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A "Dandelion" Filament Eruption and Coronal Waves Associated with the 2011 February 16 Solar Flare

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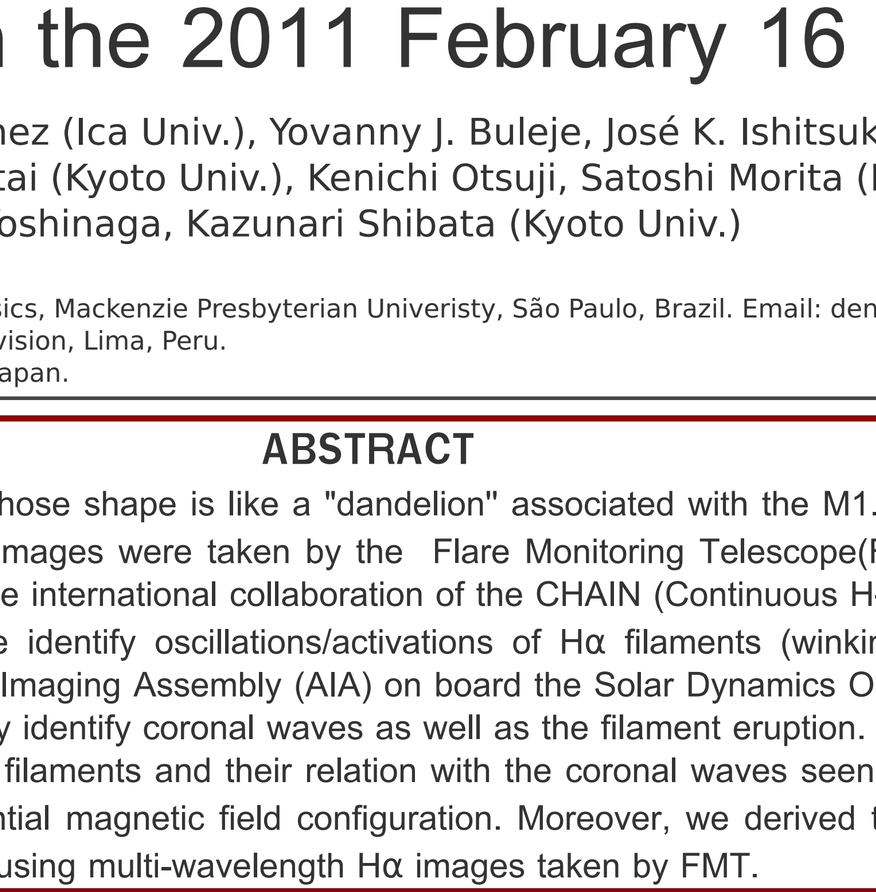
ABSTRACT

We observed a filament eruption in Hα images, whose shape is like a "dandelion" associated with the M1.6 flare, occurred on 2011 February 16 at the active region NOAA 11158. The Hα full disk images were taken by the Flare Monitoring Telescope(FMT) relocated from Hida Observatory of Kyoto University to Ica University in Peru, under the international collaboration of the CHAIN (Continuous H-Alpha Imaging Network)-project. There is no Moreton wave observed in Hαs, whereas we identify oscillations/activations of Hα filaments (winking filaments) at distant locations. In the extreme ultraviolet data taken by the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) and Extreme Ultraviolet Imager (EUVI) on board the STEREO-A, we clearly identify coronal waves as well as the filament eruption.

We present a detailed examination of the winking filaments and their relation with the coronal waves seen in EUV images, and also the features of the traveling coronal wave in relation to the potential magnetic field configuration. Moreover, we derived the three-dimensional velocity field of Hα erupted filament that drove the coronal waves, by using multi-wavelength Hα images taken by FMT.

Introduction

Coronal disturbances associated with solar flares, such as Moreton waves, X-ray waves, EIT/EUV waves, and so on, have been discussed in relation to MHD fast mode waves or shocks in the corona. To solve the mechanism of coronal disturbances, full disk observations with high spatial and temporal resolutions in multi-wavelengths are crucial. Associated with flares, filaments and prominences at distant locations are sometimes activated or excited to oscillate. This so-called "winking" motion are thought to be triggered by a Moreton wave or are caused by flare-associated invisible Moreton wave (Smith & Harvey 1971; Shibata et al. 2011).



Observations and Data

- Date: 2011 February 16th
- Start: 14:19 UT, Peak: 14:27 UT
- Active Region (AR): NOAA 11158 (S20^{0}W32^0)
- Flare class: M1.6 on the GOES scale.

Full-disk observation by:

- FMT: Hα center, Hα±0.8Å (20s cadence)
- SDO/AIA: 193Å, 171Å, 304Å (12s cadence)
- STEREO-A/EUVI: 195Å
- HINODE/XRT

◄ **Figure 1.** Full disk solar image in Hα line center, taken by FMT at Ica University, Peru. The lateral panels show the filament eruption in Hα±0.8Å and 193Å and 195Å wavelengths.

ANALYSIS AND RESULTS

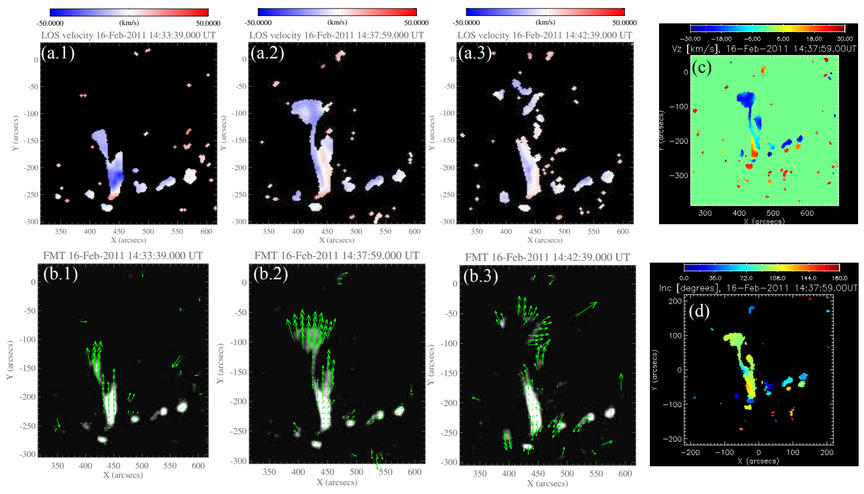
The Hα 'Dandelion' filament eruption

- On 2011 February 13th, a filamentary structure appeared along the neutral line of the AR-11158, evolved for about 3 days, and sustained multiple eruptions, even the X-class flare of the Feb. 15th.
- The Feb. 16th flare might induced certain instability on the unstable filament, causing finally its activation and disruption.

Winking filaments and EUV waves

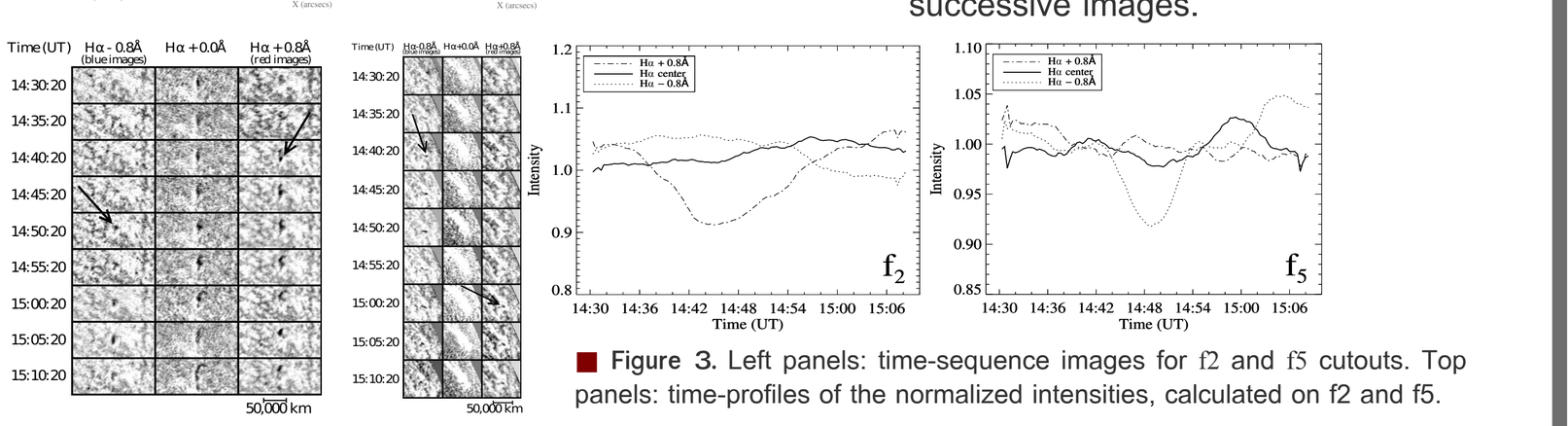
- We identified a clear "winking" (activation/ oscillation) features for filaments ' f_2' and 'f_5', in Hα wing images. These evidences are also observed in the time-profile intensities (Fig. 3).
- *What phenomenon triggered the winking motion of the filaments?*

- We derived the speeds of the EUV waves in the 'f_2' and 'f_5' directions, as well as the time arrival of the wave-fronts to these regions. Resulting in: ~370 km/s, 14:40UT for 'f_2' and ~630 km/s, 14:37UT for 'f_5'.

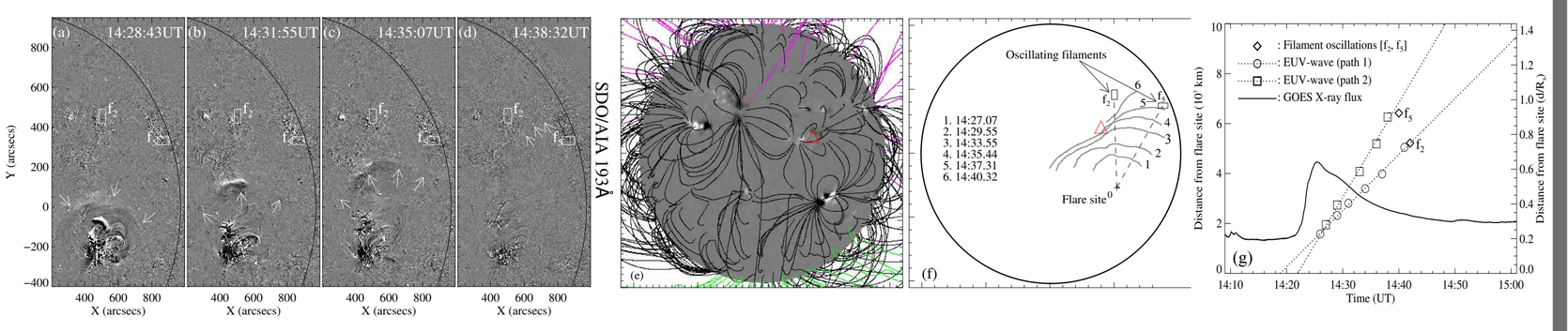


◄ **Figure 2.** Line of sight (LOS) velocity and tangential velocity maps (panels: a.1-a.3 and b.1-b.3). Doppler velocity Vz (panel c) and inclination maps (panels: c and d, 0^0 is to observed).

- Based on Beckers' cloud model, the LOS was obtained by calculating the Hα profiles and measuring the Doppler shift. The tangential velocity, was calculated by tracing the motion of the internal structures on successive images.



■ **Figure 3.** Left panels: time-sequence images for f2 and f5 cutouts. Top panels: time-profiles of the normalized intensities, calculated on f2 and f5.



■ **Figure 4.** (a–d) Running difference images. (e) Coronal magnetic field extrapolation (PFSS model). (f) A schematic illustration of the coronal waves progressions. The red triangle denotes the region where the wave-fronts experience deceleration. (g) Time-distance diagrama of the Moreton coronal waves.

Summary & Conclusions

Associated with the flare, we observed a surge-like filament eruption, winking filaments and EUV waves. We succesfully derived the 3-dimentional velocity field of the erupting filaments. Since we did not observe Moreton waves, it is likely that the EUV waves triggered the oscillation of the filaments. These expectations are in good agreement with the derived traveling speeds of the wave-fronts and the time arrivals, that are also supported by the time-distance diagram.

References: Asai A., Ishii T.T., Isobe H., et al 2012, ApJ, 745, L18.
Smith S. & Harvey K., 1971, Phys. of Solar corona, 156.
Shibata K., & Magara T., Living Rev. Sol. Phys.,8,6.