Transient fine-scale brightenings, flows and flux cancellation in the cool arch filament system observed with HiC2.1

Sanjiv K. Tiwari[1,2*], Navdeep K. Panesar[3], Ronald L. Moore[3,4], Bart De Pontieu[1], Amy R. Winebarger[3], and the HiC2.1 Science Team

[1]Lockheed Martin Solar and Astrophysics Laboratory, 3251 Hanover Street, Building 252,Palo Alto, CA 94304, USA

[2]Bay Area Environmental Research Institute, NASA Research Park, Moffett Field, CA 94035, USA

[3]NASA MSFC, & [4]CSPAR UAH, 320 Sparkman Drive, Huntsville, AL 35805, USA

*tiwari@lmsal.com

Abstract: Solar active regions (ARs) contain the brightest and hottest coronal EUV loops -- the core of an AR is typically the brightest structure inside the AR. In the present work we report fine-scale transient brightenings and flows in the coolest loops (the counterpart of chromospheric arch filament systems long observed in H-alpha filtergrams of bipolar emerging flux regions) seen in the core of an AR observed in 172 Å by Hi-C2.1. Some of these are rooted, at one of their feet, in mixed-polarity field in the photosphere. We complement the 5-min Hi-C2.1 data with SDO/AIA/HMI and IRIS SJ images and spectral data, and examine fine-scale events, flows and their photospheric magnetic field. We find counter streaming flows in the arch filament system, similar to that long observed in filaments. There are scattered fine-scale brightening events. Most, if not all, of these brightenings are at sites of converging opposite-polarity magnetic flux (implying flux cancellation, sometimes resulting from flux emergence). The fine-scale flows stem from some of the brightenings. Flux cancellation at these sites apparently results in fine-scale explosions that drive the counter streaming flows. In the IRIS spectra, we look for evidence of upflows from brightenings at ends of loops of the arch filament system.

Overview

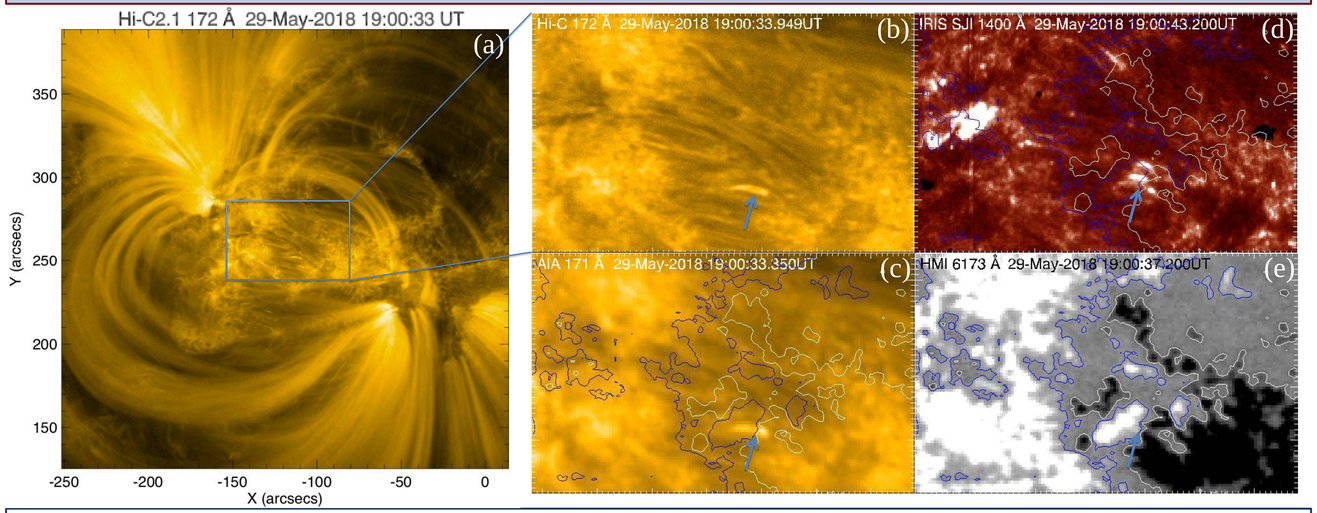
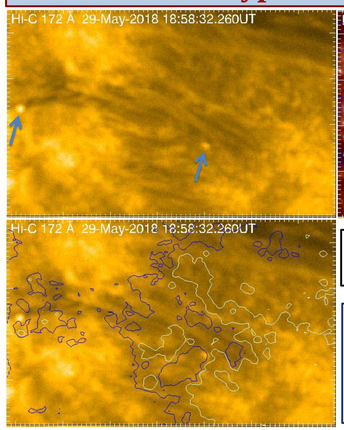


Fig. 1. (a). HiC2.1 full image in 172 Å, with the cool arch filament system outlined by the blue box, which is zoomed in panel (b). Panels (c) AIA 171, (d) IRIS SJ 1400, and (e) HMI line-of-sight (LOS) magnetogram, are of the same field-of-view (FOV) as (b). In (e) white/black areas have positive/negative flux saturated at +/-400 G, outlined by blue/white contours of 25G, which are also overplotted in (c) and (d). An arrow in each panel from (b) to (e) points to a transient event (categorized as Type II) described later. Also see videos.

Type I. Confined dot-like eruptions on polarity inversion lines



Note in the light curves: type I -- 94 peaks later; type II -- 304 peaks later

Light curves--3X3AIA pixels from the central location of each event type

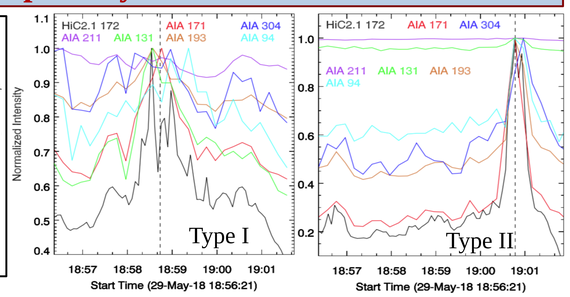


Fig. 2. Two examples of dot-like eruptions on or near a polarity inversion lines. Apparently these are small loops, which get transiently heated, probably in the same way as Type II loops get heated. However due to their small sizes we can not see the nature of plasma flow. These are different from Regnier's (2014) HiC193 bright dots in lifetimes, locations and brightnesses. See videos.

Type II. Confined eruptions in loops: double-loop configuration/interaction

One example of this type eruption is shown by arrows in panels (b)-(e) of Fig. 1. These have dominantly unidirectional flow as they start erupting. Their photospheric magnetic field is consistent with double-loop interaction (with a three-legged structure, supported by IRIS 1400 SJ image) leading to flares, jets and surges, as proposed by Hanaoka et al. (1997). A cartoon corresponding to our example loop event (in Fig. 1b-2) is shown in Fig. 3. Apparently the loops in AIA may appear as bright dots in IRIS/transition region: many bright dots seen in IRIS could be either different loop systems (similar to type I), or different parts of a single loop system.

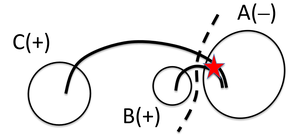
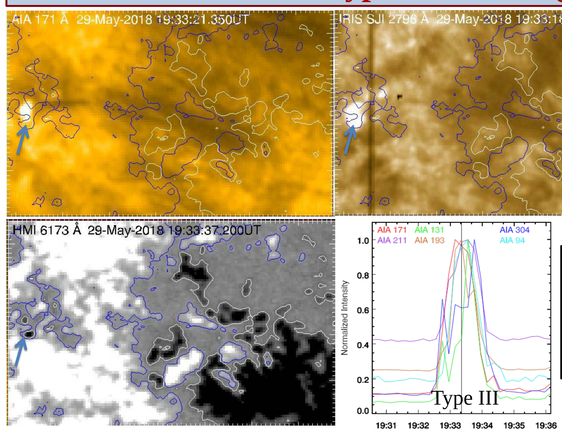


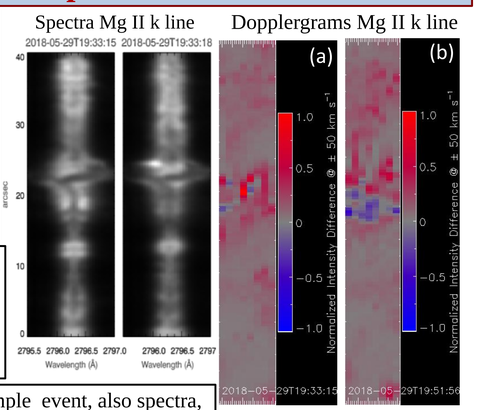
Fig. 3. Three legged structure

Type III. Jet/surge like confined eruptions



Spectra--first two slit positions from the raster during example event shown in the left and in Dopplergram (a).

AIA light curves during the initial phase of the surge-like example eruption. Almost all channels peak together.



Dopplergrams: (a) example event, also spectra, (b) ex.2 during the rise/upflow of plasma-videos

Fig. 4. Surge-like activity accompanied by transient brightenings and flows at the base. These start at a location of mixed-polarity field -- first flux emergence is seen, then flux cancellation leading to this event. Plasma flows up/out to the right and then back.

Event Type	AIA Peak Time	Neutral line	Hi-C2.1	IRIS SJ/Spectra	Flux emergence	Flow	Flux converge-nce/cancellation	Lifetime (seconds)
I	18:58:45	Yes	Yes	Yes/No	Yes	Not clear	Yes	98
I	18:58:33	Yes	Yes	Yes/No	No	Not clear	Yes	83
I	19:01:57	Yes	Yes	Yes/No	Yes	Not clear	Yes	60
II	19:00:45	Yes	Yes	Yes/No	Not clear	Unidirectional	Yes	120
II	18:58:57	No	Yes	Yes/No	No	Unidirectional	Yes	48
II	18:57:21	Yes	Yes	Yes/No	Not clear	Unidirectional	Yes	115
III	19:33:21	Yes	No	Yes/Yes	Yes	Bidirectional	Yes	265
III	18:42:33	Yes	No	Yes/Yes	Yes	Bidirectional	Yes	240
III	18:49:57	Yes	No	Yes/Yes	No	Not clear	Yes	168

Summary and Outlook: We find three types of transient brightenings, each at mixed-polarity flux. A few of these cases, particularly in the Type II (loop eruptions with mostly unidirectional flow) have flux emergence before flux cancellation, thus suggesting a loop-interaction scenario, as suggested by Hanaoka (1997) for flares, jets, and surges. Counter streaming flows, driven by explosive events at base, are found in most of the large loops in the arch filament system. Because the light curves peak nearly simultaneously, and for none of the events show a systematic trend of cooling, all three types might have transition-region and/or chromospheric (and not coronal) origin. Spectra available for type III show complex activities at their base, and upflowing cool material as expected in a surge/jet activity. A detailed study is underway.

SKT gratefully acknowledges support by NASA contracts NNG09FA40C (IRIS) and NNM07AA01C (Hinode). NKP is supported by an appointment to the NASA Postdoctoral Program at the NASA MSFC, administered by USRA through a contract with NASA. RLM and ARW are supported by funding from the NASA's Science Mission Directorate. B.D.P. gratefully acknowledges support from NASA grants NNX16AG90G, and NNG09FA40C (IRIS). Use of data from HiC2.1, IRIS, and AIA+HMI (SDO) is acknowledged.