Proceedings of the International Astronomical Union

Date of delivery: 5 May 2016

Journal and vol/article ref: IAU 1600019

Number of pages (not including this page): 3

This proof is sent to you on behalf of Cambridge University Press. Please check the proofs carefully. Make any corrections necessary on a hardcopy and answer queries on each page of the proofs.

Please return the marked proof within 5 days of receipt to:

Managing editor of this symposium

Authors are strongly advised to read these proofs thoroughly because any errors missed may appear in the final published paper. This will be your ONLY chance to correct your proof. Once published, either online or in print, no further changes can be made.

To avoid delay from overseas, please send the proof by airmail or courier.

If you have no corrections to make, please email to save having to return your paper proof. If corrections are light, you can also send them by email, quoting both page and line number.

• The proof is sent to you for correction of typographical errors only. Revision of the substance of the text is not permitted, unless discussed with the editor of the journal. Only one set of corrections are permitted.

• Please answer carefully any author queries.

• Corrections which do NOT follow journal style will not be accepted.

• A new copy of a figure must be provided if correction of anything other than a typographical error introduced by the typesetter is required.

If you do not send any corrections to the editor within 5 days, we will assume your proof is acceptable.

• If you have problems with the file please contact lwebb@cambridge.org

Please note that this pdf is for proof checking purposes only. It should not be distributed to third parties and may not represent the final published version.

Important: you must return any forms included with your proof. We cannot publish your article if you have not returned your signed copyright form.

NOTE - for further information about Journals Production please consult our FAQs at http://journals.cambridge.org/production_faq
Author queries:

Typesetter queries:

Non-printed material:
Muti-wavelength observations of filament oscillations induced by shock waves

Yuandeng Shen
Yunnan Observatories, Chinese Academy of Sciences, Kunming 650011, China
email: ydshen@ynao.ac.cn

Abstract. Two cases of filament oscillations induced by large-scale coronal shock waves are presented. For the first case, a chain of transverse oscillating filaments are observed in a proper order after the passing of a shock wave, and it is found that they were triggered by the surface component of the dome-shaped shock wave. For the second case, simultaneous transverse oscillation of a limb prominence and longitudinal oscillation in an on-disk filament are launched by a single shock wave. It is found that the interaction angle between the shock wave and the prominence axis is the key to launch transverse or longitudinal filament oscillations. In addition, filament magnetic fields are estimated, using the measured parameters.

Keywords. Shock Waves, Filaments, Oscillations, Prominences.

1. Introduction

Large amplitude filament (prominence) oscillations could be classified into transverse and longitudinal oscillations (Arregui et al. 2012, Tripathi et al. 2009). Previous studies indicate that the former type is often trigger by shock waves such as chromosphere Moreton and coronal extreme-ultraviolet waves (e.g., Ramsey & Smith 1966, Eto et al. 2002, Okamoto et al. 2004, Gilbert et al. 2008, Shen et al. 2014a, 2014b), while the latter is usually associated with nearby micro flare, filament, and jet activities (e.g., Jing et al. 2003, 2006, Vršnak et al. 2007, Li & Zhang 2012). The velocity amplitude, period, and damping time of transverse oscillations are in ranges of 6 - 41 km s$^{-1}$, 11 - 29, and 25 - 180 minutes, while those for longitudinal oscillations are 30 - 100 km s$^{-1}$, 44 - 160, and 115 - 600 minutes, respectively. Theoretical studies of filament oscillations can be found in Kleczek & Kuperus 1969, Hyder 1966, and Luna & Karpen 2012. So far, the driving mechanism of oscillating filaments and their relationship between shock waves are still unclear. Here, two cases of filament oscillation cases are presented to diagnose the properties of the oscillating filaments and the associated coronal shock waves.

2. Results

The first case was on September 06, 2011. Four successive winking (oscillating) filaments (F1–F4) and a micro jet are observed right after the X2.1 flare in AR11283, and their start times are obviously depending on their distances to the flare (see Figure 1 (a)). In EUV observations taken by the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO), a bright shock wave is observed in the northwest of AR11283, which composed of two components: a fast (850 km s$^{-1}$) and a slow (542 km s$^{-1}$) shock waves. By comparing the start time of filament oscillations and the position of the shock wave speeds, it is found that the oscillating filaments are associated with the slow component. F1 is taken as an example to show the filament oscillation. One can see the obvious periodically appearance and disappearance of the filament at the red- and blue-wings, indicating the downward and upward motions of the filament.
Filament oscillations induced by shock waves

The periods, velocity amplitudes, and damping times of the oscillating filaments are in the ranges of 11–22 minutes, 6–14 km s\(^{-1}\), and 25–60 minutes, respectively. Using these parameters, it is estimated that the radial component magnetic field of the oscillating filaments are in the range of 5–10 Gauss.

The second case was on August 09, 2011. An X6.9 flare occurred in AR11263, which launched an impulsive coronal shock wave that triggered the transverse oscillation of a prominence (P) and the longitudinal oscillation of a filament (F2). Figure 2. (a)–(d) show the condition before the flare. In the time-distance plot (Figure 2. (e)), one can see that the prominence start to oscillate immediately after the passing of the shock wave. It is measured that the oscillation period of the prominence is 13.5 minutes. Large amplitude longitudinal oscillation was observed in F2 after the passing of the shock wave (see Figure 2. (f)), whose oscillation period is about 80.2 minutes. Using the measured parameters, it is obtained that the radial component magnetic field of the prominence and the poloidal field of the filament are about 8 and 3 Gauss, respectively.

A simple scenario is proposed to explain the different oscillation patterns observed in the prominence and the filament (see Figure 2. (g) and (h)). It is propose that the orientation of a filament or prominence relative to the normal vector of the incoming shock wave should be an important factor for launching transverse or longitudinal filament oscillations, i.e., if the wavefront is perpendicular (parallel) to a filament axis, transverse (longitudinal) oscillations could be expect in the filament.
3. Discussions
According to Veronig et al. (2010), a coronal shock wave usually has a dome shape in the upward direction, and on the lateral one can observe another surface shock wave that has a relative lower speed. For the first case, the fast wave should be the dome part, while the slow one should be the lateral surface wave. Therefore, considering the relationship between the start time of the oscillating filaments and the speeds of the shock waves, it is proposed that the chains of filament oscillations are triggered by the slow wave component. In summary, it is conclude that coronal shock waves is a good agent for triggering and connecting successive but separated solar activities in the solar atmosphere. They can not only efficiently launch filament oscillations and other solar eruptive activities, but also important for diagnosing filament and the surrounding coronal parameters.

Acknowledgements
This work is supported by Chinese foundations (11403097, 2015FB191), and the Youth Innovation Promotion Association (2014047).

References
Hyder, C. L. 1966, Z. Astrophys., 63, 78
Kleczek, J. & Kuperus, M. 1969, Sol. Phys. 6, 72