

Self-cancellation of solar ephemeral regions observed by SDO

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Abstract. We study the ephemeral regions (ERs) in the quiet Sun observed by the Solar Dynamics Observatory, and find that they can be classified into two types: normal ERs (NERs) and self-cancelled ERs (SERs). We identify 2988 ERs among which there are 190 SERs, about 6.4% of the ERs. The total self-cancelled flux is 9.8% of the total ER flux. We suggest that the self-cancellation of SERs is caused by the submergence of magnetic loops connecting the dipolar patches, without magnetic energy release.

Keywords. Sun: activity, Sun: photosphere, Sun: surface magnetism

1. Introduction

Solar ephemeral regions (ERs) are small-scale dipolar magnetic structures with short lifetime and their properties have been investigated by many authors (Harvey & Martin 1973; Schrijver *et al.* 1998; Hagenaar *et al.* 2003). Yang *et al.* (2009) studied magnetic field evolution in a coronal hole region, and reported that the dipolar patches of an ER separated first and then moved together and canceled with each other. Wang *et al.* (2012) studied the solar intranetwork magnetic fields and found an intranetwork dipolar flux emergence followed by cancellation of its two poles with opposite polarities. Based on statistical results, our present study is dedicated to know how often and to what extent the ERs in the quiet Sun perform the self-cancellation behavior, i.e., an ER canceling itself after emergence.

2. Observations and Results

We adopt the full-disk line-of-sight magnetograms obtained from 2010 June 11 12:00 UT to 2010 June 15 12:00 UT by the Helioseismic and Magnetic Imager (HMI; Scherrer *et al.* 2012) on board the Solar Dynamics Observatory (Pesnell *et al.* 2012). We differentially derotate all the magnetograms to a reference time, 2010 June 13 12:00 UT.

We track the ERs according to their evolution, and identify 2988 ERs during the four days. We find that these ERs can be classified into two types according to their performance: normal ERs (NERs) and self-cancelled ERs (SERs). Each NER emerged and grew with separation of its dipolar patches, which canceled or coalesced with other magnetic flux eventually. Most of the ERs are NERs and the number of NERs is 2798. Each SER emerged and its dipolar patches separated at first, but then a part of magnetic flux of the SER moved together and canceled gradually. Figure 1 shows the evolution of an SER as an example. There are only 190 SERs, about 6.4% of the ERs.

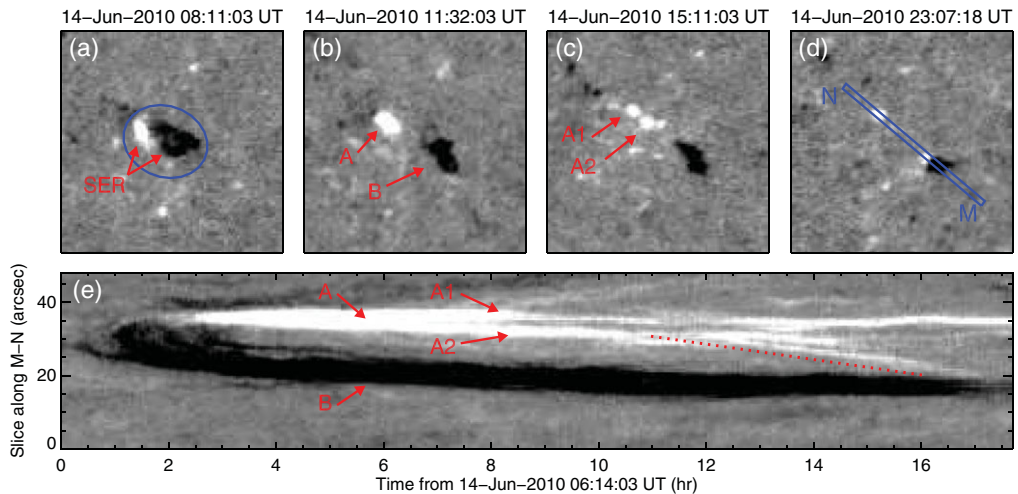


Figure 1. (a)-(d): Sequence of HMI magnetograms displaying the evolution of an SER. The field-of-view is 50×50 arcsec². (e): space-time plot along slit M-N.

For SERs, only part of the magnetic flux is self-canceled. The mean value of self-cancellation fraction of SERs is 62.5%, and the total self-canceled flux is 9.8% of the total ER flux. We also find that, the higher the ER magnetic flux is, (1) the easier the performance of ER self-cancellation is, (2) the smaller the self-cancellation fraction is, (3) the more the self-canceled flux is.

3. Discussion

Magnetic flux cancellation is a description of flux disappearance when two magnetic patches with opposite polarities encounter, so it is an observational phenomenon. In theory, the disappearance of magnetic flux can be resulted from the retraction of magnetic loops into the sub-photosphere, if the two poles are still connected by initial loops (Zwaan 1987). We suggest that the self-cancellation of SERs is caused by the submergence of magnetic loops connecting the dipolar patches. During this process, no magnetic reconnection occurs and no magnetic energy is released.

Acknowledgements

This work is supported by the National Natural Science Foundations of China (11203037, 11025315, 40890161, 10921303, 41074123 and 11003024), the CAS Project KJ CX2-EW-T07, and the National Basic Research Program of China under grant 2011CB811403.

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