

Limb flares measurement from Langkawi National Observatory on 5th January 2016

F Kamarudin, M R Tahar and N R Saibaka

Langkawi National Observatory, National Space Agency, Empangan Bukit Malut,
07000 Langkawi

*E-mail : farahana@angkasa.gov.my

Abstract. Sun is the source of energy and has a lot of activity that will be influence the Earth. One of the solar activities is the limb flare or prominence. It release energy and expel outward the Sun surface. Langkawi National Observatory (LNO) had started photographic solar activity in H α since 2008. LNO used the dedicated solar telescope to monitor and observed the solar activity daily. In 5th January 2016, LNO captured one limb flare at the south-west position of the Sun. The maximum height of the limb flare is 267,347 km and it increase gradually build up the velocity. Luckily, this eruption does not facing and directed towards Earth so there was no significant impact.

1. Introduction

The Sun is a giant ball of hot gasses held together by its immense gravity. It can occasionally release high energetic plasma from its magnetic fields in many forms like filaments, prominences, solar flares and coronal mass ejections (CME). Our Sun is filled by various activities and it occurs in the different layers of solar atmosphere like photosphere, chromosphere and corona. Some of the higher energy activities cause what we call space weather and it can affect and interrupt some technologies on Earth like communications, power grids and satellite navigations [1].

The chromospheric layer is one of the remarkable layers of our dynamics sun. Observers and researchers can see the developing of new active regions, plagues, prominences, flares and others features in this layer. Generally, there are two main spectral lines are used to observe the solar activity at chromosphere layer which is Hydrogen- Alpha (H- α) line at 3834 Å and Calcium-K line at 3868 Å [2]. For researchers, they detect prominences in the H- α band spectrum. A prominence is like a puff of material noticeable above the solar surface. They appear bright against the dark background of space in the solar limb due to the reduced emission loss thus it increase the brightness temperature in that line. But prominence is called as dark filament when it seen on the disk as it appears darker as compared to the more energetic surface of the chromosphere. [2][3].

A systematic observation of prominence has been carried out for almost 125 years from various parts of the world. Early observation of solar prominence is observed during the solar eclipse made by Muratori (1239) and Vassenius (1733) [4]. Beginning from 1860 the observations and study of prominences has been done with aided tools like photography and spectroscopy. In 1900's, Brocchino and Borocas had studied the relation prominence to the solar cycle [5].

Prominence will appear in variety of shapes and size. Sometimes it can persist almost few thousand kilometers to nearly radius of the Sun. It also can be seen by few hours, days or several month. Sometimes it can unexpectedly explode and reconstruct in same shape and position. Classification of prominences can be divided into 2 classes as below:-



Table 1. Prominence classification

Class	Name	Description
I	Quiescent (long lived) prominence	a) Prominence or filament in or near active regions & in quiet regions b) Rising prominence
II	Active (flare associated, temporary) prominence	a) Limb flares b) Surges c) Sprays d) Loops

Usually the quiescent prominence will be form in active region, between two active regions or over polar coronal holes (called polar crown). The dynamics of prominence can be understood as a contribution of magnetic-force resistance to gravitational attraction of interior and solar surface [6]. This paper is organized as follow. In section 2, we will introduce the Langkawi National Observatory (LNO) Solar Observatory and our H- α solar observation procedures. The analysis of the solar limb detected is discussed in section 3. Meanwhile, in Section 4 we will discuss about our results. Finally, our work of this paper is summarized in the last section.

2. Langkawi National Observatory: H-alpha solar observation

In Malaysia, there are several H- α observation that is done by various parties. Most of these observations however are not continuous or conducted routinely. LNO is an exception as it is well equipped and staffed, can therefore carries out continuous H- α observation. LNO is situated north of Malaysia, on the Langkawi Island with latitude of 6.307147°N and longitude 99.781205°E [1]. The main focus of LNO is more on optical astronomy related researches and is one of the facilities under National Space Agency of Malaysia (ANGKASA). LNO is furnished with 3 solar observation systems to observe the sun in different wavelengths which are white light for monitoring the photospheric activities, H- α (6562.8Å) and Calcium K-line (3933.7Å) for monitoring the chromospheric activities. In this paper, we will be focusing on the output from the H- α system that recorded an active prominence or flare at the solar limb which happened on the 5th January 2016.

LNO uses digital images for all their solar observations. The imaging train consists of a Lunt 60mm f/8.3 dedicated solar telescope with an additional 50mm aperture double stack filter to increase the effective bandwidth down to <0.5 Å. The telescope's filter is an etalon design. Meanwhile, rear blocking filter used in tandem with this telescope is a Lunt's straight-thru B3400. With this blocking filter, the Sun's image is very bright and chromospheric activities can easily be seen despite the double stack setup. The telescope rides atop a Paramount ME tracking mount to follow the motion of the Sun throughout the day. Both etalon filters are easy to adjust to the preferred ultra-narrow H- α band of 6562.8Å. We used a SKYnyx 2-2 M CCD camera for recording the solar events in video format. The SKYnyx 2-2M is capable of recording lossless 8 & 12 bit monochrome images at 12 fps in full resolution of 2 megapixels. This capability makes it suitable for monitoring the sun activity in H- α due to the rapid changes of the solar chromosphere features like solar flares and active prominence. On our setup, the Sun disk diameter is around 1086 pixels. It will make 1 pixel equals to 1286 kilometer of the Sun.

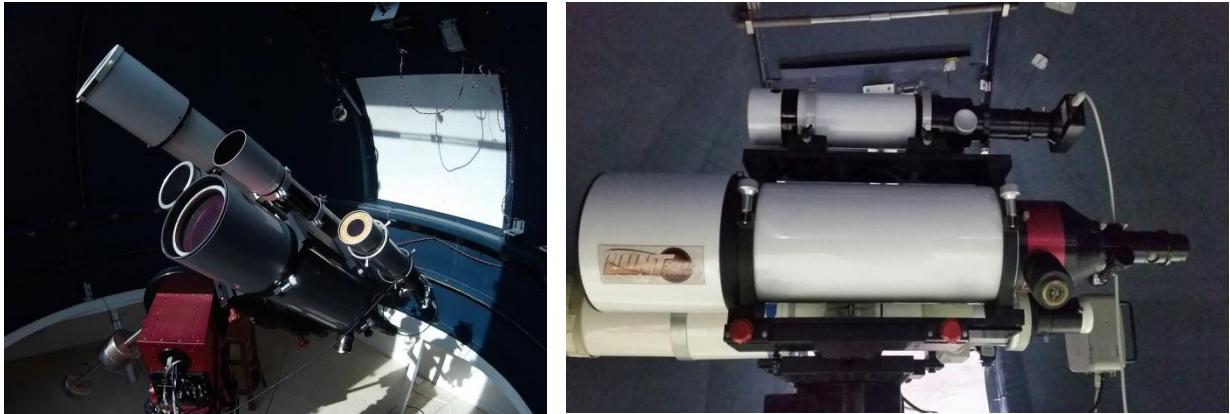


Figure 1. Instrumentation used for H- α imaging and data collection at LNO:- Double-stack solar telescope, SKYnyx 2-2M Video CCD Camera and Lunt Blocking Filter

H- α observations at LNO are performed daily whenever the weather permits (including holidays). Usually, we record H- α images between 9:30 AM until 4:00 PM, after the white light observation was completed. Observers will adjust the exposure time to fill 2 thirds of the CCD's well size to ensure it is well within the linearity range and corresponds to the atmospheric conditions at the time observation. The quality of atmospheric condition which involves seeing and sky condition is recorded along with every solar observation at LNO. They are rated ranging from 1 to 5, with 1 representing poor conditions and 5 for perfectly clear blue sky with very stable atmospheric turbulence [7]. Due to Malaysia's tropical weather, sometimes it is a bit difficult to get the best image even in good weather condition due to high humidity.

Firstly, observers need to ensure the H- α image is in focus. The sky condition is a contributing factor to determine the best focus where the spicules can be seen at the limb of the Sun in excellent sky conditions. Once good focus has been achieved, the observer will start to record the solar image at every 1 minute interval. Later, the data will be processed and viewed using Registax and observers will look for feature changes at the surface or limb of the Sun. The daily solar observing data from LNO are published on the LNO website and the additional data can be requested with an inquiry to LNO.

3. Limb flare analysis

Figure 2 shows the H- α image taken by LNO on 5th January 2016. During that day, a limb flare was observed at the south-west side of the Sun between 0235 UTC and 0423 UTC. This active prominence originates from AR2473 due to the same longitude position during this active region at the Sun surface. This sunspot or active region has been producing many eruptions ever since it appeared on the eastern solar disk on 21st December 2016.

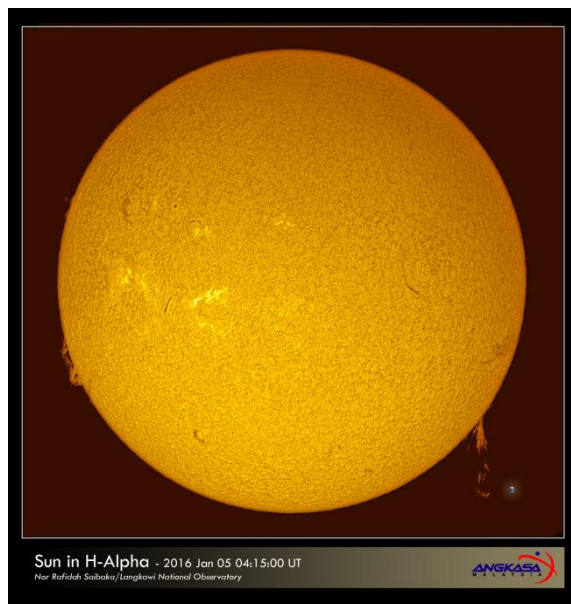


Figure 2. Limb Flare taken from LNO at 5th January 2016



Figure 3. The maximum height identification and calculation

During the energy release process, the beginning height of this limb flare is 13,435 km and it reached the maximum height of 267,347 km as in Figure 3. It is calculated by multiplying the pixel along the height measurement of the burst with the image resolution (1286 km/pixel). It is due to unstable state of the magnetic fields at this active region.

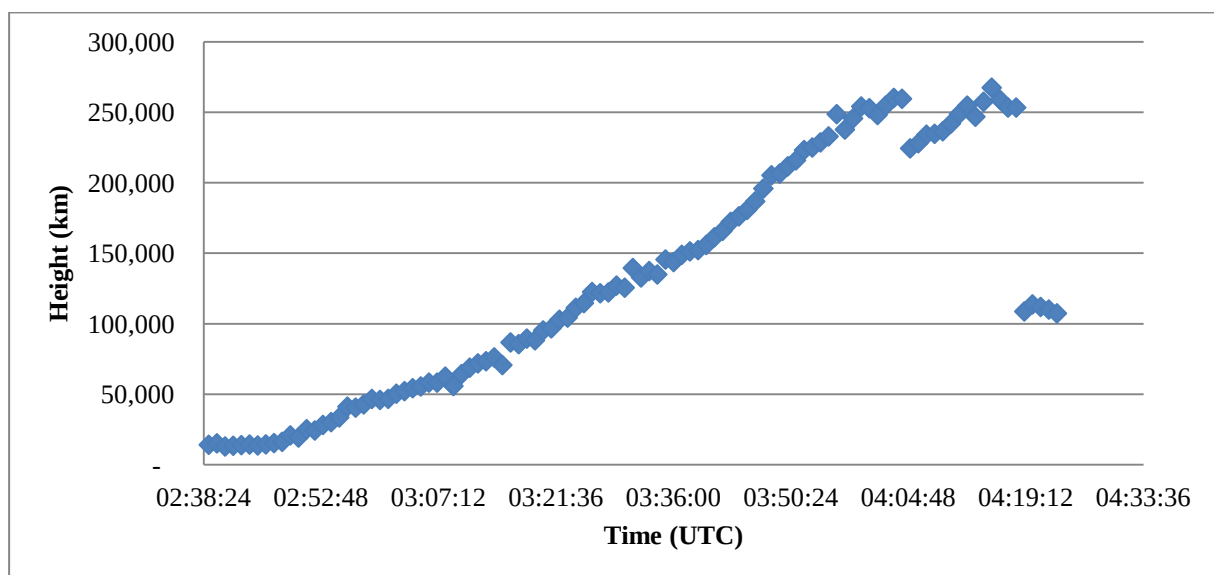


Figure 4. Limb flare height measurement in kilometre over time of observation on 5th January 2016

From the height measurement in the H- α wavelength as shown in Figure 4, the speed of the flare's height shows some slow gradual build-up. This is also reflected in the Figure 6. As the flare increased in height, the speed of height increment also increases slowly. Mostly this is due to the distance to the gravity pull that starts to weaken as it gets further away.

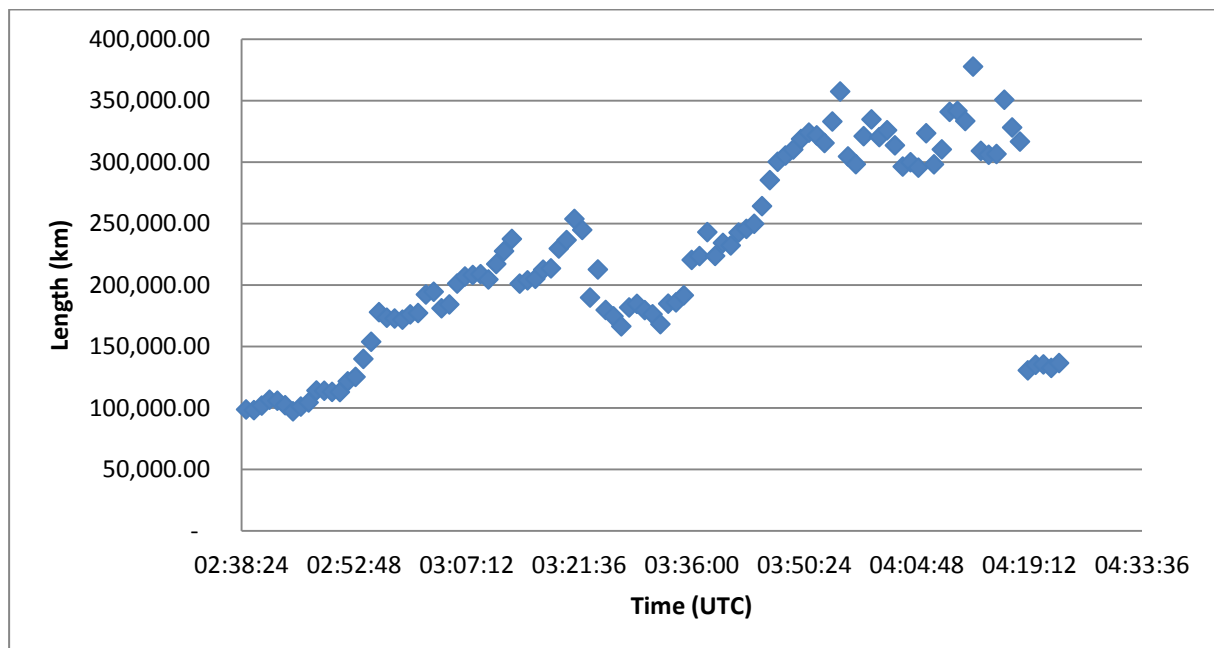


Figure 5. Limb flare length measurement in kilometre over time of observation on 5th January 2016

This beginning flare length is 74,781.79 km and it reached its maximum length of 377,636.93 km was shown in Figure 5. This shows that the flare detached from the Sun surface at the maximum point of its height and length.

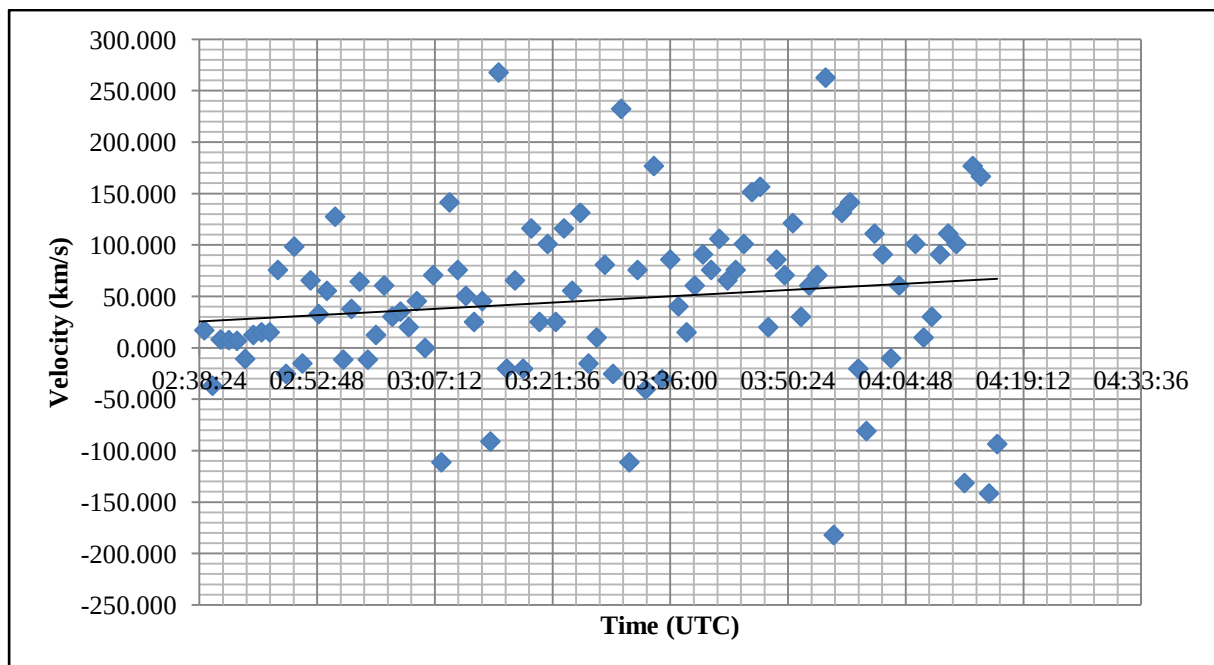


Figure 6. Shows the velocity (vertical) over time

Interestingly, the velocity of the flare along the length of the flare position decreases over time as it loses or starts to dissipate its energy. As evident in Figure 7, the overall pattern decreases over time but at the same time the fluctuations also increase as it get more unstable. This is the opposite of what is happening to the flare's vertical velocity which is increasing.

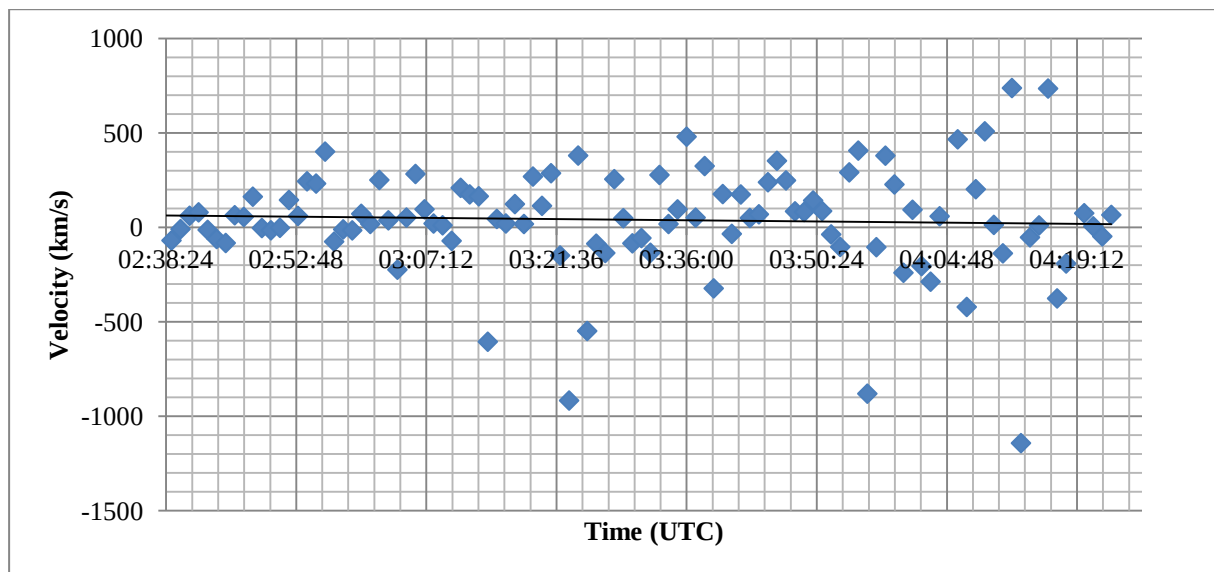


Figure 7. Velocity of the flare along its path.

4. Conclusion

From this paper, LNO is capable to carry out H- α observation of the Sun. This particular limb flare which is AR2473 was recorded on 5th January 2016. The maximum height of the flare is 267,347 km and the maximum length is 377,636.93 km. The speed of this flare eruption was slow gradually built up. This is due to gravity pull back to the Sun surface. As the flare erupts, the velocity is increased as it gets further from the Sun surface. Luckily, this eruption was not facing Earth and will not cause the space weather effect to Earth.

References

- [1] Kamarudin F, Tahar M R, Saibaka N R and Padang L A L 2016 Relative sunspot number observed from 2013 to 2015 at Langkawi National Observatory *Adv. Sci. Lett.* **23**(2) 1285
- [2] Bhatnagar A. & Livingston W, 2005 Fundamentals of Solar Astronomy, World Scientific Publishing (New Jersey: Hackensack)
- [3] Zirin H 1989 Astrophysics of the Sun (New York: Cambridge University Press)
- [4] Papics P I 2007 Solar Prominences, Solar Flares and Coronal Mass Ejections <http://papics.eu/SolarPhenomena.pdf>
- [5] Parenti S 2014 Solar Prominences: Observations *Living Rev. Solar Phys.* 11
- [6] Naufal L *et al.* 2016 Prominence measurement of total solar eclipse: March 9th 2016 Ternate Indonesia *J. Phys. Conf. Ser.* 771
- [7] USSPS Code (2000) [Online] [Accessed 15th March 2016] Available from <http://www.spaceweather.org/ISES/code/od/ussps.html>