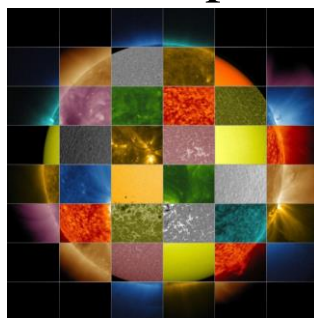




## Prominences in H alpha and He II

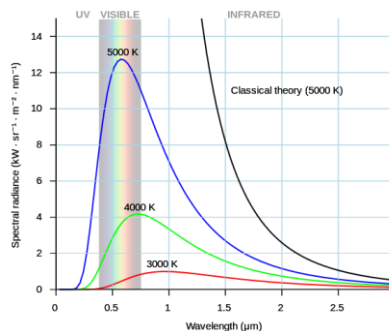
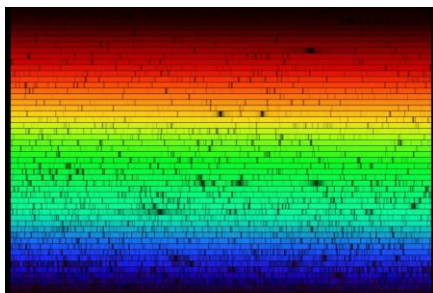


Author: Georgi Vasev  
 Team leader: Yoanna Kokotanekova  
 Astronomical observatory  
 by Youth center – Haskovo, Bulgaria  
 2016



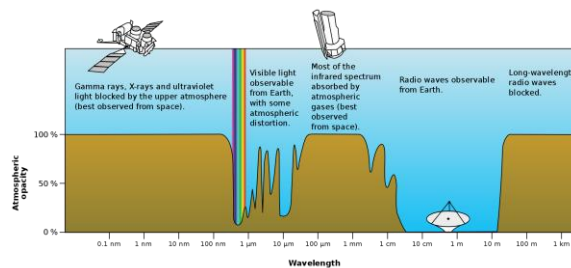
## Spectrum of the Sun

Our star is G2V spectral class. It is the closest example to the Earth for an absolutely black body and emits in all wavelengths – from  $\gamma$ -rays to the Radio. Because of his surface temperature –around 5700 K - our star has the strongest radiation in the green part of the spectrum (5550 Å). The spectrum of the Sun is interspersed with atomic absorption lines from the tenuous layers above the photosphere. Modern observations of sunlight can detect many thousands of lines. The strongest and most important lines in the solar spectrum are K line of Ca II at 3934 Å, H alpha from the Balmer series at 6563 Å and some coronal lines like He II for example. They help us to understand the physical conditions in the different layers and in the different solar active features.



# Absorption ability of Earth's atmosphere

We know that the Earth atmosphere has the ability to absorb part of the light that comes from the Sun. Gamma rays, X – rays and ultraviolet rays are not reaching the surface of the Earth. This is very good for people because they are very harmful. The infrared rays are also absorbed so if we want to watch Sun in these wavelengths we have to go above the atmosphere. The first time people surveyed the X-rays was in 1948 with the help of a V-2 rocket. But nowadays we have solar space observatories which are high above our atmosphere and have no obstacles watching the Sun in absolutely all wavelengths.

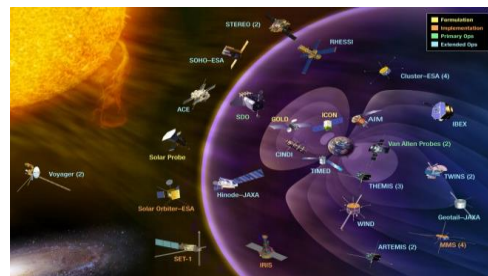


## Solar space observatories

There are a lot of solar space telescopes. Even though the Sun is the closest star to our planet, it is still a big mystery. These telescopes help us very much and are crucial part of studying the Sun as a whole. From OSO (Orbiting Solar Observatories), Skylab and SMM (Solar Maximum Mission) to the most modern SoHO, SDO, STEREO, Hinode, Proba etc. they all have one mission – to understand how our star functions. They keep watching the Sun constantly and give us priceless information but we still do not know many things about sunspots, prominences, solar flares and all of the active features on the Sun. The future-planned missions have the task to reveal us some of these important answers. Some of the most famous solar telescope take part in my project because we have to be very thankful for their work.

Future missions:

- Aditya-1
- Solar-C
- Solar Orbiter
- Solar Probe Plus
- Solar Sentinels



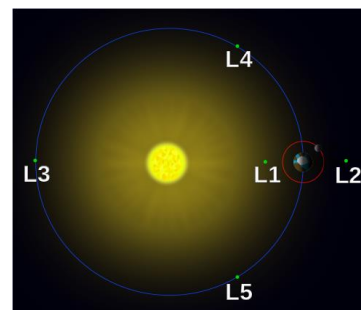
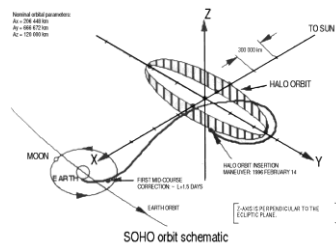
# SoHO

SoHO is a solar space observatory launched on 02.12.1995 with an Atlas 2 rocket. It starts regular observations in May 1996. Both NASA and ESA lead the project. At the beginning it was planned that the mission would last 2 years but SoHO is still in space and on 02.12.2015 celebrated his 20 birthday.



## More about SoHO

SoHO weights approximately 2 tons. It is build up by two modules. The service module is the smaller one and cares for the electrical supply, temperature control, the location and communication. The main module is situated on the top of service module and contains all of the scientific instruments. SoHO has an orbital period of 1 year and is situated very close to the first point of Lagrangian but exactly on it because the communication will be very difficult due to the radiointerferation generated by the Sun.

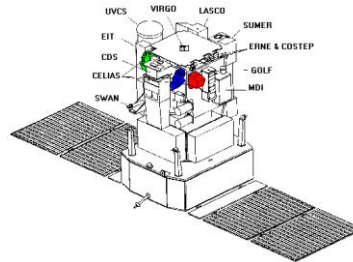
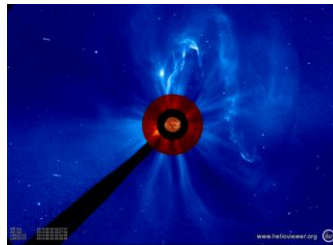


# Scientific instruments

The aim of the SoHO mission is to explore the Sun from its core to the Corona and the solar wind. This is very useful for our living because the Solar Corona and the solar wind influence us.

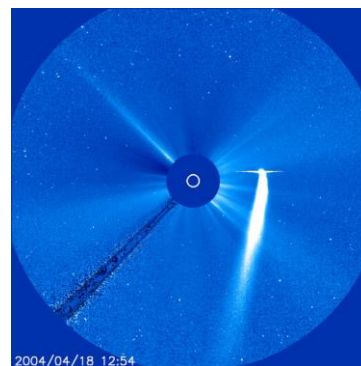
SoHO has the following instruments:

- GOLF – measures the vibrations in the solar core
- VIRGO – watch the vibrations of the core
- MDI – measures vibrations and magnetic fields
- SUMER – explores the physics of the corona
- CDS – explores the physics of the corona and the chromosphere
- EIT – follows the lower part of the corona and the chromosphere
- UVCS – measures the acceleration of the solar wind
- LASCO – photographing the lower part of the corona
- SWAN – measures the density of the solar wind



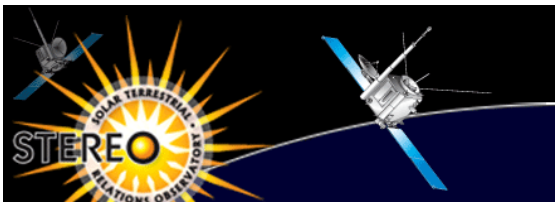
# Surveys and results

SoHO is watching the Sun constantly and its observations are uploaded on the internet in real time. Apart from its regular observations of the Sun SoHO has found more than 3000 comets. As you can see this is a very successful space mission.



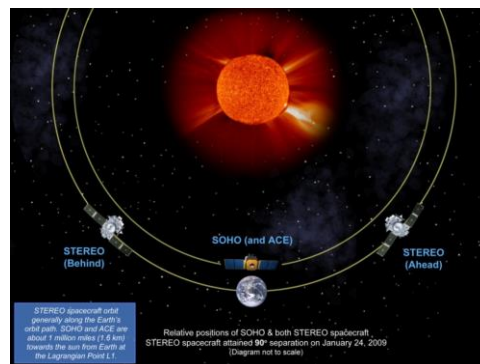
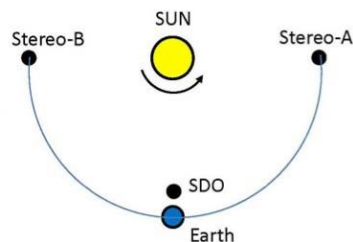
# STEREO (Solar TERrestrial Relations Observatory)

STEREO is NASA's third mission connected with the Sun. It is launched in October 2006. The mission offers an amazing viewpoint of the Sun – Earth system. The mission consists of two almost identical space crafts. One of them is moving in front of the Earth and the other one is moving behind Earth. The aim is Sun to be watched from all sides.



## More about STEREO

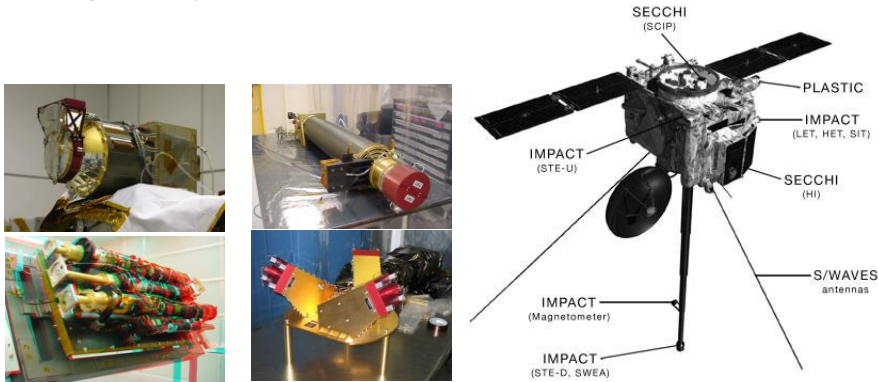
Each of the spaceships weights about 640 kg. They are powered by solar panels and are build in "John Hopkins" University laboratory. On 06.02.2011 they both were distanced on 90 degrees from Earth and offered us to see the whole Sun.





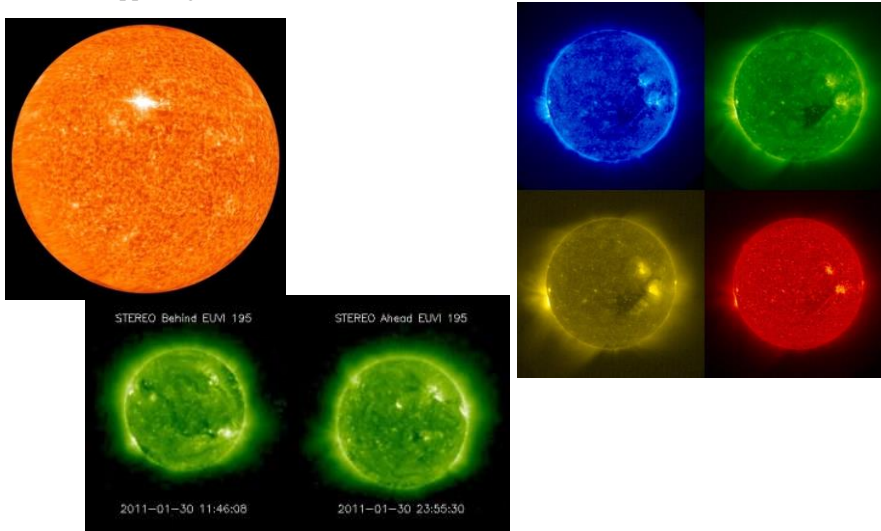
## Scientific instruments

- SECCHI – Explores CME's and their eventual impact with Earth
- IMPACT - Explores the plasma and solar energetic parts
- PLASTIC – Explore the plasma of the protons and heavy ions
- S/WAVES – interplanetary radio, which follow the changes of the solar disturbance through their way to the Earth.



## Benefits from STEREO mission

STEREO offers us a great possibility to watch the whole Sun at once and to know what is happening on its surface.

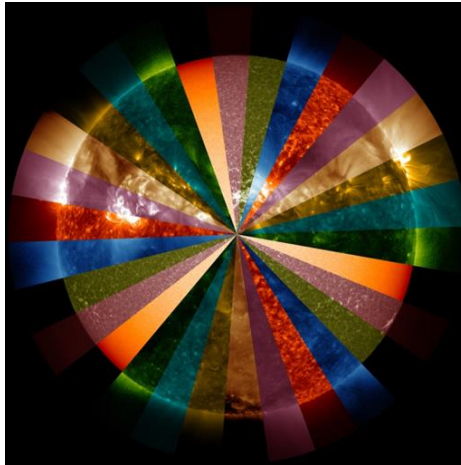


# SDO(Solar Dynamic Observatory)



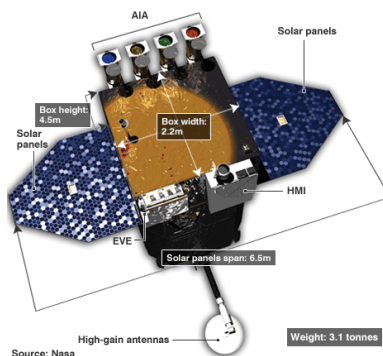
SDO watches the Sun since 2010. It is launched on 11.02.2010 and it is part of the LWS (Living with a star) program. The target to SDO is to study the influence on Earth created by the Sun by photographing our star in many wavelengths and exploring the solar atmosphere.

Event though the Sun is the closest star to our planet, it still a big mystery and SDO has to help us to understand where the solar energy comes from and how our star actually works.



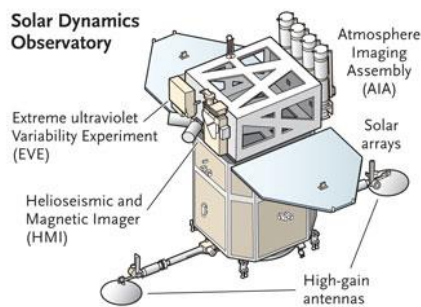
## More about SDO

Many people think that SDO is inheritor to SoHO. SDO sends a lot more data than SoHO. SDO is situated on geostationary orbit on 35000 km from earth's surface. SDO rounds the Earth for the same period our planet turns around its axis. It weights 3100 kg and it is planned to be working from 5 to 10 years.



## Scientific instruments

- EVE - explores the extreme ultraviolet emission with very high resolution as never before.
- HMI – studies the solar variability and features the exterior of the sun and the different components of the magnetic activity
- AIA – provides constantly observations of the solar chromosphere and corona in seven extreme ultraviolet variabilities.

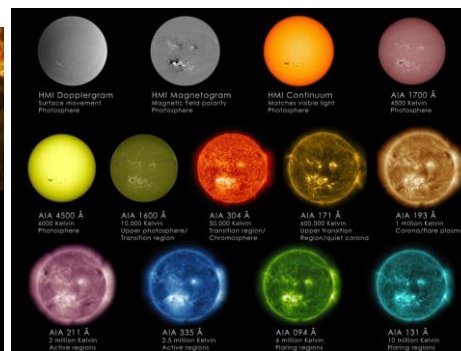
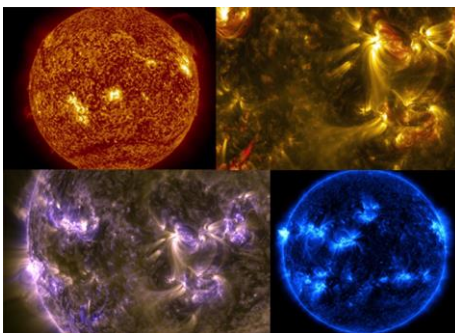


## Surveys and results



Today the space time topic is very actual. SDO is taking picture of the Sun constantly in its full spectrum.

The researches, which are made with SDO, are pointed to the connection between solar activity and earth life





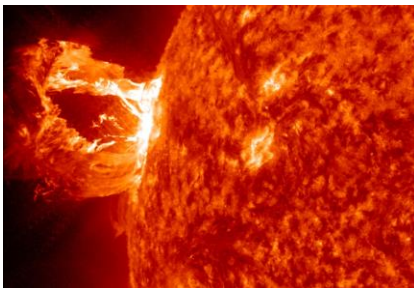
## Our instruments



Our Astronomical observatory in Haskovo makes regular observations of the Sun. We use 80/1200 refractor telescope and camera CANON EOS 350D equipped with standard SFO solar filter to picture the sun spots. We also use Coronado PST telescope equipped with H alpha filter and camera CANON EOS 60D to observe solar prominences and filaments. After that we use the realtime SDO Gallery to orientate our pictures in N-S position correctly and to compare each of them.

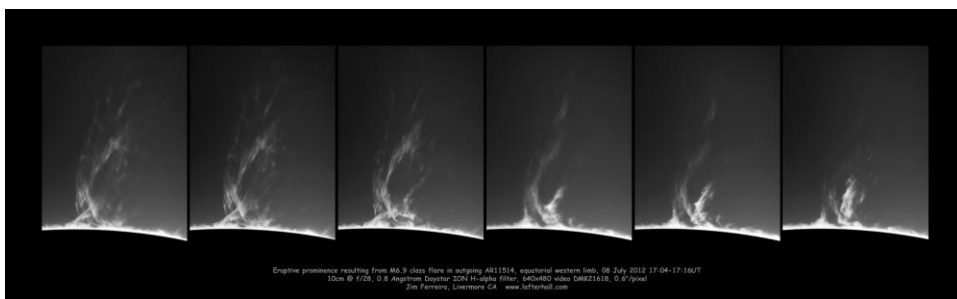
## Prominences and Filaments

Prominences and filaments are the same active features. They are formed in the corona but typically possess temperature hundreds of times lower and densities hundreds to thousands of times higher than the corona. They are created for about a day but can last for weeks and even months. During this time they constantly change its length, thickness and shape. Prominences may reach hundreds of thousands of kilometers into space. The difference between prominence and filament is that the filament is projected on the solar disk while the prominence outside it (on the solar limb). Unfortunately, we were unable to watch the prominences with the telescope in white light except during total solar eclipses. For our daily observations we needed a special H alpha filter for this. The Coronado telescope has one.

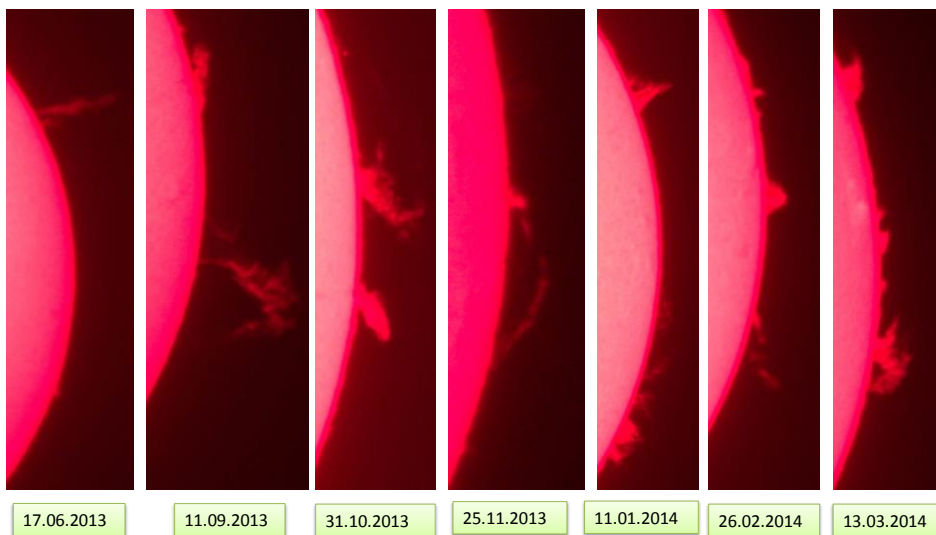


# Physical characteristics of prominences and filaments

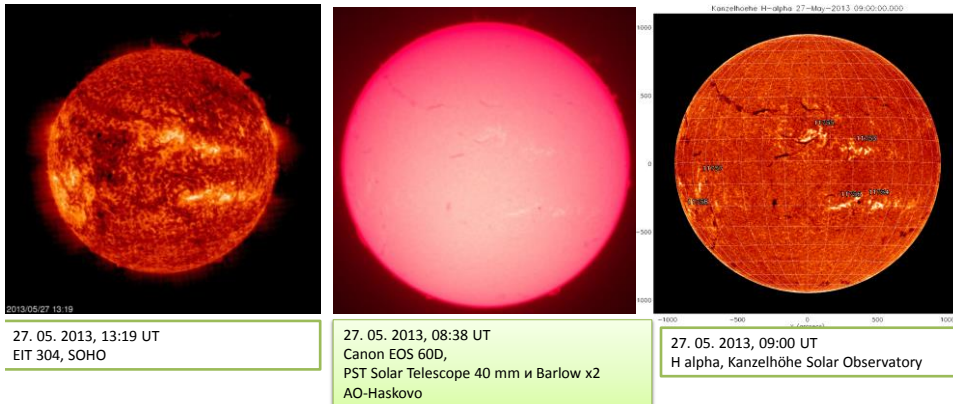
The spectrum of prominences contains mainly lines from Balmer's series of hydrogen, neutral helium and H and K lines of ionized calcium. The perfect lines for observation are H alpha, H beta, and H gamma. The prominences are connected with the solar magnetic field which is very important for their formation and evolution. Their forms are very variable and they usually reach height of 30000 km above the photosphere but there are also extremely long prominences. They also have different thickness, density and temperature. The spectrum of prominences shows that their temperature is around 20000K.



## Our observations in H alpha



# Identification

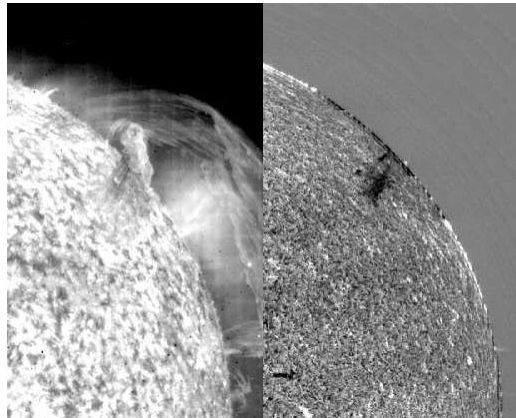


To process our pictures we can use for orientation and comparison images from some ground-based solar observatory or SDO images. The earth solar observatories are also picturing the Sun in H alpha like us but the bad weather conditions do not allow regular observations. SDO is photographing the Sun permanently.

However, the prominence images from SDO are taken in He II. This is the reason why our images and these taken from SDO are not very similar. Here we are going to discuss the differences and will show you part of our observations.

## The difference

When we are observing in H alpha, we can see the cooler part of the prominence with temperature around 10000K. Unfortunately, Earth's atmosphere absorbs the extreme ultraviolet rays (He II) so we can't observe in this wavelength. He II observes the hotter part of the prominence - about 60000-80000K. That's why there is a difference. For example, if we have an eruptive prominence, we will see it in He II because it is hot but we might not see it in H alpha.

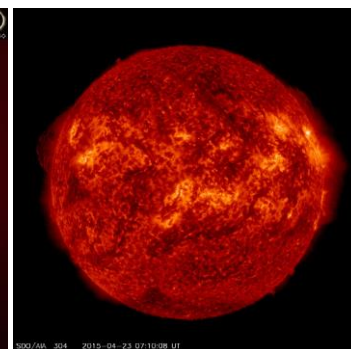
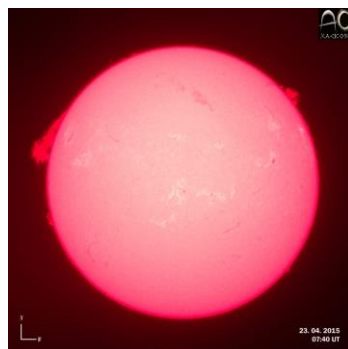
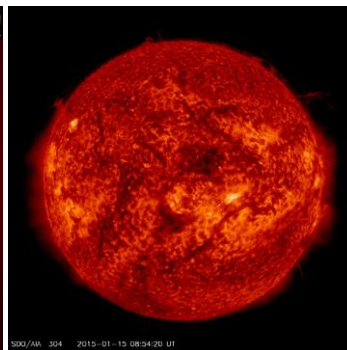
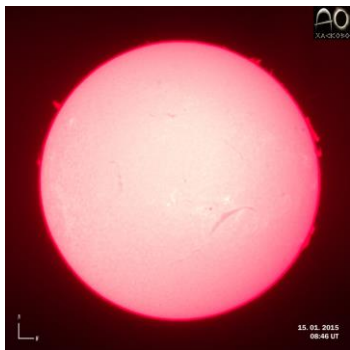
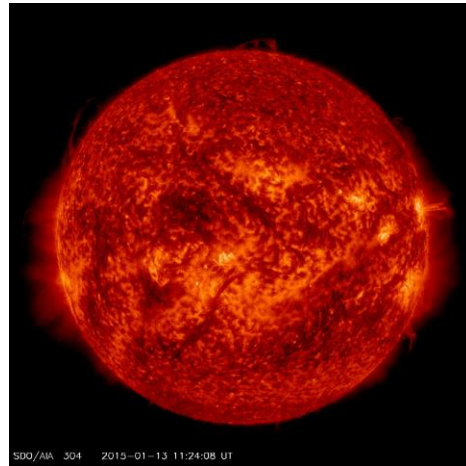
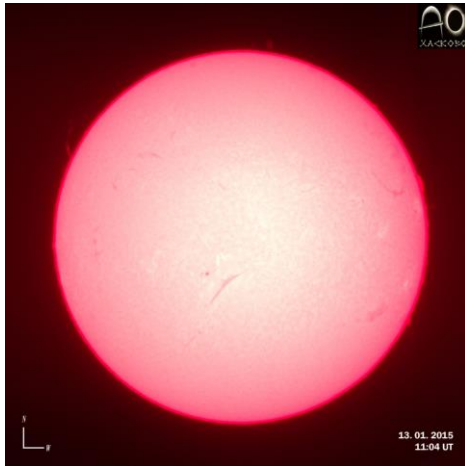


Both of these pictures are taken on the same day and date.

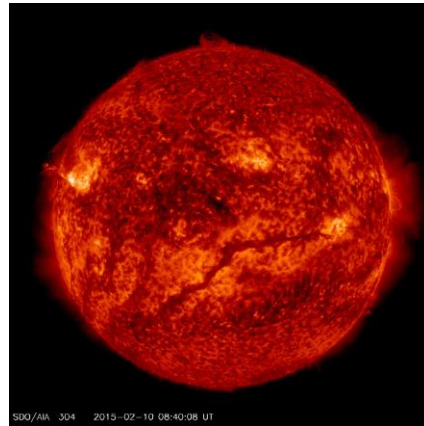
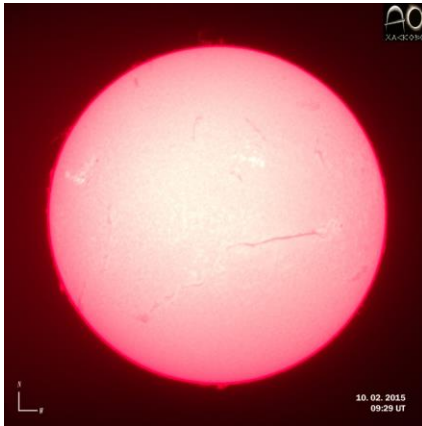
08.26.1997 at 16:07 UT  
from SoHO and BBSO  
(Big Bear Solar  
Observatory) respectively.

## The comparison

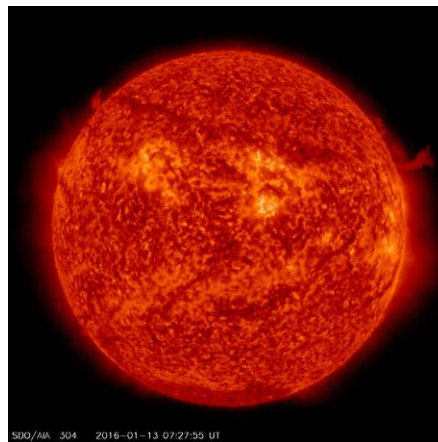
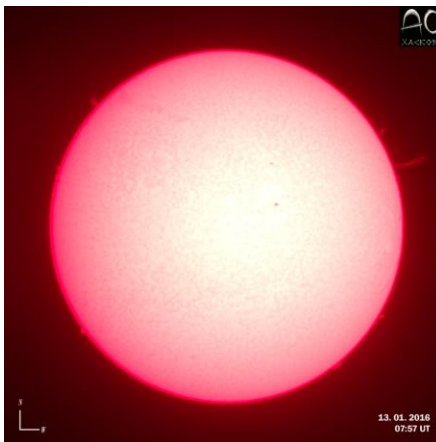
In the next couple of pictures we will show the comparison between our observation in H alpha and SDO images in He II. It easy to spot the different characteristics and morphological features of filaments and prominences.



In these pictures there is a large filament  
very well seen in He II but much dimmer  
in H alpha.

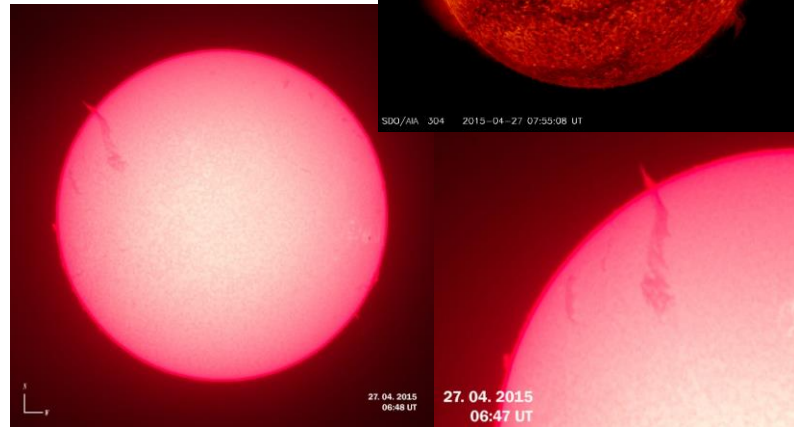


The big prominence here in He II is thicker. The same in H alpha is  
more feathery.  
There is also a long filament that go across the whole sun. It is much  
better seen in He II than in H alpha.

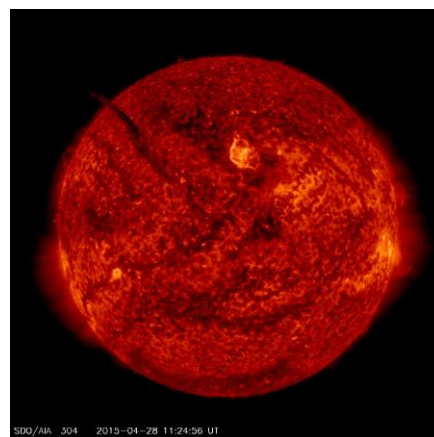
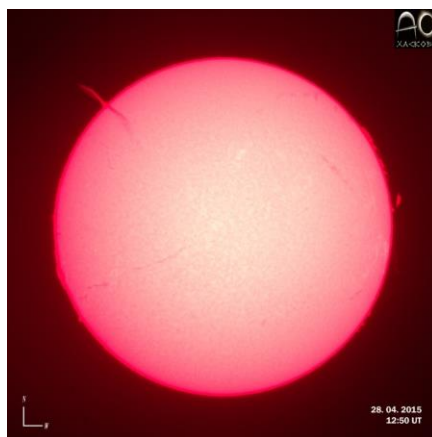




In these pictures we can see very beautiful prominence. It is well seen in both H alpha and He II but in He II it is much more long and thick. Nevertheless, in H alpha the structure of the filaments and its "legs" are more visible because of the lower temperature of this part of the prominences.

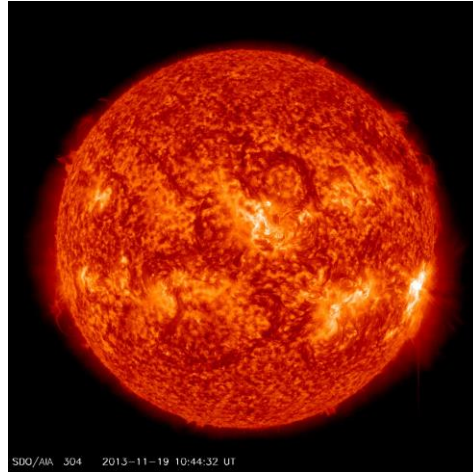
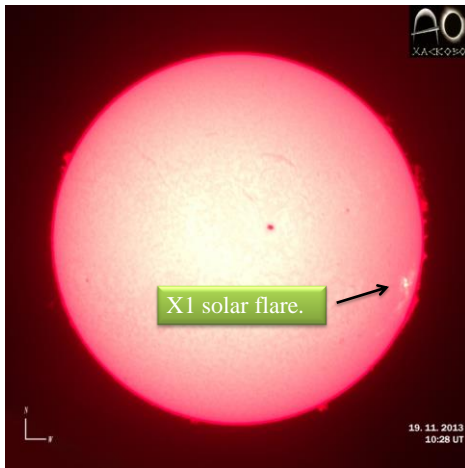


The difference here is becoming more obvious. The filament in H alpha is starting to disappear compared to the long and thick structure that it has in He II. What is interesting is that the prominence is higher in H alpha than in He II.

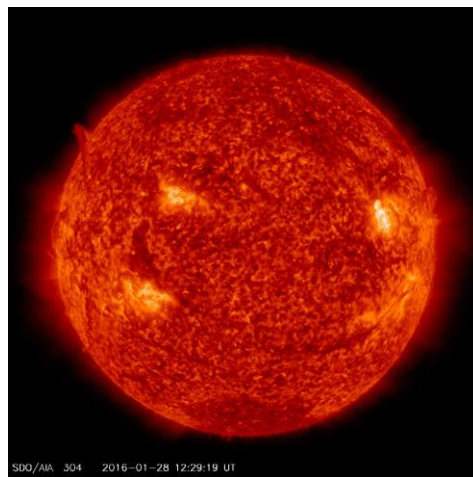
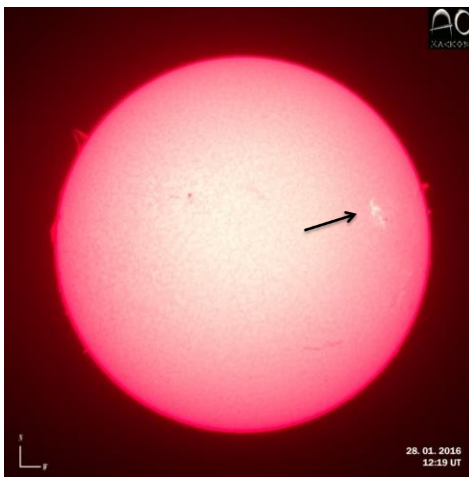


On the next two couple of pictures we present not only the prominences, but also the solar flares we captures with our small H alpha solar telescope.

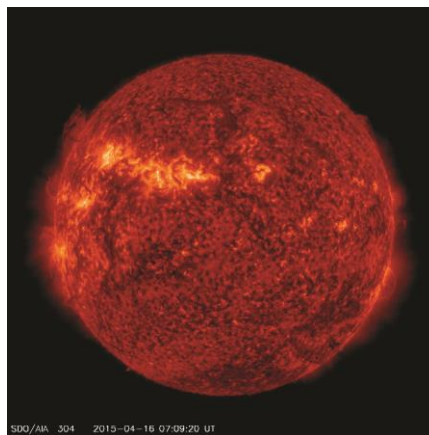
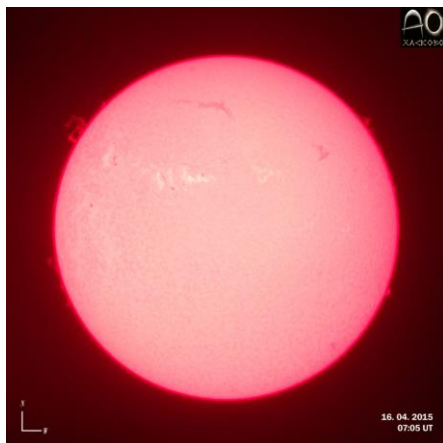
X1 solar flare.



C9 solar flare.



Here we can see that in H alpha we observe sun spots and active regions too. They are different from these in He II but in any case we are able to distinguish them.



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- <http://www.spaceweather.com/>
- <http://www.hraastro.com/>
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- <http://www.astronomyknowhow.com/hydrogen-alpha.htm>
- [http://www.solarmonitor.org/full\\_disk.php?date=20160111&type=bbso\\_half&indexnum=1](http://www.solarmonitor.org/full_disk.php?date=20160111&type=bbso_half&indexnum=1)
- <http://www.swpc.noaa.gov/>