Simultaneous observation of a hot explosion by NST and IRIS

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We present the first simultaneous observation of the so-called hot explosion in the cool atmosphere of the Sun made by New Solar Telescope (NST) of Big Bear Solar Observatory (BBSO) and Interface Region Imaging Spectrograph (IRIS) in space. The data obtained during the joint IRIS-NST observation on 2014 July 30. The explosion of interest started around 19:20 UT and lasted for about 10 minutes. The IRIS brightening was observed in 3 channels of slit-jaw images and the Si IV emission profile showed the highly blue-shifted (~30 km/s) single-gaussian type. Wing brightening with a related surges were observed in both bands of the NST Fast Imaging Solar Spectrograph (FISS) instrument. The elongated granule seen in NST TiO data contributed to the emergence of positive flux to trigger the hot explosion. These observations suggest that an inclined IRIS hot explosion occurred in the cool atmosphere of the Sun can simultaneously observed as an Ellereman bomb (EB) in Ha wing.

The IRIS brightening was observed in 3 channels of slit-jaw images, which covers temperature range from 4,000 to 30,000 K. The brightening occurred in the lower right corner (560°, 30°) of the field of view.

The above figure shows IRIS intensity profiles of the brightening that peaked at 19:26:53 UT. The thin solid line is the averaged spectrum and the averaging was performed over the limited spatial and temporal ranges. It should be noted that we could not obtain the average profiles over the quiet region due to the IRIS observing mode (site and store) and they do not present the quiet sun information.

Figure shows TiO broadband images. At 19:06:13 UT, a remarkable elongated structure appeared at the edge of a small sunspot in NOAA AR 12211. This structure continuously stretched out and moved toward the brightening site. Similar event was studied by Lim et al. (2012) who concluded that these photospheric flows were associated with flux emergence.

In AIA 1600 Å channel, light curve is well consistent with the IRIS brightening. In AIA 171 Å channel, we found that dark material appeared around the brightening time. In AIA 304 Å channel showed no remarkable features regarding this brightening.

The major polarity of the brightening site is negative and a part of positive flux transferred from main sunspot to the brightening site. Although the positive flux contributed only a small portion to the total flux, it showed highly dynamic evolution and seemed to play an important role in triggering the brightening. Around the peak time of the IRIS brightening, there is no significant changes in the longitudinal magnetic field. It means that the IRIS brightening may be due to magnetic reconnection between the emerging flux (+) and existing flux (-) in the higher atmosphere, and not due to reconnection of U-shaped field lines that supposedly occurs in the photosphere.

We also analyzed vertical motions of plasma. We were able to identify red-shifted signals (~1 km/s) in the HMI dopplergram related to the brightening. The Doppler upflow velocity of EB is estimated to be around 11 km/s.

The above figure shows occurrence of EB and its relation to the hot explosion in NST images.

Figure shows time series of FISS raster scans that show atmospheric levels in the blue wing, line centers, and the red wing of the Ha 6562.8 Å and Ca II 8542 Å spectral lines. We found several wing brightenings accompanied by eruptions of dense chromospheric material. There are no associated emission signatures in the Hα line center. Temporal evolution of the brightening seems to be to well associated co-temporal in both bands. Surge had a projected speed of ~26 km/s.

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The velocity pattern of the event showed a series of downflows and upflows related to the hot explosion: HMI downflows of about 1 km/s (about 150 km, photospheric height), FISS downflows with a speed of about 7 km/s (chromospheric height), Ellereman bomb (EB) upflows of about 11 km/s (maybe chromospheric height), Si IV upflows of about 30 km/s (transition region temperature, but maybe chromospheric height), and surge eruption with a projection speed of about 26 km/s (upper chromosphere or higher). Based on our results, we suggest the magnetic field configuration for our event (the above figure). In the figure, the hot explosion and EB can occur simultaneously by magnetic reconnection between newly emerging flux and pre-existing negative flux in the middle or upper chromosphere. Watanabe et al. (2008) studied the association between EB and emerging flux tubes and discussed three triggering mechanisms for EBs. Our event seems to follow their model 3, i.e., magnetic reconnection occurs at the footpoint of the emerging flux tube.