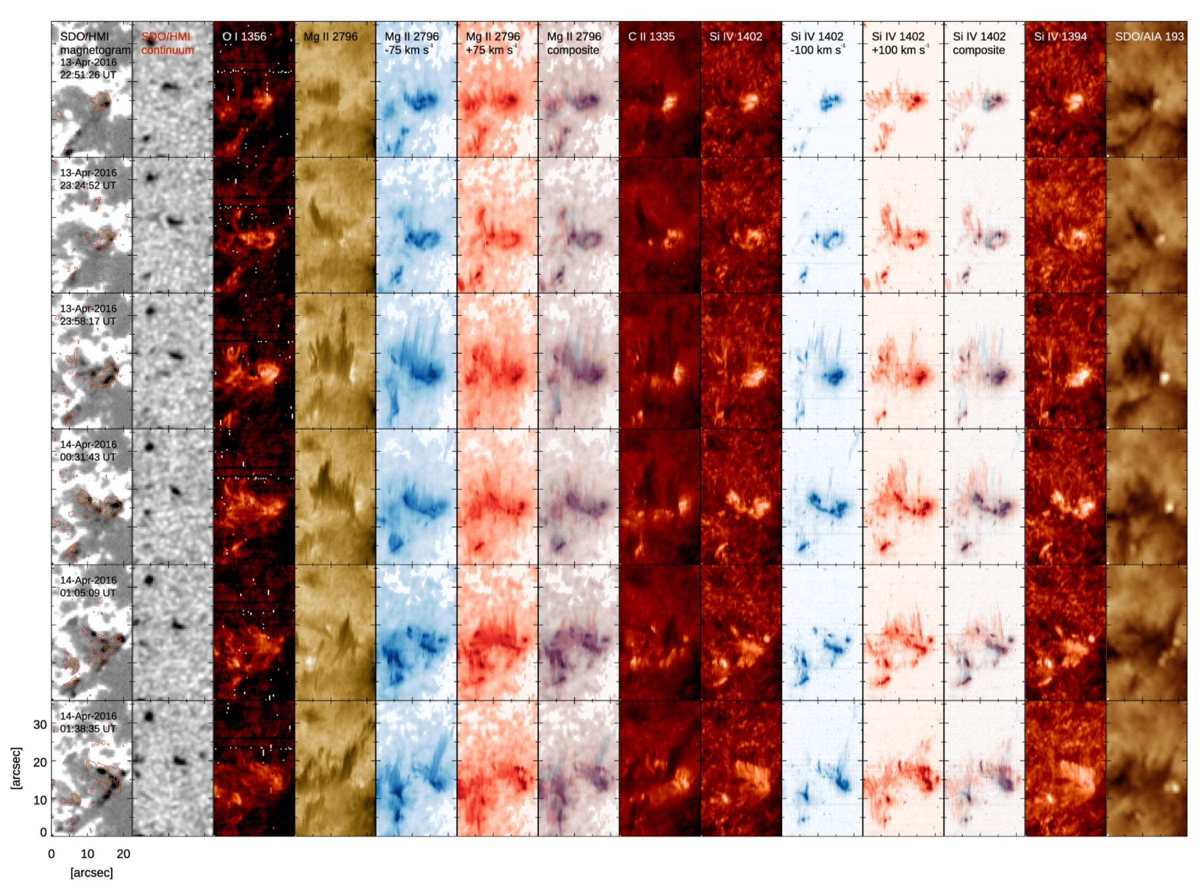


Left: Active Region NOAA 12529 as seen in *SDO*/HMI continuum filtergram and in the simultaneous LOS magnetogram. The box indicates the EFR. The dashed box indicates the FOV of the *IRIS* slit. *Right*: Cotemporal *IRIS* SJIs.



Synoptic view of the evolution of the EFR at different atmospheric heights, during the *IRIS* sequence. Simultaneous *SDO*/HMI continuum filtergrams, magnetograms and *SDO*/AIA filtergrams are also shown as a reference.

Abstract

High-resolution UV observations of the solar atmosphere, complemented by photospheric measurements conveying information about the magnetic configuration of the region of interest, allow us to investigate the magnetic and plasma processes that drive coronal heating and energy release.
Here, we report on small-scale flux emergence and flux cancellation events and on the energy release phenomena simultaneously observed in coordinated campaigns involving ground- and space-based observatories (e.g., SST, IBIS, Hinode, SDO), focusing on recent results obtained by the IRIS satellite.
We discuss our findings illustrating how magnetic reconnection can explain the occurrence of such small-scale energetic events and how they are expected to be improved with upcoming observations from next-generation space missions, like Solar Orbiter and EUVST.

We reported[1,2] on multi-wavelength ultraviolet (UV) high-resolution observations taken with the *IRIS* satellite[3] during the emergence phase of an emerging flux region (EFR) embedded in the unipolar plage of active region NOAA 12529. These data were complemented by measurements taken with the spectropolarimeter aboard the *Hinode* satellite and by full-disk observations from *SDO*.

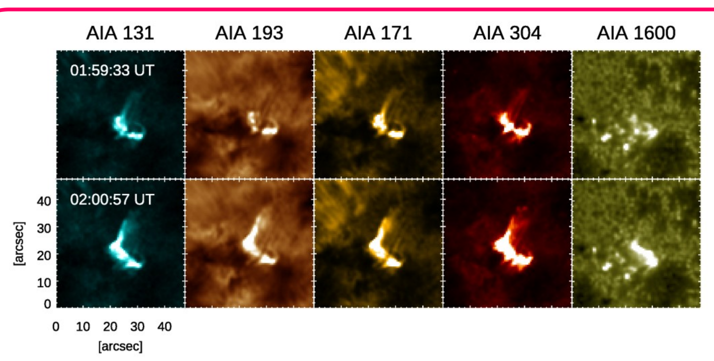
In the photosphere, magnetic flux emergence is recognized in the appearance of opposite emerging polarities, separating from each other. The region between them is characterized by nearly horizontal fields and fuzzy granulation. A pre-existing photospheric flux concentration of the plage is seen cancelling with the opposite polarity flux patch of the EFR.

In the upper atmospheric layers, recurrent brightenings resembling UV bursts[4], with counterparts in all UV/EUV filtergrams, are identified in the EFR site. An arch filament system overlies the EFR in the chromosphere. Plasma ejections are also found at chromospheric and coronal levels, above the AFS and near the observed brightness enhancement sites.

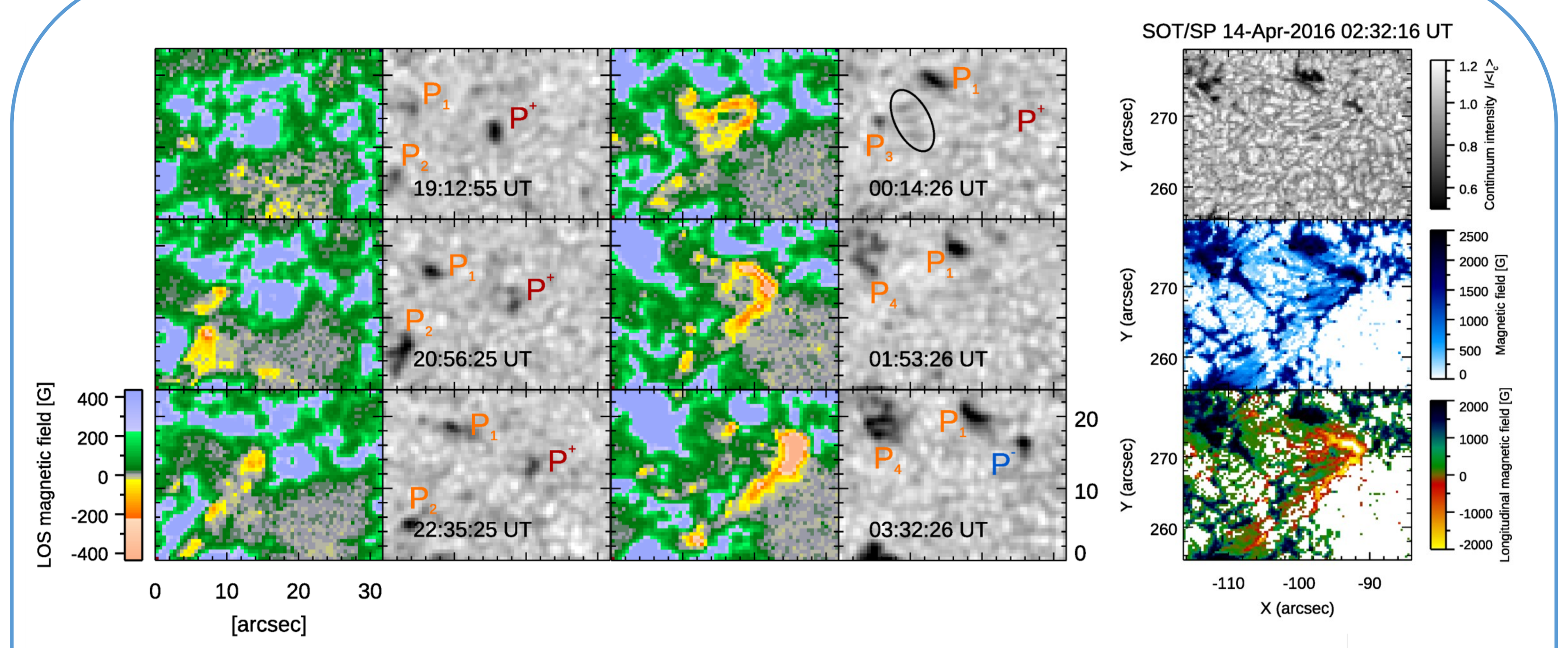
IRIS spectral features indicate the heating of dense plasma in the low solar atmosphere and the driving of bi-directional high-velocity flows, with speeds up to 100 km/s. Most important, we unravelled Fe XII emission, pointing to plasma heated up to 1 MK in the core of the brightening sites.

At a later stage of the flux emergence, an eruption suddenly occurs. The formation of a circular ribbon is clearly detected, likely caused by a fan-spine magnetic topology due to the presence of parasitic polarities.

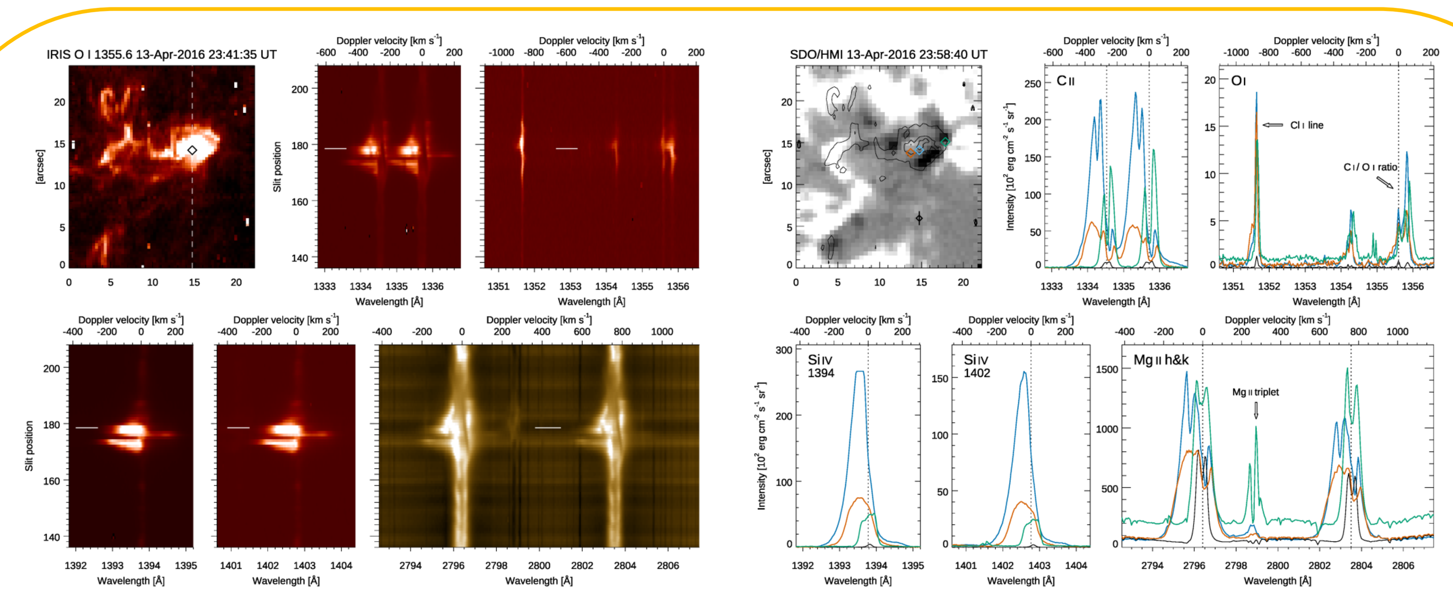
Comparing these findings with previous observations[5] and numerical models[6,7,8], we suggested evidence of several long-lasting, small-scale magnetic reconnection episodes between the new bipolar EFR and the ambient field. This process, leading to flux cancellation, appears to occur higher in the atmosphere than usually found in UV bursts, being responsible for heating and plasma ejections that involve all the atmospheric levels.

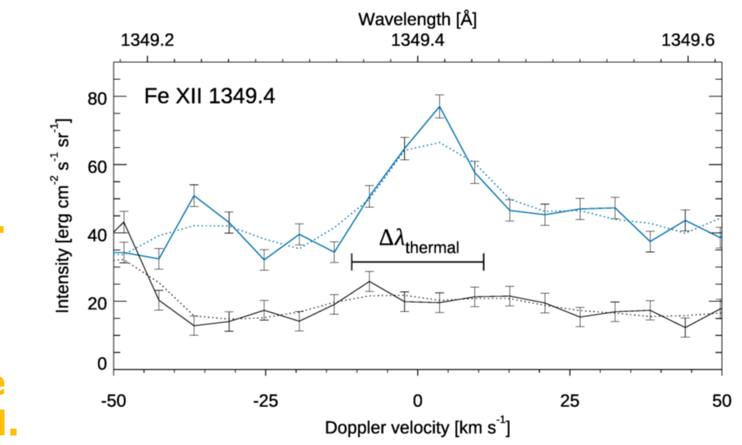


SDO/AIA filtergrams showing the evolution of the eruption occurred in the EFR site starting at 01:56 UT on April 14. Images illustrate the morphology at different atmospheric heights with decreasing temperature formation, from the corona (131 Å) down to the chromosphere/upper photosphere (304 Å and 1600 Å).



Left: Evolution of the EFR as inferred from *SDO*/HMI observations. *Colored panels*: LOS magnetograms. *B/W panels*: simultaneous continuum intensity images. *Right*: Maps of the normalized continuum intensity (top), magnetic field strength (middle), and longitudinal field component (bottom) deduced from *Hinode* SOT/SP close to the peak of the EFR flux.





Top panels: *IRIS* spectra relevant to the UV burst. Left: Spectrograms in the UV burst core. Right: Spectra at different positions across the UV burst (blue: UV burst core). Spectral features are indicated in the profiles. *Bottom* panel: Spectrum around the Fe XII coronal line, obtained by summing the signal in the 3x5 pixels region around the UV burst core. The black line represents the background.

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