Various Local Heating Events in the Earliest Phase of Flux Emergence

TORIUMI, Shin, KATSUKAWA, Yukio (NAOJ)
CHEUNG, Mark C. M. (LMSAL)

Solar active regions (ARs) are formed through the emergence of magnetic flux from the convection zone, and when it emerges to the surface, various sporadic local heating events are observed in the lower atmosphere (chromosphere and transition region). With the aim of understanding the mechanisms of such heating events, we analyzed the coordinated observation data of flux emergence by Hinode and IRIS. As the emergence is hard to predict, there are not many observations of this kind so far, and thus the data set we show here, which is composed of optical and near-UV observations by the two instruments, is particularly rare.

The target emerging region appeared within NOAA AR 12401 on August 19, 2015 (Fig. 1). We first analyzed the Hinode Ca II H images and picked up 151 heating events. Out of the 29 events that are also covered by the Hinode's photospheric magnetic measurement, we found that 7 events occur in the locations where positive and negative polarities are closely nearby (mixed-polarity events), while another 10 are located in unipolar regions (unipolar events).

IRIS UV spectra of the mixed-polarity events show enhanced and broadened profiles with tails reaching ± 150 km s^{-1}, which are suggestive of the strong heatings and bi-directional jets. Each event leaves flare-like light curves with fast rise and extended decay. Moreover, Hinode revealed that most of this group have U-shaped photospheric magnetic fields. From these observational results, we concluded that the mixed-polarity events are caused by magnetic reconnection [2,3].

For the unipolar events, we did not find strong intensity enhancements in the IRIS UV spectra, but they showed systematic red shifts. The Doppler velocities measured from the peaks of the spectra were up to 40 km s^{-1}, which indicates the strong downflow that exceeds the local sound speed. These results suggest that the unipolar heating events are due to shocks or strong compressions caused by fast downflows along the overlying arch filament system [4].

As shown above, the combination of the photospheric vector magnetogram by Hinode and the UV spectroscopic data by IRIS allows us to discuss the mechanisms of a variety of local heating events in the emerging flux regions. Future missions that provide the the detailed field information not only in the photosphere but also in the upper atmosphere may further reveal the relation between the dynamics of magnetic fields and the chromospheric and coronal heating.

Emerging flux region (2015-08-19 10:47 UT)

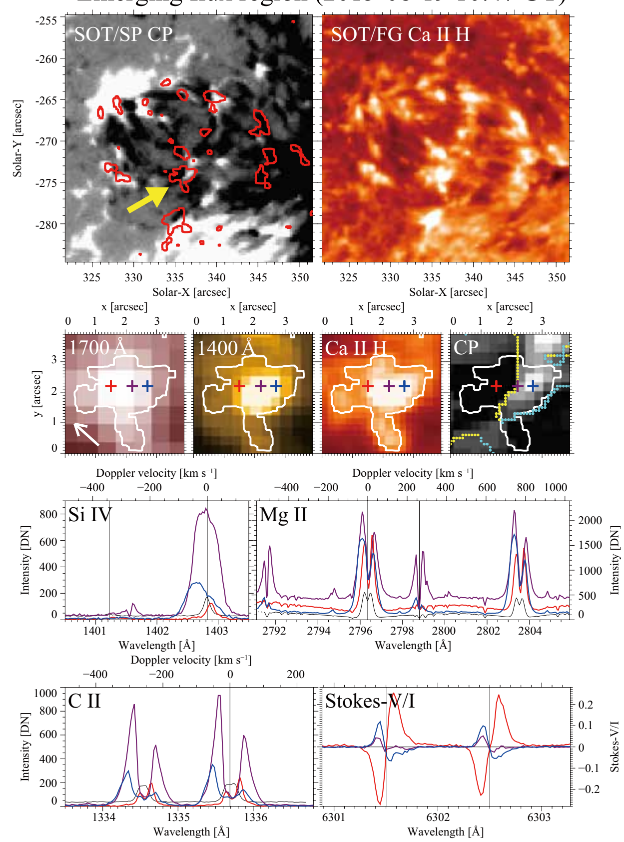

Figure 1: Flux emergence event in NOAA AR 12401. Top row shows Hinode/SOT photospheric magnetogram (left) and Ca II H intensity (right: also red contours in the left image). Sample heating event with yellow arrow is shown in the rows below: The second row shows the near UV and Ca II H intensity images and photospheric magnetogram (yellow and turquoise dots represent where the fields have U- and Ω-shaped configurations, respectively). Bottom two rows are the IRIS UV spectra and photospheric circular polarization (colors correspond to the + signs in the second row).

References

[1] Toriumi, S., et al.: 2017, *ApJ*, **836**, 63.
[2] Ellerman, F.: 1917, *ApJ*, **46**, 298.
[3] Rutten, R. J., et al.: 2013, *J. Phys.: Conf. Ser.*, **440**, 012007.
[4] Shibata, K., et al.: 1989, *ApJ*, **345**, 584.