H-alpha and Our Sun

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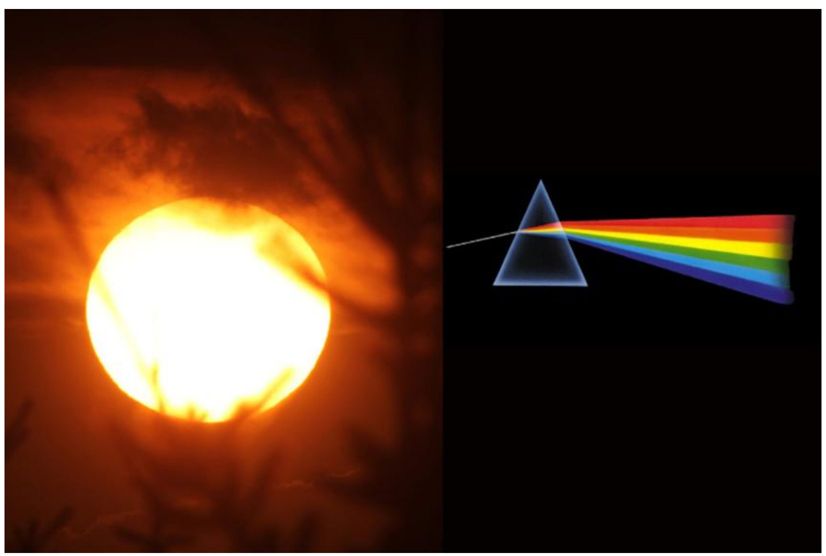
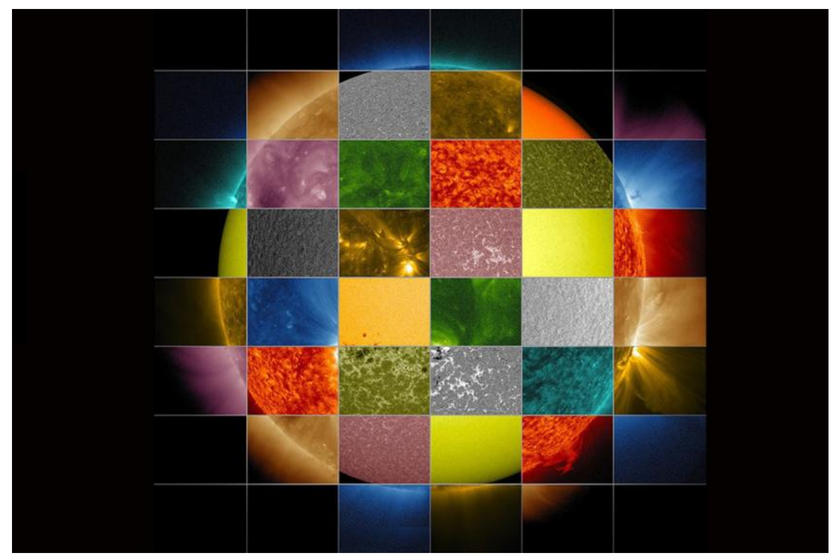
We have seen many times how light decomposes into different colors when it passes through raindrops or glass prisms. In this project we focus on one narrow line of the light spectrum – the H-alpha line. The information it can provide to us about the space objects is enormous, and its contribution to the knowledge about our star – the Sun is unimaginable. Our team's small contribution to this field is the observations of the solar prominences we regularly perform with the use of H-alpha filters. In this report we describe some of the interesting and accessible practical tasks we perform and demonstrate very useful exercises for understanding the enormous scales of the events occurring on the Sun.



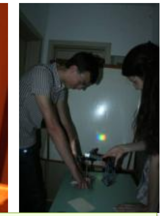


Spectrum

When most students see the famous picture of Sir Isaac Newton with a prism refracting the light, they probably do not get amazed. What is really the importance of his experiment? For the first time in 1671, Sir Isaac Newton uses the word spectrum (from Latin spectrum – image) when explaining the result from the following experiment he made. When a beam of light passes through the prism part of the light is reflected from the surface of the prism, and another part is refracted, and we can see the decomposition of white light into different colors from the visible spectrum (red, orange, yellow, green, blue and violet).

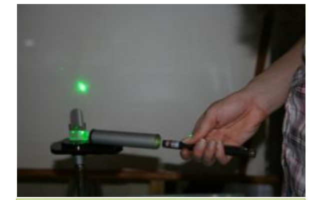
We made our own experiments using different prisms , spectroscopy, filters, lasers, etc. to determine the properties of the dispersion of the white light when passing through their planes.

Experiments



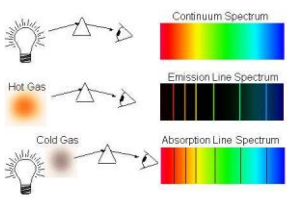
Besides the sunlight, we decomposed the light of a candle and of a torch.

We put different-colored filters behind the spectroscope so we could show that only a small amount of the spectrum (only one color) passes through the filters.



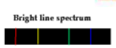
Here we demonstrate that the monochromatic light (emitted by red and green lasers) does not decompose after passing through a prism's plane.

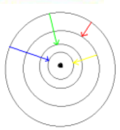
Spectral Lines



A hot opaque body, such as a hot dense gas (or a solid) produces a ***continuous spectrum*** – a complete rainbow of colors.

When the light from a certain source passes through a colder cloud of gas, this gas absorbs photons with specific wavelengths and creates the so called ***absorption spectrum*** - dark lines on the continuum spectrum.





According to the classic Bohr model of the atom when the electrons jump from a higher-energy orbit to a lower one, emitting a photon of certain energy and frequency which responds to a certain wavelength - an ***emission spectrum*** is created, and we see bright lines on a dark background.

What can we learn from this "colorful picture" ?

- On the first place, with its help, we can unambiguously determine the chemical composition of the bodies.
- The kind of the spectral lines which we receive, whether in emission or absorption, tell us not only about the kind of the matter but about the physical processes which occur in the body. Good examples for that are the effects of the density, as wells as the electric and magnetic fields.
- Thanks to the spectral analysis we can define the temperature of the emitting body and its local movements.

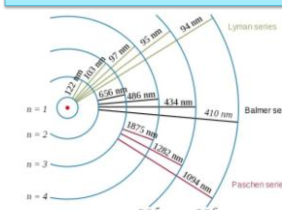
The difference between the energy orbits in Bohr's model and the wavelength of the absorbed or emitted rays are calculated using Rydberg's formula:

$$\frac{1}{\lambda} = R\left(\frac{1}{(n')^2} - \frac{1}{n^2}\right) \qquad (R = 1.097373 \times 10^7\ \mathrm{m}^{-1})$$

where *n* is the initial energy orbit and *n'* is the final orbit, *R* is the constant of Rydberg.

H-alpha Line

According to our current ideas about the Universe Hydrogen is the most abundant element - about 75% of the visible matter. That is why its spectrum is the one which is best studied and most interesting to the scientists. Its Hα line is considered to be the most widespread and most important spectral line.

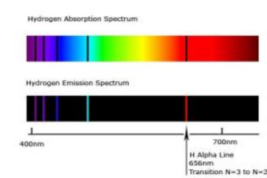


The spectral lines created from the transition of an electron from energy orbit with quantum number n ≥ 3 to energy orbit with quantum number n=2 is part of the so called **Balmer series.** The orbit change of an electron from level 3 to level 2 produces the **Hα line**.

It has been proven that to change the energy of an electron in order to make it jump from level 1 to level 3, energy close to the energy for ionizing the atom is required. It is almost impossible for the electron to change into excited state and jump to a level higher than 3 without being ionized.

As a consequence of that, an electron escapes the atom and later attaches to another free proton, and together they form a new hydrogen atom.

When they recombine we cannot be certain on which level the electron will end up. That is why for some time the atom is in a process of relaxation, as a result of which when the electron goes from level 3 to level 2 energy is released in the form of „Hα photon".



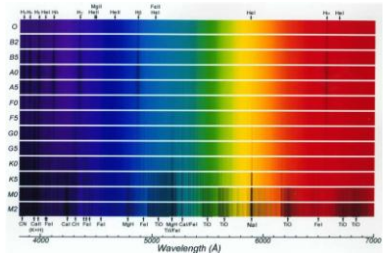
Because of that the astronomers use the Hα line to search and analyze ionized hydrogen in the Universe.

The Hα line has wavelength of 656.281 nm and is observed in the red range of the visible spectrum.

H-alpha in Stars

In Astronomy the Hα line is very important for studying a variety of objects in the Universe.

One of the good examples for this is the spectral classification of the stars. It shows the dependency between the surface temperature of a star and its luminosity. However, it also examines the spectral lines (including the Hα line) and how strong they are in the spectrum of the star. Analysis of the different spectral classes of the stars and the appearance of the Balmer's series show us that when looking at a star's spectrum we can use the behavior of the Hα line and determine its spectral class, temperature and reach conclusions about its luminosity and stage of evolution.



- In the spectrum of the stars from class O the Hα line is comparatively weak, but still visible. In this case it is an emission line.
- In the spectrum of the stars from class B the Hα line is averagely clear.
- The stars from class A have very strongly demonstrated hydrogen lines in their spectrum.
- In the stars from spectral class F we observe fading hydrogen lines.
- The most remarkable lines in the spectrum of the stars from class G are the lines of the hydrogen and potassium, but regardless of that, they are weaker compared to the class F stars.
- For the stars from class K it is typical that the hydrogen lines in their spectrum are very weakly marked.
- In the spectrum of the most widespread stars from class M no absorption lines of the hydrogen cannot be observed .

Nebulae in H-alpha

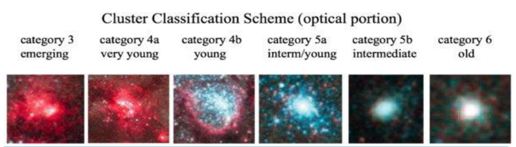
The Hα line could bring us much information about the nebulae. The strongest line of radiation in the emission nebulae is located at the end of the red range of the visible spectrum and coresponds to the Hα line. This emission comes from the so called H-II regions. In the other types of nebulae - planetary, protoplanetary and remains of supernova stars, the strength of the Hα line weakens more and more. This is how, thank to the spectrum, we can classify nebulae and learn much more about them: as a result of what event they formed, what matter they consist of, their age and many others.

NGC6888 Crescent Nebula
NGC6888 Crescent Nebula is an emission nebula which can be observed in Hα. At the picture we can see the traces of the predominant Hydrogen gas.

The Nebula IC 1795 in Cassiopeia
We see the strongly marked presence of the Hα, line, triggered by the ionization of hydrogen atoms affected by the energy of forming young stars.

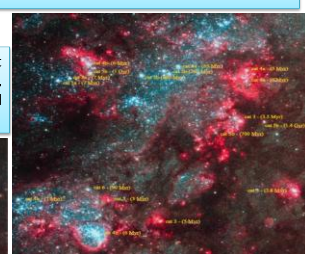
Star Clusters in H-alpha

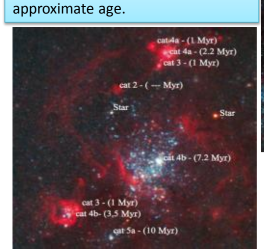
The Hα line gives us a lot of information about star clusters. We know that there are two types of star clusters - open (young) and globular (old). With the help of the emission Hα line and its morphology we can determine the age of the star cluster. It gives us information about the stars which form the cluster and with the help of this information we can reach to conclusions about the cluster we are studying. This method can become the basis for a new classification of star clusters, based on more accurate data of their age.



The classification of star clusters, created as a consequence of systematic observations in the Hα line.

Star formations (in Hα) in different parts of the field of the galaxy M83, together with their estimated approximate age.





These figures are combinations of visible and Hα images.

Galaxies in H-alpha

The Hα line gives us much information about galaxies as well. As we know that galaxies are gravitationally bound system consisting of stars, an interstellar medium of gas and dust, plasma and invisible dark matter. The most important fact to mention is that the Hα line tells us about star formation in the galaxy and the development of stars in the last stages of their existence measured through the number of supernovae in the galaxy. When a star explodes as a supernova, it ejects a large amount of energy, and in a couple of days or even weeks it could become as bright as 10 000 stars. In the same time the Hα line from the spectrum of the star could become significantly brighter for months or years. When we observe through a 75-Å-passband Hα filter through certain intervals (once or twice a year) we can determine the number of supernovae and the kinds of star population in the galaxy.

NGC 300
In This image in Hα , we can notice the bright regions which correspond to bright young stars that started to form only a few million years ago.

The Galactic center
We are again witnessing bright regions of ionized Hydrogen (HII - regions) which trace the intensive star formation at the center of our galaxy.

The Galaxy NGC 1365
The image is taken with an Hα-filter. It aims to show the star-forming regions and the emission nebulae which mainly occupy the spiral arms and the bar of the galaxy.

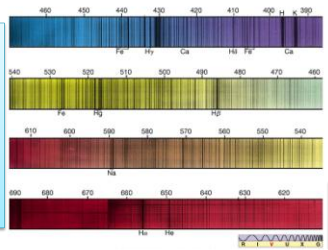
The Sun in H-alpha

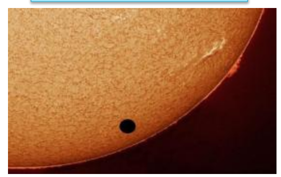
The Hα line is mainly used for studying the Sun.

Just like in the Universe, in the Sun as well, the most widespread chemical element is hydrogen (90% of it) and it is mainly found in ionized state. What we are able to observe with naked eye is the solar atmosphere which consists of three layers - photosphere, chromosphere and corona. The photosphere has continuous spectrum but the emitted photons pass through the colder structures of the chromosphere and the corona. Because of that the spectrum we manage to receive from the Sun is an absorption spectrum.

Image of the Sun in Hα.

One of the most intensive lines in the solar spectrum is Hα. Thanks to it we receive information about the physical condition of the absorbed matter.





The transit of Venus on 08.06.2004 pictured with Hα filter so it could stand out on the background of the Sun's chromosphere.

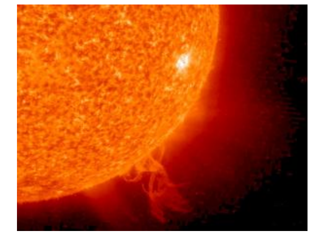
Prominences

From all the phenomena and activities of the Solar cycle, the most appropriate for observing in the Hα line are the ***prominences.*** They are amazing formations, which are located in the corona, but their temperature is hundreds times lower, and their density hundreds and even thousands times higher than the corresponding temperature and density of the surrounding environment. Regardless, the prominences could be very stable and exist for months. This is comparable to putting a ball of ice cream in the oven and looking at it not melting for hours. That is why prominences are of such interest to the solar physicists.

Solar prominence photographed during the total solar eclipse in 1992.

The first observations of prominences were made back in the remote past, but just about 170 years ago the only way to observe prominences was during Solar eclipses when the Moon would cover the solar disc and the formations on the limb were visible. Because the prominences consist mostly of hydrogen, their color with naked eye is pink-blue.

With optical tools a prominence was observed for a first time during the total solar eclipse in 1824.



Solar prominence pictured with Hα filter.

Some Facts

Prominence spectra show that their temperature is around 20 000 K.

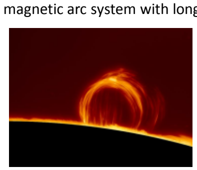
The average height of the prominences above the chromosphere is about 30 000km.

It is considered that their stability is due to the magnetic field which keeps them in equilibrium with the corona.

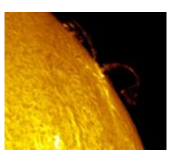
Many different types of prominence classifications exist, but the one which is the most widespread is based on the length of the life of the prominences.

The first class unites the ***short-lasting prominences***. This class is divided into three types: type Ia – loop prominences and coronal rain, type Ib - surge and type Ic – spray prominences. The prominences from the different types have different physical characteristics. For example the surge prominences reach to the speed of about 100-200 km/s with height 50000 km and they last around 10-20 minutes. The matter in these prominences goes back using the same trajectory on which it was ejected before. The spray prominences reach the speed of 600 km/s and after that disperse in the corona.

The second class is the so called ***quiescent prominences***. It separates into two types: type IIa - prominences or filaments inside or close to active regions, and type IIb - prominences or filaments in inactive regions. The most important physical characteristic of these prominences is that they "live" much longer than the short-lasting prominences. This is due to the magnetic arc system with long leaf-like structures situated vertically in relation to the solar surface.

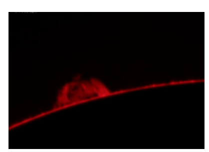


Loop prominences



Surge prominences

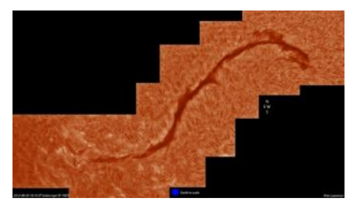
Spray prominences

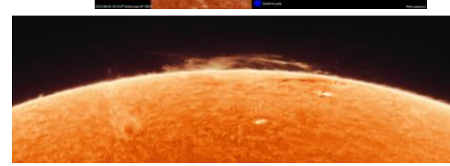


Quiescent prominence

Achievements in H-alpha

As a result from the development of technologies and the large-scaled spreading of specialized solar telescopes, which observe prominences in Hα, today we know a lot more about their structure, morphology, dynamics and evolution.





Solar Instruments

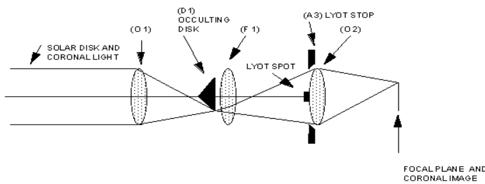
For the first time in 1931 Bernard Lyot invented an optical tool with which to observe the solar corona, including prominences which are close to the limb, without the need of a total solar eclipse. This device eliminates as much as possible of the photospheric light and scattered light from the optical details, and was called coronagraph.

Lyot's coronagraph

The basics in the structure of this prominence-telescope are the cone shaped diaphragm (D1) and the interference H-alpha filter.

The cone shaped diaphragm or also called artificial moon eclipses the visible disc of the Sun and this way allows us to see the formations of the limb. The narrowband H-alpha filter has the task to only let the light from this range of the spectrum to pass through.

Schematic layout of a Lyot's coronagraph



Solar Filters

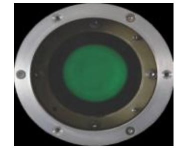
In the different types of prominence telescopes one needs to use different narrowband filters which let only the red spectral line H_α (λ=6562.801 Å) pass. They differ by their structure and the width of the spectral band they pass.

The width of the passing band of light in a filter is corresponds to the spectral interval in which the amount of passing light is half of the maximum of the intensity at that wavelength.

- Lyot filter - consists of 7 quartz lamellae and 9 polaroids (polarizers). Sadly, when using it there is a huge loss of light and the prominences are not that bright.
- Fabry–Pérot filter - it is the cheapest and the most simple interference filter, which consists of 3 layers of evaporated in vacuum matter on a glass surface. Its passband is not narrow enough and it is not very appropriate for observing prominences.
- Completely dielectric filters - they consist of a couple of non-metallic layers (30 or more), whose thickness is controlled spectroscopically. They have a smaller passband compared to the Fabry–Pérot filter with passband about 30 Å, and with them you can successfully observe prominences in both clear or slightly cloudy sky.

Regardless of their high price it is preferable to use one of these completely dielectric filters with passband wider than 30 Å. Filters with passbands about 3-4 Å are even more suitable. The best ones are less than 1 Å.

H-alpha filter

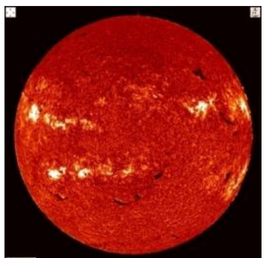


Lyot filter

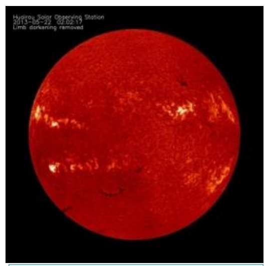
Fabry–Pérot filter

Ground-based H-alpha Observatories

Catania Astrophysical Observatory, Italy



Big Bear Solar Observatory, USA



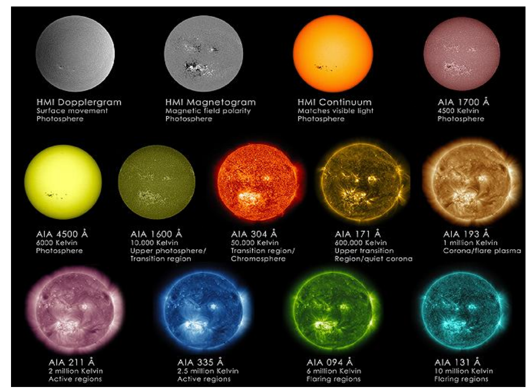
Huairou Solar Observatory, China

The Hα line is in the visible range of the spectrum, because of which the telescopes that observe in it can be located on Earth. Solar observatories are spread all over the terrestrial globe, which gives the opportunity for scientists to have full monitoring of the Sun during the different parts of the day and in bad weather by sharing their observations.

Every solar telescope is constructed in a differing way and uses different solar filters. This is the reason why the images made by these telescopes have differences and they help each other to study the various aspects of the physics of the prominences and of the Sun as a whole.

SOHO and SDO

Studying the prominences in the light of H_α line is very valuable, but still limited. On one side, we can receive information about them in other wavelengths. Besides that, the prominences are only a small part of the active processes in the Sun and we want to answer the numerous questions linked with their physics and evolution. This can happen if we have the complete picture of the solar activity. For this we need the priceless help of the space solar observatories like SOHO and SDO which observe the sun in a very wide range of the spectrum and they can do that uninterruptedly.

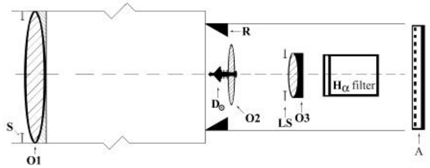


SOHO, the Solar & Heliospheric Observatory, is a project of international collaboration between ESA and NASA to study the Sun from its deep core to the outer corona and the solar wind.

SDO, the Solar Dynamics Observatory, is a program designed to understand the causes of solar variability and its impacts on Earth. SDO was created to help us understand the Sun's influence on Earth and Near-Earth space by studying the solar atmosphere on small scales of space and time and in many wavelengths.

The Coronagraph in NAO-Rozhen

In Europe there are only 5 observatories and 6 telescopes from the "coronagraph" type. One of them is located in the National Astronomical Observatory (NAO) - Rozhen with Institute of Astronomy by Bulgarian Academy of Sciences.

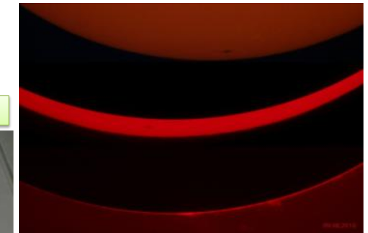


The coronagraph telescope for observing prominences in Hα, which is installed in the Solar tower in NAO-Rozhen is from the Lyot type. It has a few very important elements. The lens *O1* is with diameter 150 mm and focal length of 2250 mm. It is produced by "Carl-Zeiss". The next important part of the coronagraph is the eclipsing disc $D_{\odot}$. It is made out of aluminum alloy and has the shape of a cone with its pin pointing to the Sun. The substitution of the eclipsing cones with different diameters is necessary because when the Earth rotates around the Sun on its elliptical orbit, the visible diameter of the Sun varies. This leads to an increase or a decrease of the diameter of the Sun's visible disc in the focal plane of *O1*.

Directly behind the lens *O3* is placed one of the main optical elements of the telescope – the H_{α}-filter. The filter which we use is of very high quality and is completely dielectric. It is constructed in such a way that the maximum passband in the center is in the H_{α} line but only when the temperature under which it works is 40°C. Especially for this purpose an electrical scheme for tracking and maintaining the sufficient working temperature for the filter is designed . The filter gives the opportunity to shift the center of the passband with ~3Å, which gives the chance of examining the inner movements of the prominence plasma with approximately 150km s^{-1}. The whole passband of the filter that we use is Δλ=1.8Å.

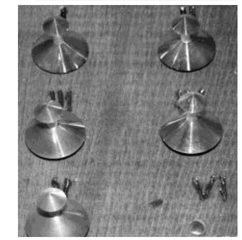
The Coronagraph in NAO-Rozhen

Coronagraph in NAO - Rozhen



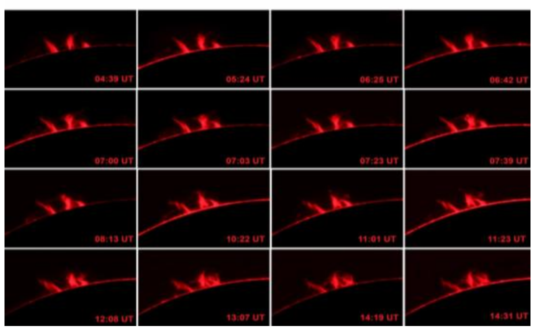
Covering of the solar disc with an artificial moon.

Diaphragms (artificial moons), which are used in the different parts of the year.

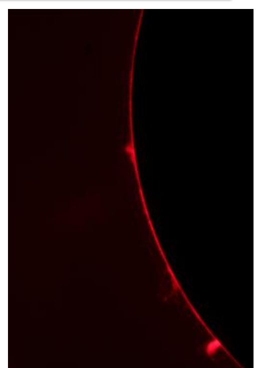


Our Observations with the Coronagraph in NAO-Rozhen

During our annual student summer school in NAO-Rozhen we have the opportunity to observe the Solar prominences with the coronagraph there.

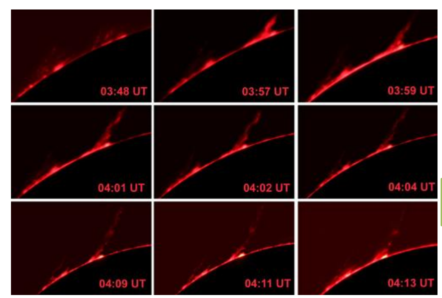


Quiescent prominence
18. 08. 2006



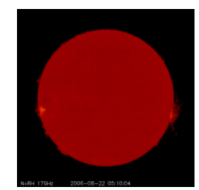
Quiescent prominence
15. 08. 2012, 09:01 UT

Our Observations with the Coronagraph in NAO-Rozhen

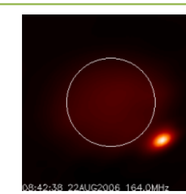


22 August 2006

The eruptive prominence from 22 August 2006, which we observed during our summer school in NAO –Rozhen was very interesting. We reported it and our calculation of its height and velocity in our previous presentations for "Catch a star". Here we would like to put an accent on our comparison and association of Hα eruptive prominences and their observations in Radio emission.



The radio image from Nobeyama Radioheliograph of the eruptive prominence on 22 August 2006 at 17 GHz.

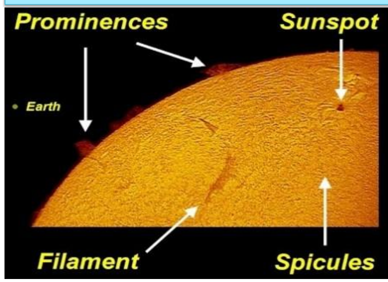


The radio image from Nancay Radioheliograph at 164 MHz indicate expanding loops inside a CME-like large magnetic system.

CORONADO PST

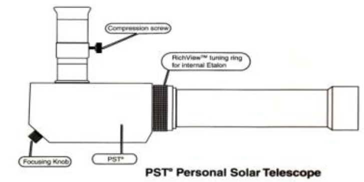
The coronagraph in NAO-Rozhen is an amazing instrument with a very good resolution, but sadly we have the opportunity to use it for only a few days of the year. Because of this reason, for the daily observations of the Sun we use a Personal Solar Telescope CORONADO.

Coronado solar telescopes are equipped with Hydrogen-Alpha solar filters to show us flares, prominences, spicules, filaments, plages, coronal mass ejections, and many more – not just the sunspots that you see through a conventional white light solar filter.



Prominences and filaments are the same phenomenon. When we observe them as bright red formations on the limb of the Sun, we call them ***prominences***, and when they are seen as dark bands on the background of the Sun's disc, we call them ***filaments***.

Structure and Parameters



Basic construction parts of the Coronado:

- Objective Lens;
- H-alpha Filter;
- Tuning Ring;
- Blocking Filter;
- Eyepiece;
- Focusing Knob.

General parameters:

- Aperture – 40 mm
- Focal Length – 400mm
- f/Ratio – f/10.0
- Bandwidth (Single Stacked) - <1.0 Angstrom
- Thermal Stability – 0.005
- Blocking – Full blocking > 10^{-5} from EUV to far IR

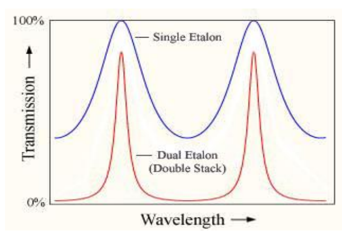
An important general constructive part of PST is the turning and focusing. The PST is equipped with a tuning mechanism that allow us to adjust performance of the solar filter by tilting the filter. The purpose of this adjustment is to compensate for possible detuning of the filter due to the change in operating conditions (such as pressure that can vary with elevation changes) and the different features on the sun which are moving with different speeds (Doppler effect).

H-alpha Filter

The general constructive part of the PST is the filter. Part one of the two-part H-alpha filter used on Coronado PST Solar telescope is an energy rejection filter and Fabry-Perot etalon which is mounted in front of the telescope's objective lens. The energy reflection portion of the ERF/etalon assembly blocks the passage of Ultraviolet and Infrared radiation into the telescope to cut off the heat buildup within the optical tube. It also allows only the crimson portion of the Sun's spectrum into the scope. Second part of the filter is a blocking filter built into the star diagonal supplied with the scope. This stops all of the "picket fence" peaks except the one that is centered on the 6562.8 Å Hα line.

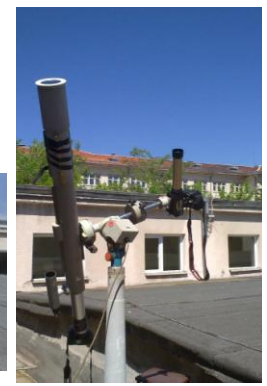
There is a specific technique that allows us to narrow down the passbend of the filter. It is called double-stacking, because it means to set a dual etalon into the scope. The double-stacking reduces the passband from the <0.7 Ångstrom width of a single etalon to <0.5 Ångstrom as shown in the red curve in the illustration to the right (the illustration is not to scale). However, this isn't very good for observing prominences since it provides maximum visibility of active regions on the solar disk.

Unfortunately, we don't have that addition.

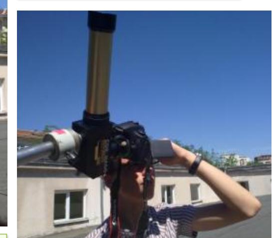


Our Working Set-up

Depending on the circumstances we put the CORONADO PST on a tripod or on a German equatorial mount.



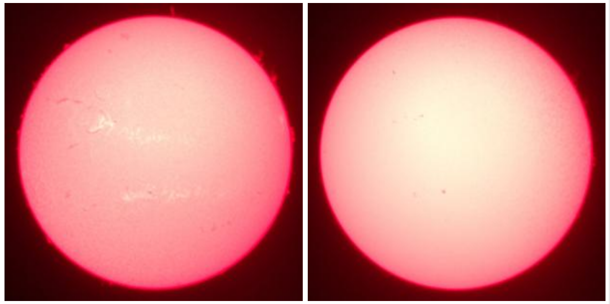
For photographing sunspots and prominences we use the following cameras:
CANON EOS 350D and
CANON EOS 60D.



Mostly we simultaneously photograph prominences with CORONADO PST and sunspots in white light with Carl-Zeiss refractor telescope 80/1200, supplied with a standard solar filter SFO.

We photograph the solar prominences using a x2 Barlow lens.

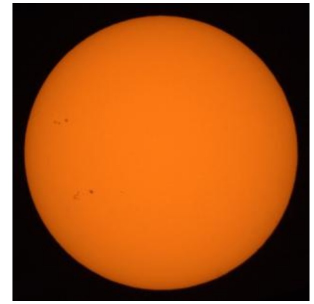
Different Positions of the Filter



25. 05. 2013,
Canon EOS 60D
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

CORONADO PST is mainly intended for observing prominences on the limb and filaments on the disc of the Sun, because they are the most easy visible and clear formations in the Hα line. Regardless of that, with the help of the ring which changes the position of the filter, the visibility of the prominences could be changed and they could "disappear" so that you could see the sunspots better. That is why it is very important to reach an optimal state in the Hα filter during an observation .

Comparison of Sunspots in White Light and H-alpha

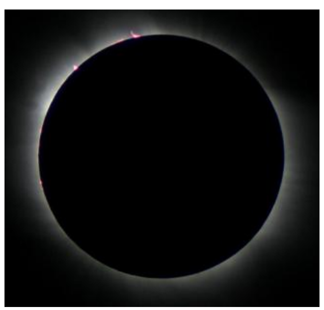


Sun and sunspots in white light,
23. 05. 2013,
Canon EOS 350D
refractor telescope 80/1200
AO-Haskovo

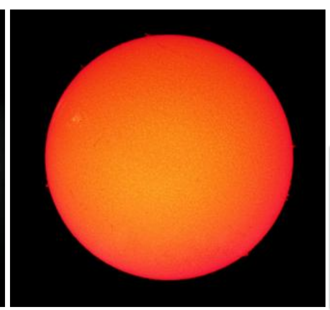
Sun and prominences in H-alpha,
23. 05. 2013,
Canon EOS 60D
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

In Hα pictures, sunspot regions are usually dominated by bright splotches (called plages) on the solar chromosphere.

Comparison of Prominences in White Light and in H-alpha



Prominences in white light during the total solar eclipse,
29. 03. 2006, Side, Turkey
Canon EOS 300D
Celestron 8 inch SC telescope
Emil Ivanov

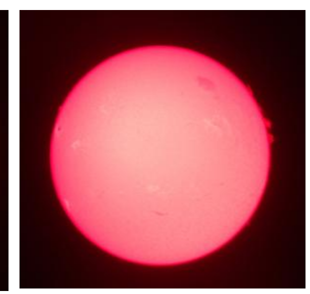


Prominences in H-alpha minutes before the total solar eclipse,
29. 03. 2006, Side, Turkey,
Canon EOS 300D
PST Solar Telescope 40 mm и x2 Barlow
Emil Ivanov

Only during a total solar eclipse prominences could be observed in white light and only if they are on the Sun's limb.

Dependence of the Sensor

11. 05. 2013, 13:59 UT
Canon EOS 350D , 8 MP CMOS sensor
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

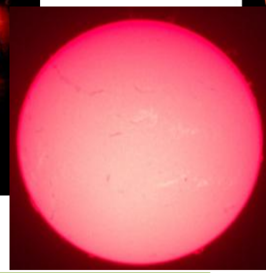


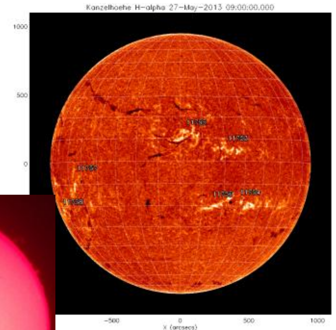
11. 05. 2013, 13:20 UT
Canon EOS 60D, 18 MP APS-C CMOS sensor
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

The receiver with which the Sun is being photographed in Hα, also has a very considerable role. We determined that with different cameras the color of the Sun is very different regardless the white balance. In addition, there is difference in the size of the Sun, the resolution, the brightness and the visibility of the separate formations and etc. In our opinion, this difference is due not only to the size of the resolution of the sensor, but to its sensitivity towards the light in Hα line of the spectrum.

Identification

27. 05. 2013, 13:19 UT
EIT 304
SOHO





27. 05. 2013, 09:00 UT
H-alpha
Kanzelhöhe Solar Observatory

27. 05. 2013, 08:38 UT
Canon EOS 60D,
PST Solar Telescope 40 mm и x2Barlow
AO-Haskovo

For comparison, orientation of the pictures and identification of the prominences we use images from the space telescopes SOHO and SDO in EIT 304 Å, also we use images from a number of on-Earth observatories, which photograph the Sun in the light of the Hα line.

Height of the Prominence

Although it is quite an imperfect device, CORONADO PST 40mm gives us the opportunity not only to observe solar prominences, but also to solve some simple math problems, which are rather useful when studying these formations.

Such a math problem is calculating the height of prominences.

The height of the most solar prominences that we observe is in the range between 20 000 and 50 000 km. But sometimes we have the opportunity to photograph a really dim matter, which is probably ejected during the eruption of a prominence.

The method we use to calculate the height of a solar prominence is extremely simple and accessible for everybody: first, we measure the diameter of the Sun in the printed image. Knowing that the real diameter of the Sun is 696 000 km, we calculate our scale. After that we measure the height of the ejected mass in the picture and by using ratios, we can calculate its real height.

The height of the pillars we photographed on 24. 04. 2013 reaches up to 284 300 km!

Length of a Filament

To measure the length of the filament we use the same method

08. 02. 2013
Canon EOS 350D
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

To demonstrate the method of work we used, we chose a filament, which we had photographed on 08.02.2013 as it is almost on the central meridian of the Sun. The closer the filament is to the limb, the bigger is the miscalculation. Besides that, in most of the cases the filaments look like a curved line, which brings even more inaccuracy.

- $\delta_{\odot}$ = 58 mm – diameter of the Sun on the printed image;
-$D_{\odot}$ = 696 000 km – real diameter of the Sun;
- k = 12 000 km/mm – scale of the image;
- l = 27 mm – length of the filament on the photograph;
- *L = l * k или 27 * 12 000 = 324 000 km*

The length of this filament is approximately 324 000 km.

Thickness of a Prominence

Most filaments observed on the solar disc look like narrow curved lines. But sometimes we have the opportunity to photograph the filaments which have a bit different look.

10. 05. 2013
Canon EOS 60D
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

In the span of a few days during May 2013 we observed an extremely thick and comparatively short filament. This provoked us to calculate its thickness.

For the calculation we used one of our images from 10th May, because on that day the filament was closest to the central meridian and the miscalculation would be smallest. Unfortunately, we do not know how the filament is inclined to the solar surface and we cannot read exactly the difference in the thickness, because the sunspot is in a big heliographic latitude. That's why we can measure only the thickness of the projection on the picture's plane.

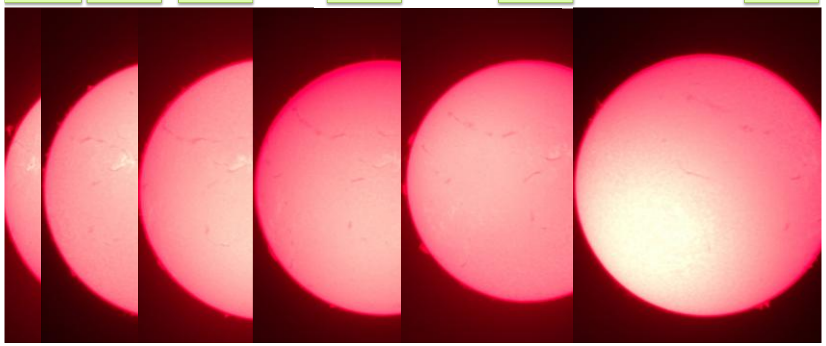
The thickness of this filament we measured was 46 000 km.

Evolution of a Filament

When the weather allows it, a sequence of photos could be made, which would show the development of a sunspot, filament, flocculi , etc. in time. This is extremely useful when studying the physics of the Sun and its active processes and phenomena.

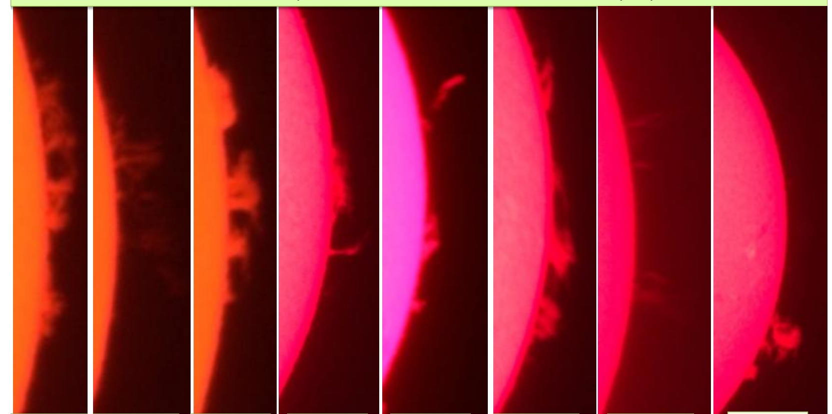
Canon EOS 60D
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo

23.05.13 25.05.13 26.05.13 27.05.13 28.05.13 31.05.13



Types of Prominences

Until now there is still no unified classification of prominences, because of which we do not attempt to determine the type of the prominences we observe, but we are glad we have the opportunity to observe and picture these whimsical events almost every day .

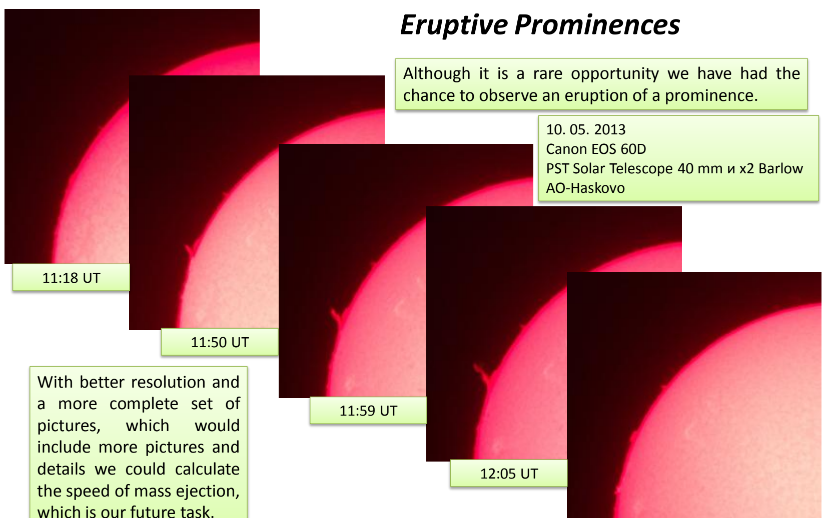


05.03.2013 02.04.2013 04.04.2013 07.05.2013 10.05.2013 11.05.2013 27.05.2013 30.05.2013

Eruptive Prominences

Although it is a rare opportunity we have had the chance to observe an eruption of a prominence.

10. 05. 2013
Canon EOS 60D
PST Solar Telescope 40 mm и x2 Barlow
AO-Haskovo



11:18 UT 11:50 UT 11:59 UT 12:05 UT 12:51 UT

With better resolution and a more complete set of pictures, which would include more pictures and details we could calculate the speed of mass ejection, which is our future task.

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