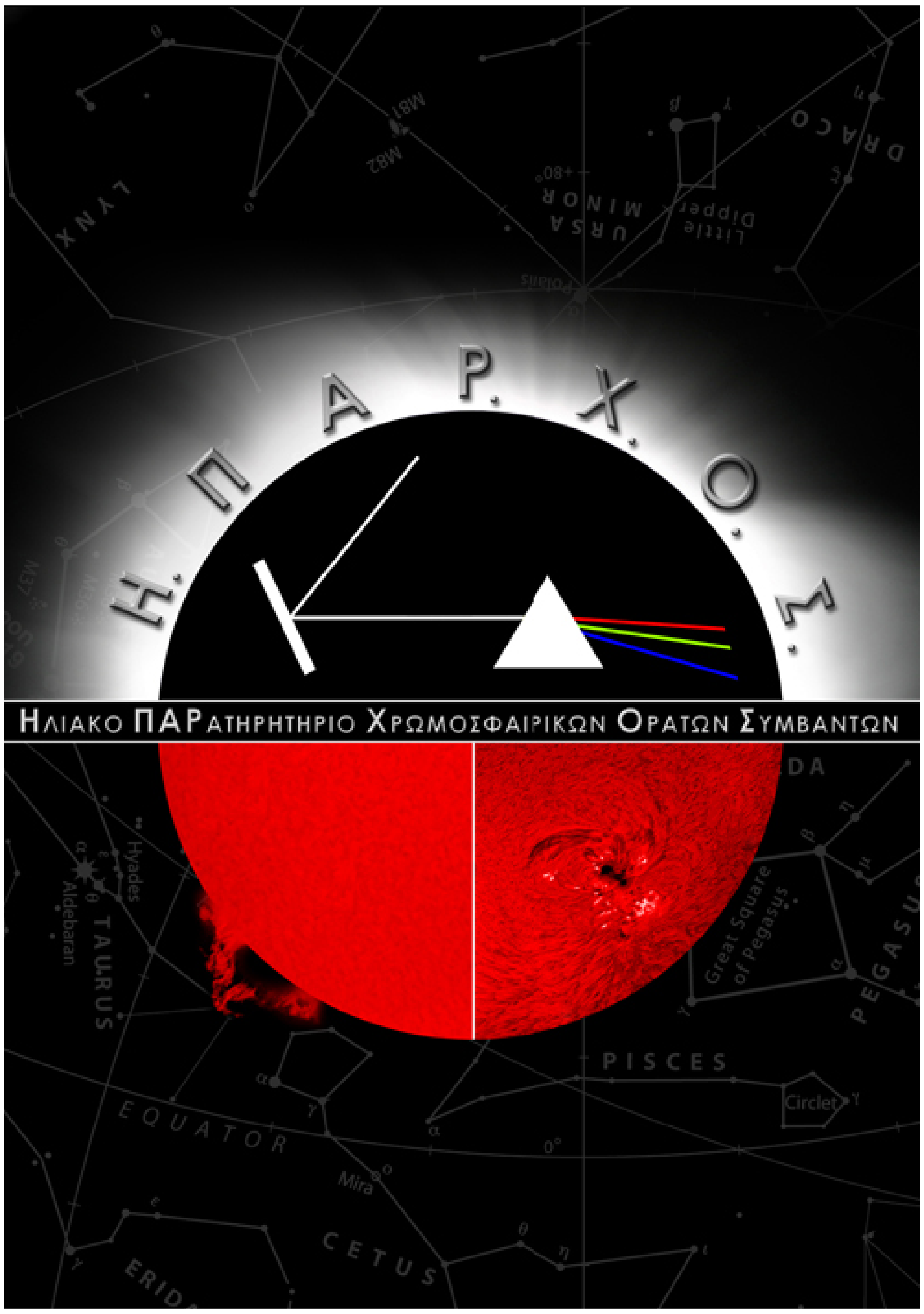


IPARCHOS Solar Observatory

Spectral analysis of the SOLARMAX CORONADO 60 Ha filter

Text-images courtesy of Aristidis Voulgaris, founder of the IPARXHOS Solar Observatory

Translation: Alexandros Filothodoros, member of the IPARXHOS Solar Observatory

Summary

The following text is deals with the spectral analysis of the Solar Hydrogen filter of the Coronado company.

As it is already known the solar Ha filter allows the immediate observation of the solar atmosphere ,the Chromosphere.

When observing the Chromosphere with a Hydrogen filter formations of burning Hydrogen become obvious.These are the prominences (bright formations outside the solar disk) or the filaments (dark formations projected on the solar disk) and one of the most violent phenomenae on our Solar System the solar flares, which are nothing else but a great release of energy and particles in a surprisingly short

period of time (of a few minutes) .The colour of the Chromosphere is distinctive red ,because of the fact that it consists of (excited) Hydrogen which radiates in the distinctive 656.26A wavelength also known as Ha (that's why the image we see through the filter is of the same red hue) .It is possible that the red colour of a solar prominence can vary , because of the Doppler-Fizeau effect , if it is moving with a relatively great speed .

The Solarmax Coronado 60 solar filter consists of two parts. The 60mm diameter etalon (objective system) of 0.7A spectral range and the blocking filter (BF diagonal mirror with the addition of a reducing and interference filter), were adjusted to a ED 80 (F=600mm) Skywatcher telescope of the Synta company. The etalon (which defines the final spectral range) adjusted to this scope was placed at the optical bank of the IPARCHOS solar observatory. (Image 1)

Image 1: The etalon of the Coronado 60 adjusted to a Skywatcher ED 80

The spectral range of the filter defines the raise of contrast of the observed Chromospheric formations and obviously the smaller it is, the better the Chromospheric formations are observed. Using the observatory's double reflection heliostat solar light was projected at the telescope's objective system with the intend of measuring the spectral range (FWHM) of the Ha filter as well as marking the tuning system , which is necessary for calculating the Doppler shift of the extremely fast Chromospheric formations .The big dispersion spectrograph (0.0923 A/pixel) was placed after the telescope (on which the etalon Coronado 60 filter was adjusted) and the focal point of the telescope was projected at the diaphragm (Perkin Elmer slit) of the spectrograph . (image 2)

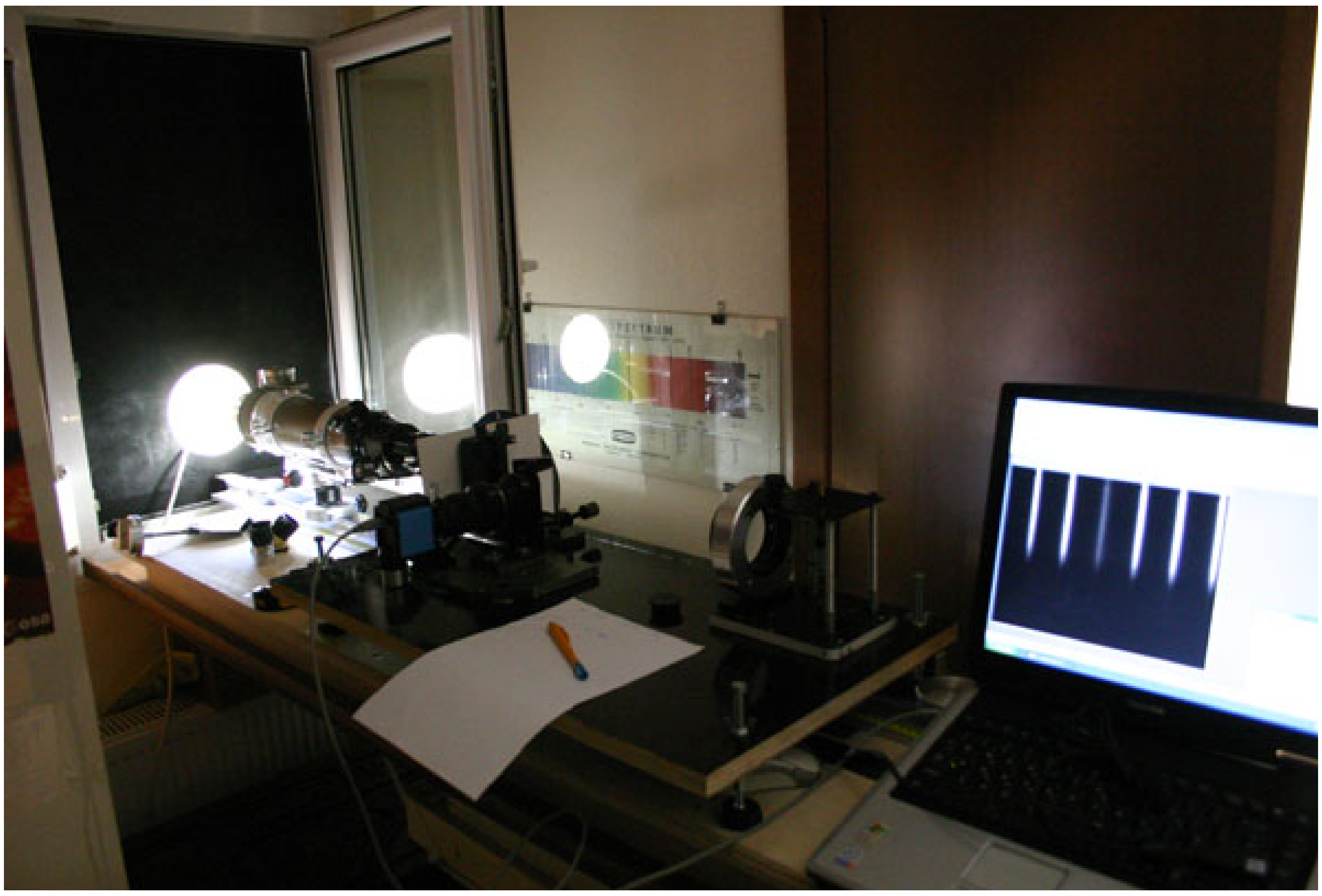
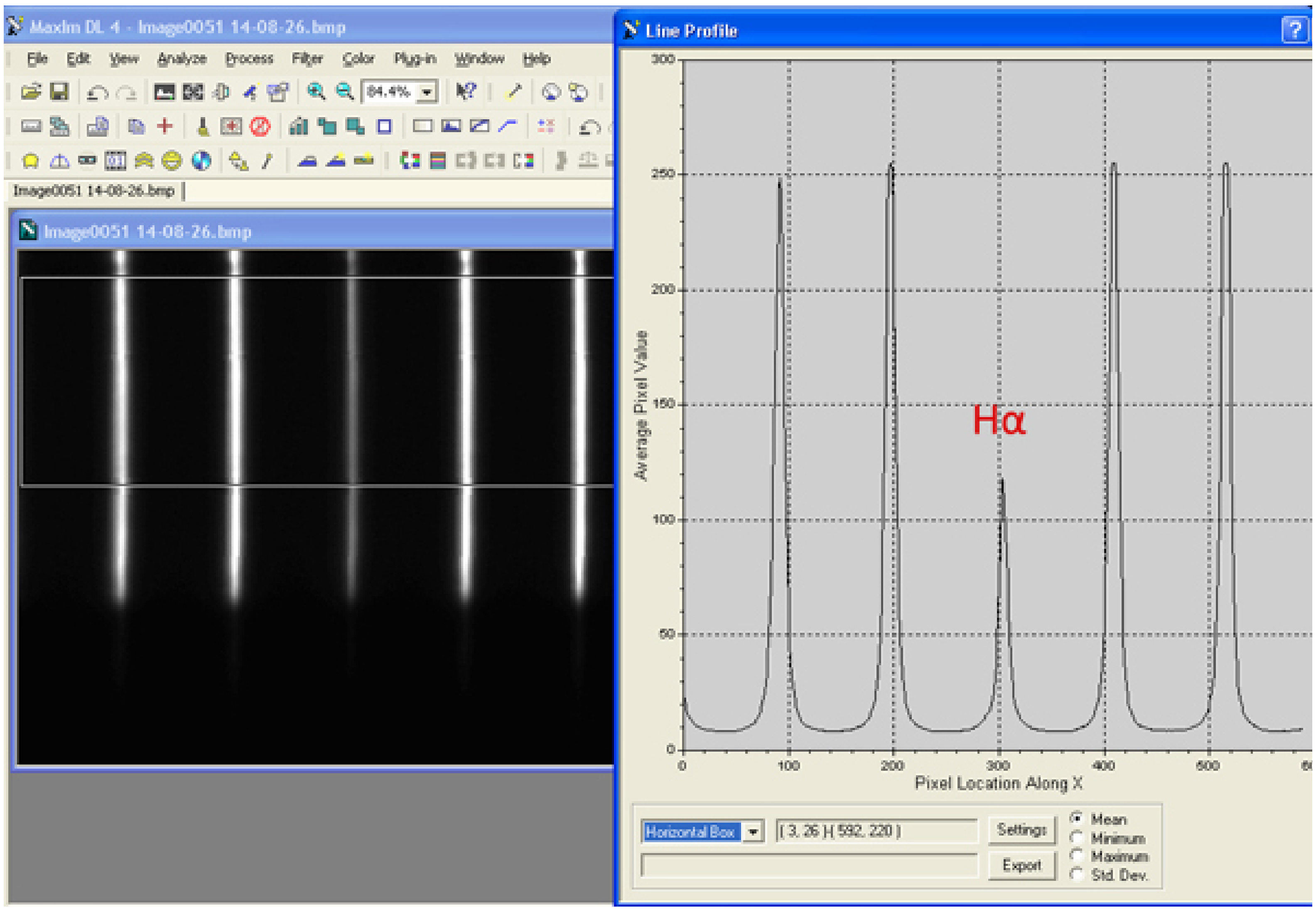


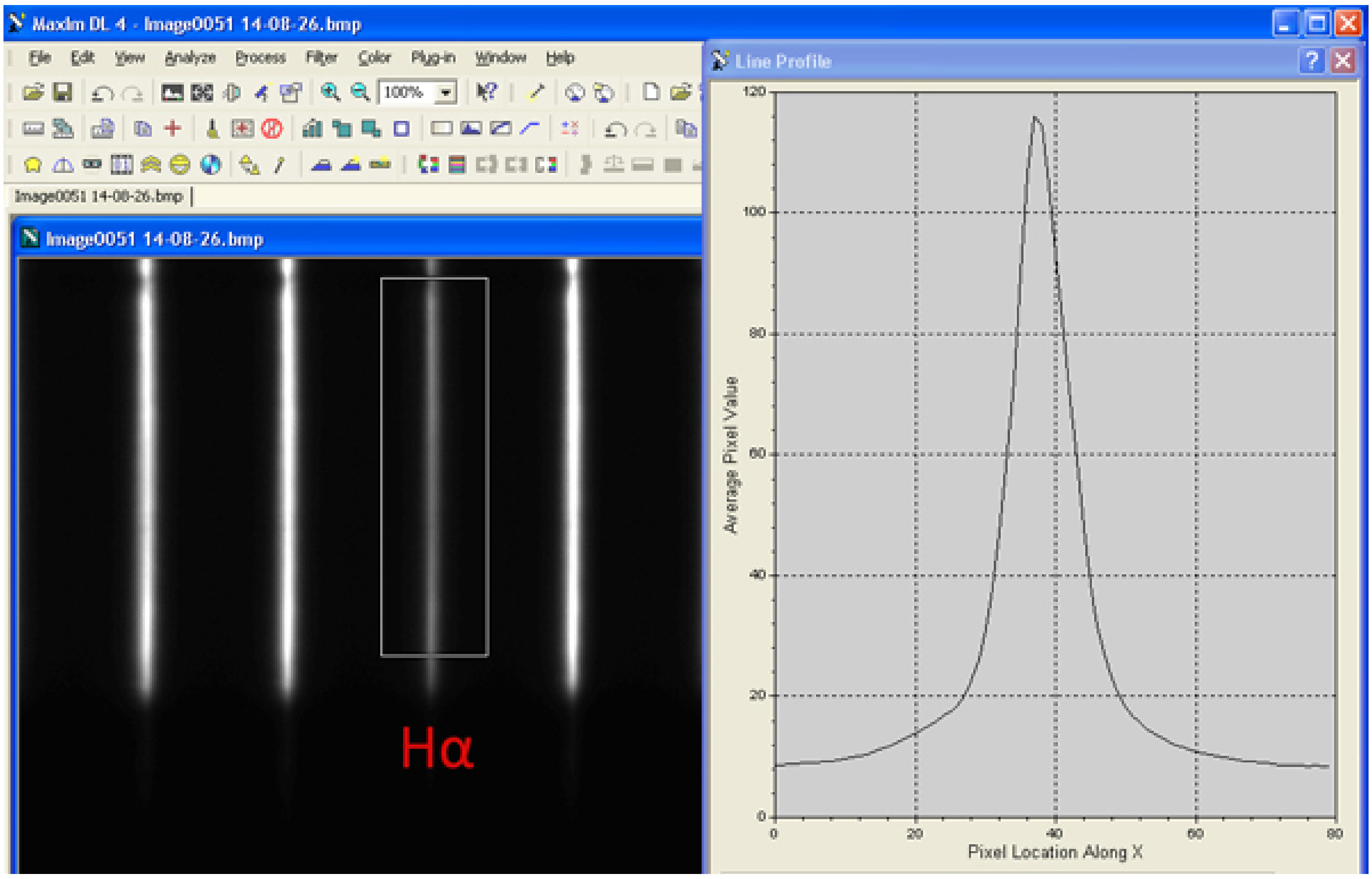
Image 2: The telescope with the Hydrogen filter and the spectrograph.

At the focal point of the spectrograph's lens a DMK of the Imaging Source company was placed. The spectra and their graphs showed a typical interference phenomenon of a Fabry-Perot filter. (image 3)



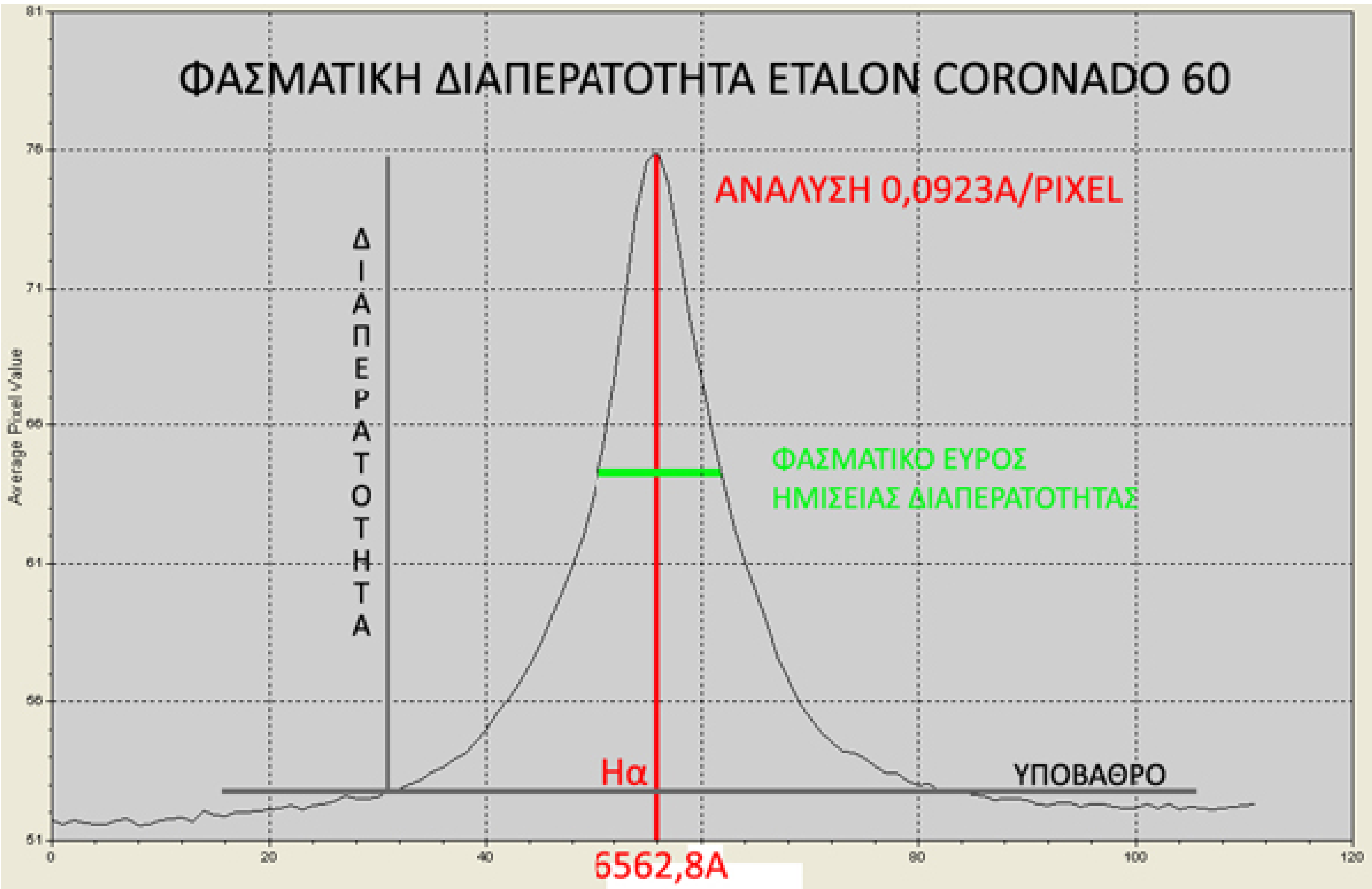
(Image 3: The etalon's spectral response in a part of the solar spectrum)

Then the interference spectrum at the Ha region with wavelength λ=6562,8 A was imaged (Image 4) .



(Image 4 : The etalon’s spectral response at the Hydrogen Ha region)

As seen in the graph of Image 5 the green line defines the spectral range of the filter which is calculated at FWHM . The measurements of the Coronado 60 etalon showed a spectral range ,at FWHM intensity, a mean standard of 0,64 A at the interferences right and left of the Ha line and 0.68A at the main interference of the Ha line.



(Image 5 : The graph of the filter's spectral range calculation)

MARKING THE FILTER'S TUNING SYSTEM

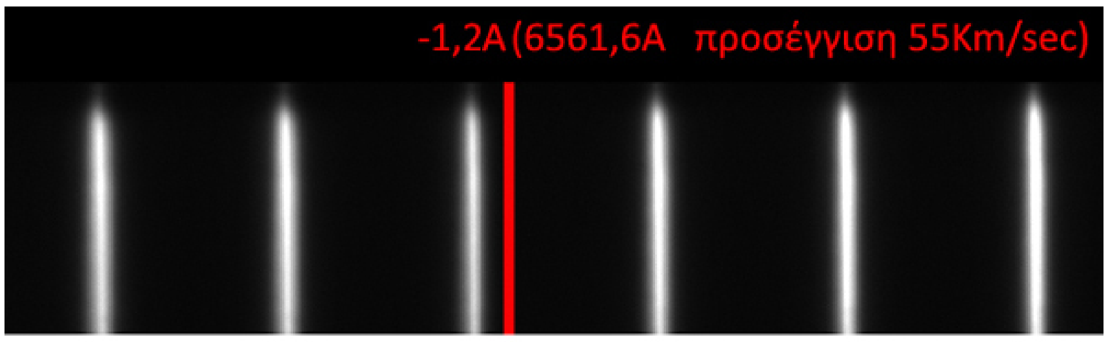
Coronado's Hydrogen filter comes with a tuning system which can be used for measuring the Doppler shift caused by the eruptive moving solar prominences (and filaments as well) at speeds that can reach 200Km/sec (at times near solar maximum) .Because of this great, for Earth's data , speed the colour of the fast moving solar prominence , changes slightly to another red hue in comparison with the red colour of a still Hydrogen source .

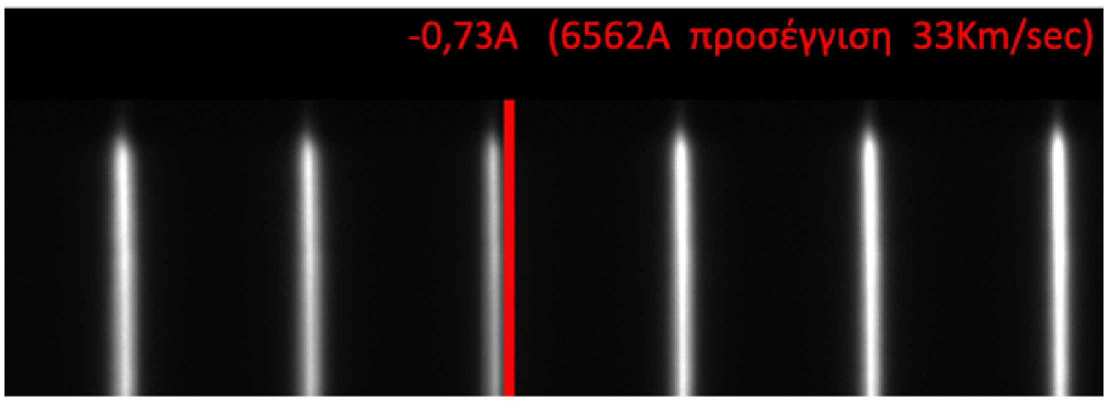
This effect is not visible to the eye because the variation in the colour hue is insignificant compared to the pitch variation of a moving sound source (e.g. an ambulance's horn) which is understood as a higher tone(when approaching) and a lower tone (when moving away) .This effect in Astronomy is known as "redshift". It happens on the spectra of galaxies moving away from ours but also on the solar prominences' spectra .

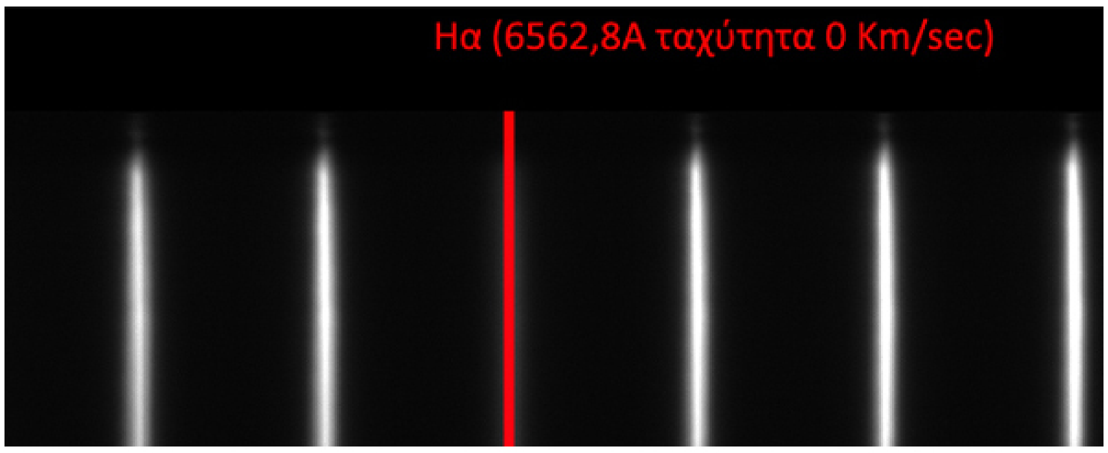
Because of the redshift , the prominences moving away from the observer change their colour to deeper red in comparison to Hydrogen's emitted colour and because of the blueshift the prominences approaching the observer turn into a lighter red colour .

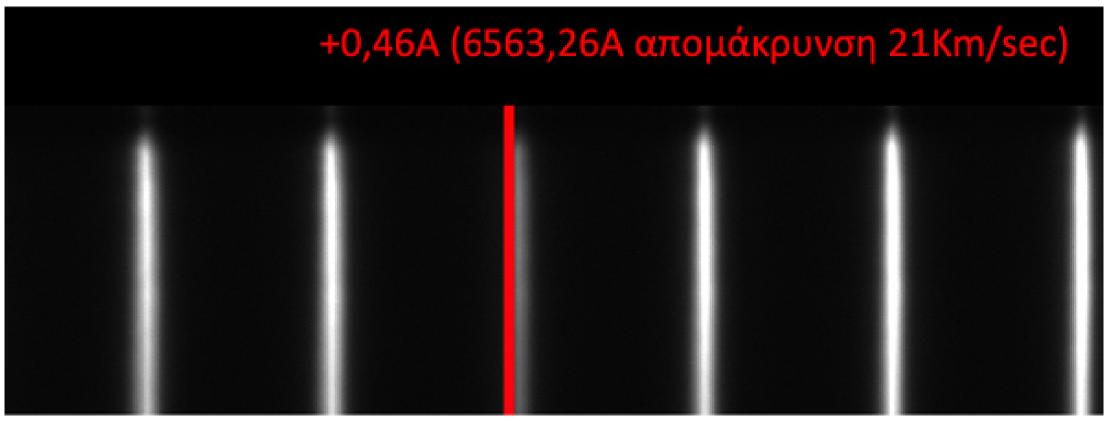
The variation (Δλ) of a specific wavelength (e.g. Ha's λ=6562.8 A) is proportional to ,the moving away or approaching ,speed of the solar prominence (and vice versa) and is calculated by the non-relativistic type $\Delta\lambda/\lambda = U/C$,

U : being the approaching or moving away speed in (Km/sec)
C: being the speed of light in vacuum







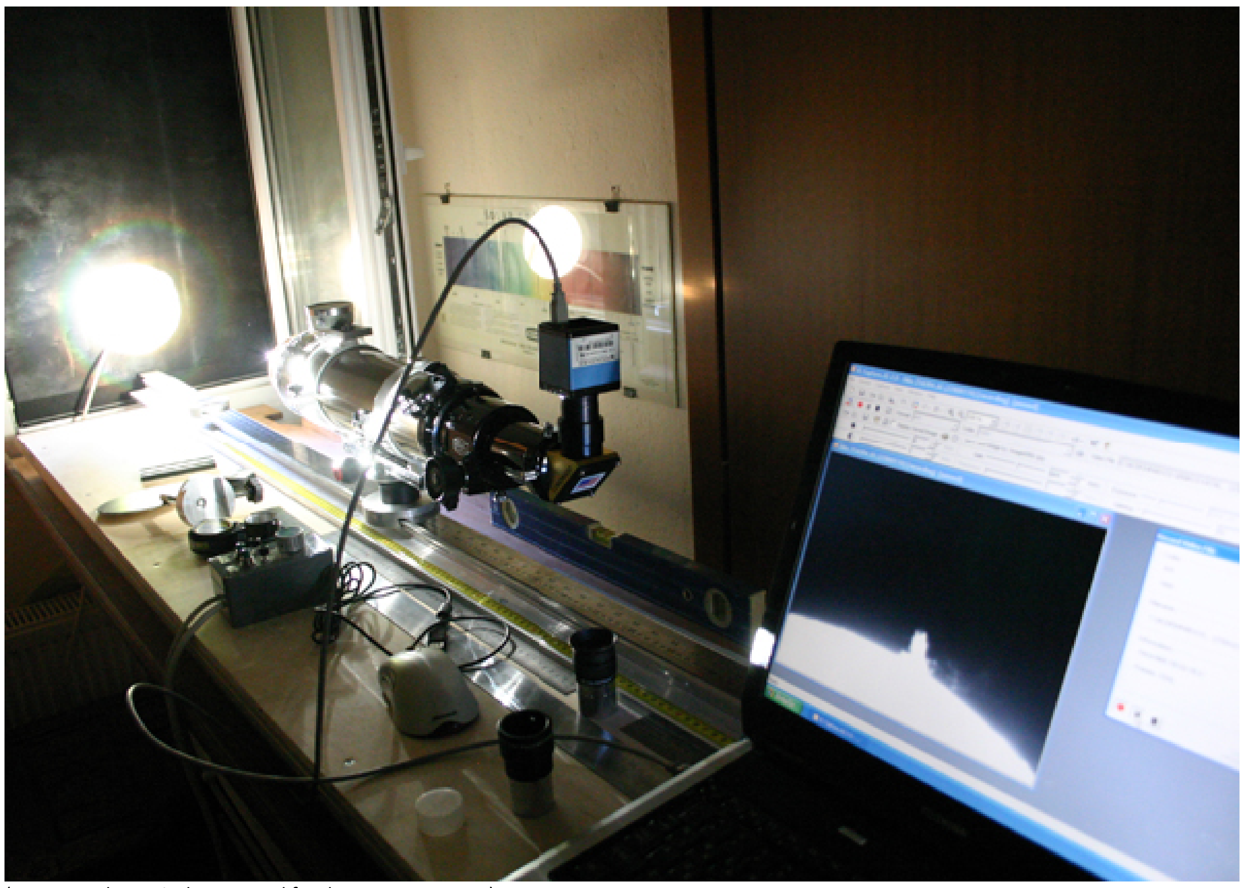


Solar spectrum in the region of Ha 6562.8A 0.0923A/pixel

(Image 6: Images shot through the Observatory's spectrograph in pre-defined areas of the tuning system .The lines' shift from the Ha line (red line) are seen while the etalon's slope is changed.)

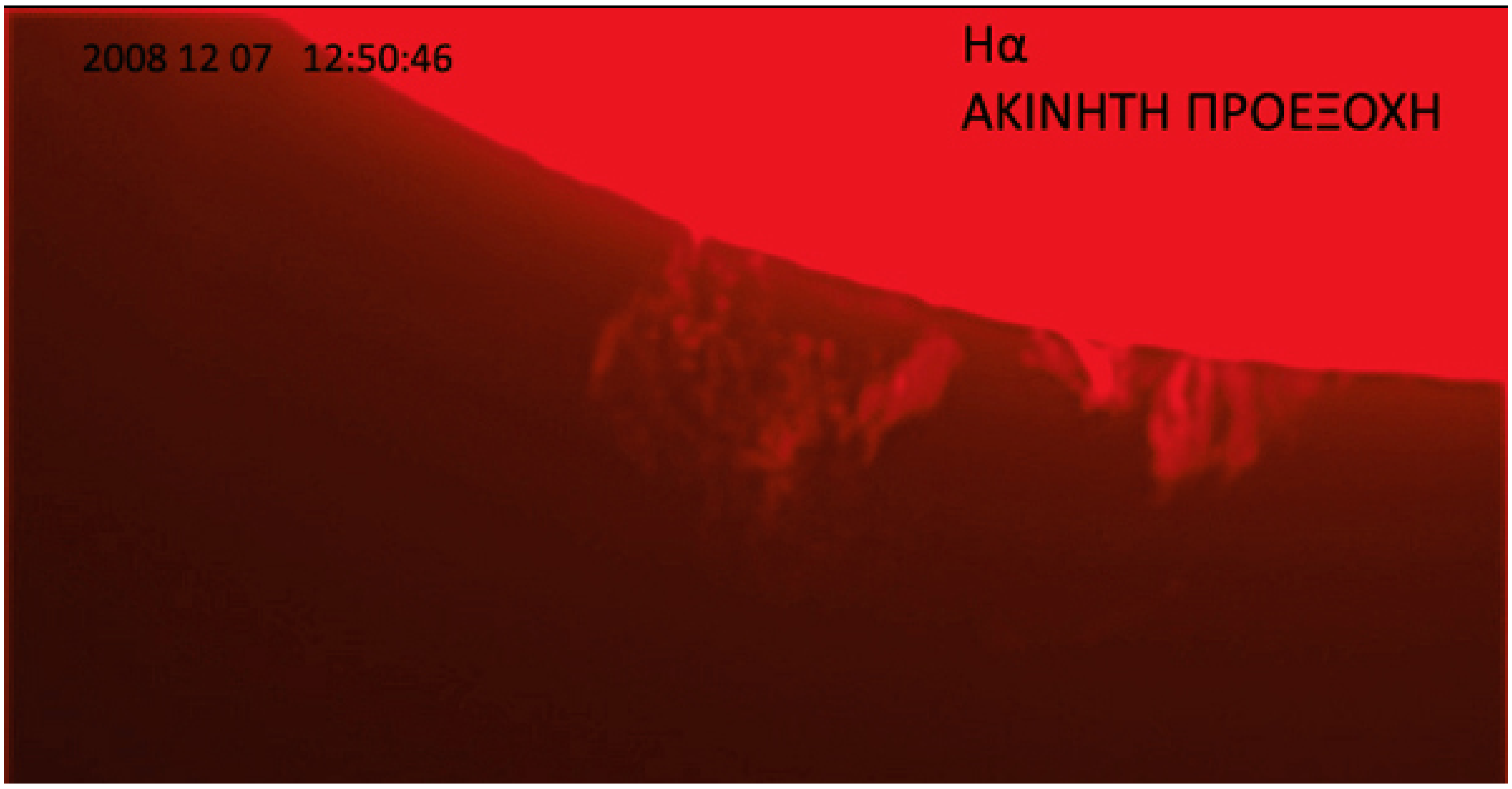
The filter's tuning is achieved by changing the etalon's angle between 0°and 1.3°.
On image 6 we can see the spectral responses shot through the Observatory's spectrograph in pre-defined areas of the tuning system .Then the respective velocities of approaching (negative values) or moving away (positive values) are calculated .

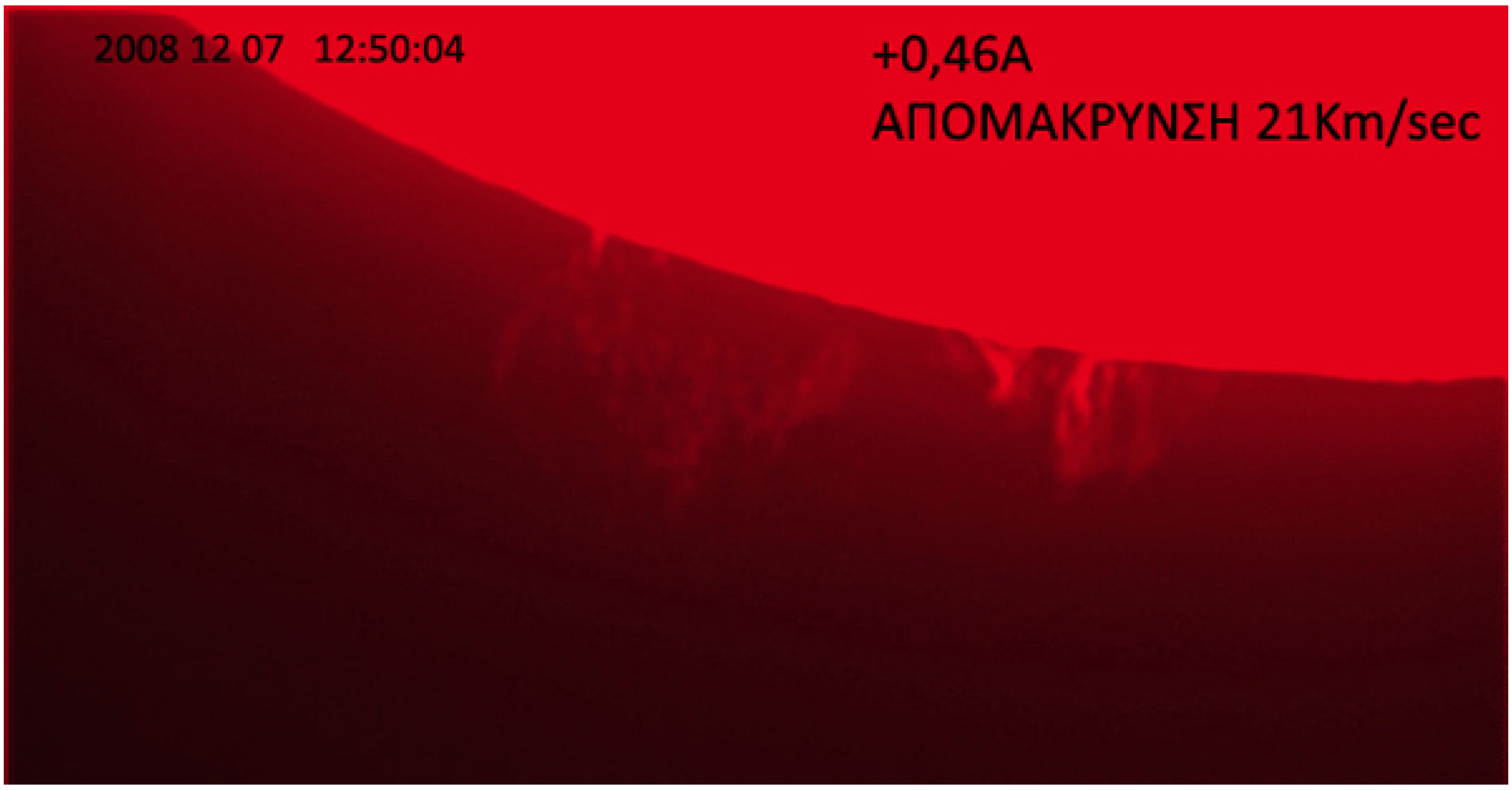
-1,2 A	**55Km/sec**
-0,73 A	**33Km/sec**
0 A	**still prominence**
+0,46 A	**21Km/sec**

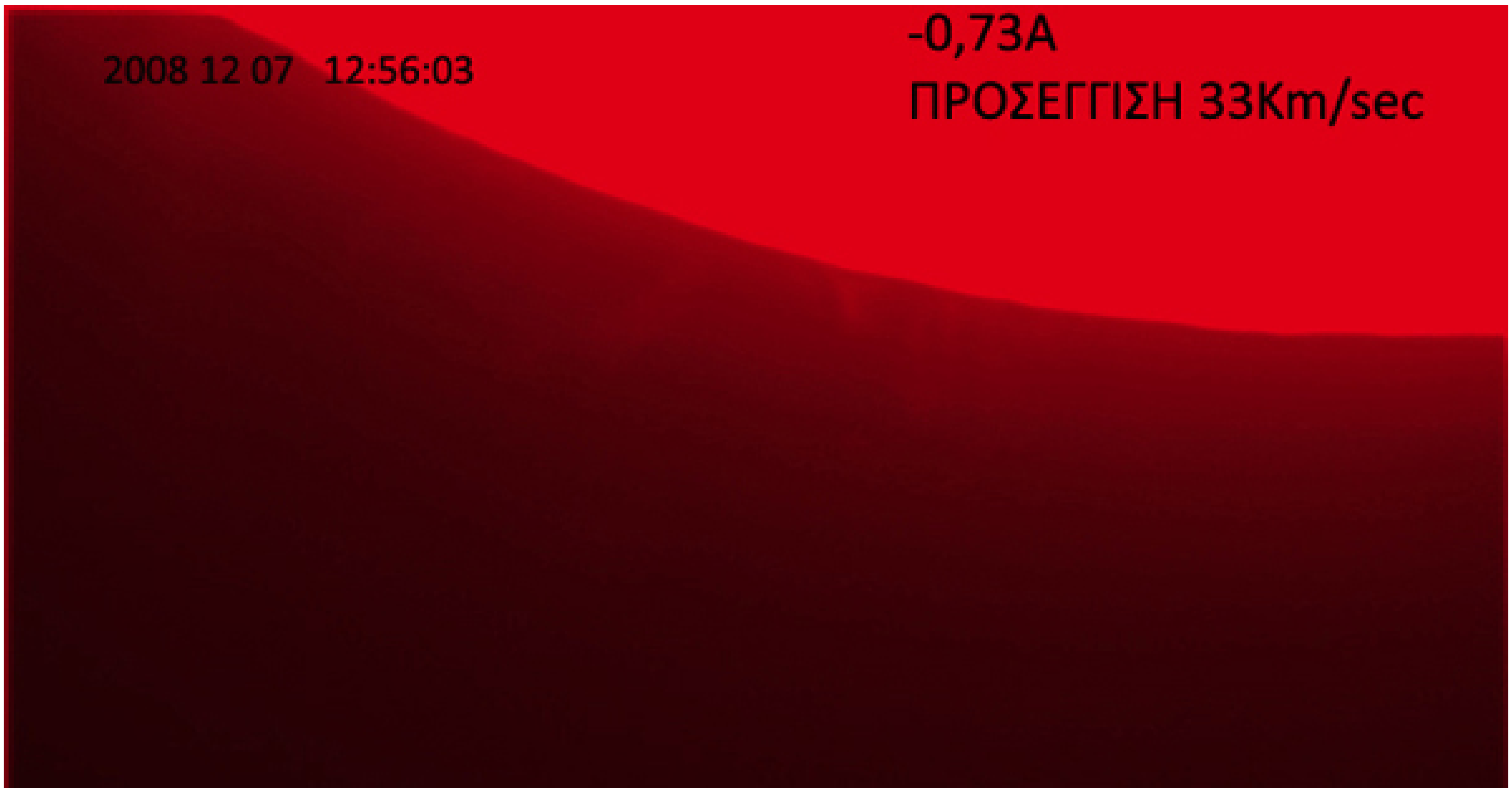


(Image 7 :The optical array used for the measurements)

In the following images an active solar prominence , shot at 7/12/2008 , UT : 10:50 , is seen , with different tunings of the solar filter . Between these three images the shape of the prominence varys , because of the Doppler-Fizeau phenomenon . Especially in images 9 and 10 the red and blue shifts , respectively, are obvious because small parts of the prominence get closer to or further from Earth .







(Images 8, 9 and 10 : Recording of the solar prominence at 7/12/2008 with the respective Doppler shifts because of its speed) .