Spicules and Macrospicules: Simultaneous Hα and He II (304 Å) Observations

A. A. Georgakilas
National Observatory of Athens, Astronomical Institute, I. Metaxa and V. Paulou, 15236 Palaia Penteli, Greece

H. Dara and Th. Zachariadis
Research Center for Astronomy and Applied Mathematics, GR-10673, Athens, Greece

C. E. Alissandrakis
Section of Astro-Geophysics, Dept. of Physics, Univ. of Ioannina, GR-45110 Greece

S. Koutchmy and C. Delannée
Institut d’Astrophysique de Paris, CNRS, 98 bis boulevard Arago, F-75014 Paris, France

J.-P. Delaboudinière and J.-F. Hochédez
Institut d’Astrophysique Spatiale, CNRS, Universite Paris XI, bat 121, F-91405 Orsay, France

Abstract. We compare simultaneous sequences of Hα and He II (304 Å) filtergrams obtained during JOP 057 SOHO campaign. After correcting the filtergrams for limb darkening we were able to find a correlation between He II macrospicules and Ha spike-like structures. It appears that He II macrospicules appear before and remain visible for a longer time than their Hα counterparts.

1. Introduction

Macrospicules are striking spikelike structures near the Sun’s polar limb which resemble the familiar giant Hα spicules. Their length is from 5″ to 60″, their width from 5″ to 30″ and their lifetime ranges from 8 to more than 45 min. They were first observed in He II (304 Å) spectroheliograms during the Skylab mission (Bohlin et al. 1975). Macrospicules rise rapidly to their maximum height and then remain static or slowly fade away. Bohlin et al. measured apparent rising velocities from 10 to 150 km s⁻¹. It is not clear if the apparent development of macrospicules is due to real mass motions or simply a visibility effect due to the changing of the excitation conditions. According to Bohlin et al. (1975)
the macrospicule phenomenon may consist of multiple events in a long lasting structure.

Moe, Engvold & Beckers (1975) compared simultaneous ground based Hα filtergrams and He II (304 Å) images. They were unable to find any significant correlation and concluded that Hα spicules and He II macrospicules are quite different. Moore et al. (1977) used the term Hα macrospicule to refer to small surge-like quiet region Hα limb eruptions having dimensions significantly larger than the usual Hα spicules. Before using this term the larger Hα macrospicules observed in the polar regions were called Polar limb surges (Godoli & Mazzucconi, 1967); they were also called spikes by Koutchmy & Loucif (1991). Moore et al. (1977) found that Hα macrospicules are similar to the EUV macrospicules in shape, size, motion and duration. Furthermore, comparing simultaneous Hα and He II observations they concluded that an Hα macrospicule is the Hα component of an EUV macrospicule.

2. Observations and Image Processing

The observations were obtained in the frame of the Joint Observing Program 57 (Delanee et al. 1997). In this work we analyze He II (304 Å) images obtained with the Extreme Ultraviolet Imaging Telescope (EIT) and Hα images obtained with the UBF at the focus of the Vacuum Tower telescope of the Sacramento Peak Observatory, on 11 and 13 December 1996. The duration of the simultaneous sequences of observations was about 1 hour each day. EIT images were obtained approximately every minute, while the rate of Hα images was one every 3 sec on December 13 and every 18 sec on December 11.
The raw images were corrected for dark current and flat field and carefully aligned. We furthermore normalized the images by computing the intensity over a large area and dividing the intensity of each pixel by this average value.

We used a technique developed by Georgakilas et al. (1997) to correct for limb darkening and enhance the spatial resolution. We first determined the position of the center of the solar disk and the solar radius, by fitting a circle to the limb. Further we computed the average intensity along circular arcs parallel to the solar limb and obtained the limb darkening profile as a function of the distance from the disk center. Subsequently we subtracted the corresponding limb darkening intensity from the intensity of each pixel.

3. Results

One should consider several factors in comparing Hα and He II (304 Å) macroscopicules. Hα images are stretched due to atmospheric distortion. Withbroe et al. (1976) proposed that macroscopicules may be very faint in Hα due to their low density. The large velocities associated with macroscopicules can easily produce Doppler shifts in excess of 0.5 Å at Hα. As the velocities during the vertical extension phase of the structures are larger than 30 km s⁻¹, then the Hα intensity is enhanced during this phase due to the Doppler brightening effect (Hyder and Lites, 1970). The Doppler brightening mechanism predicts intensity maxima during ascending and descending phases, when the velocity transverse to the line of sight is large. According to Labonte (1978) the brightening during the descending phase is not observed due to the change in the state of the material in the macroscopicule. The macroscopicule undergoes a monotonic expansion with a corresponding reduction in density.

In order to further improve the spatial resolution of the Hα features we added filtergrams at Hα center, Hα+0.5 Å and Hα-0.5 Å. From figure 1 it is obvious that He II macroscopicules have corresponding spike-like structures in Hα. However there is not always a one to one correlation. In order to further investigate this point, we followed the development of a macroscopicule from his first appearance until it faded out.

Figure 2 shows a characteristic example observed on December 13 at selected times which reveal the various phases of the phenomenon. On this day we had only Hα line center filtergrams. The macroscopicule makes its appearance in He II and it is relatively faint. We cannot observe it in Hα while diffuse material has spread over a large volume in He II. Ten minutes later, at 18:28:58 UT, we observe an intensity enhancement (brightening) at the base of the feature in both lines, giving the impression of the beginning of a new event. Subsequently the macroscopicule expands upwards in both lines. After about 6 minutes the decay phase begins; the macroscopicule fades first in Hα and after about 4 min in He II.

4. Summary and Conclusions

We compared simultaneous Hα and He II (304 Å) filtergrams obtained during JOP 057 campaign. From this preliminary study we conclude that He II macroscopicules have corresponding spike-like structures in Hα. However, de-
Figure 2. Simultaneous H\(\alpha\) and He II (304 Å) filtergrams showing the development of a macrospicule.

Depending on the state of the material (temperature, density, velocity), some part of macrospicules emit more strongly in He II whereas others are better visible in H\(\alpha\). Furthermore, it appears that they start to be visible in He II well in advance of H\(\alpha\) and remain visible longer during the decay phase. This may be the main reason that early observers didn’t succeed in finding a significant correlation between He II and H\(\alpha\) features. In general, He II structures appear to extend higher and spread over a larger area than their H\(\alpha\) counterparts.

Acknowledgments. One of the authors (A. G.) would like to thank professor R. N. Smartt and the staff of the Sacramento Peak Observatory for their warm hospitality and their help in the observations.

References

Hyder, C. L., & Lites, B. W. 1970, Solar Phys., 14, 147
Labonte, B. J. 1979, Solar Phys., 61, 283