XUVI

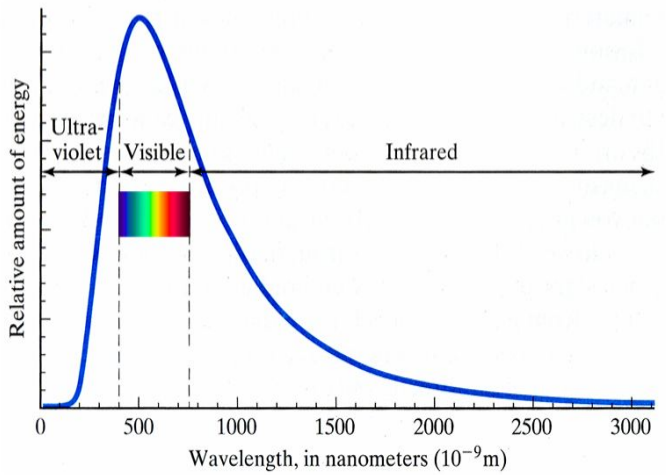
First Lecture
29.05.2020

Goals

1. What is Solar Spectrum?
2. Sunspots
3. What is a Solar Flare?
4. Where, Why and How is the energy released?
5. Stages of Flare

The Solar Spectrum

1. The solar spectrum consists of a continuum with thousands of dark absorption lines superposed. The lines are called the Frauenhofer lines, and the solar spectrum is sometimes called the Frauenhofer spectrum. These lines are produced primarily in the photosphere.
2. The relative amount of energy shown in graph alongside is simply calculated using Stefans' Boltzmann Law.
3. The sun has its strongest output in the Green
4. Our eyes are most sensitive in the green.

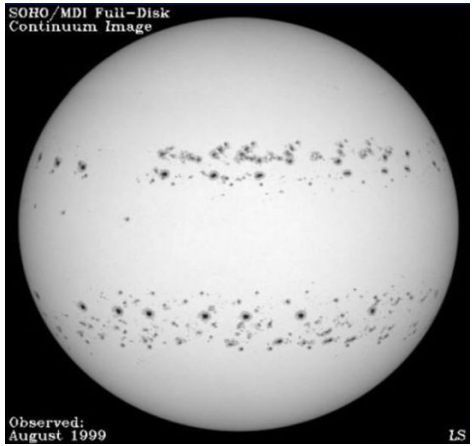


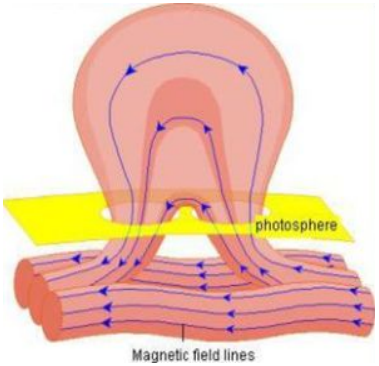
Planck's Law of Radiation

1. A hot body(such as Sun) emits electromagnetic radiation with a characteristic spectral shape.
2. The peak frequency of the spectrum is proportional to the absolute Temperature T and the peak wavelength is inversely proportional to T, since $\lambda=c/f$.
3. The surface of the Sun radiates at 6000 K. Its thermal radiation peaks in the visible (green).
4. The surface of the Earth radiates at 300 K. Its thermal radiation peaks in the far infrared

Sunspots

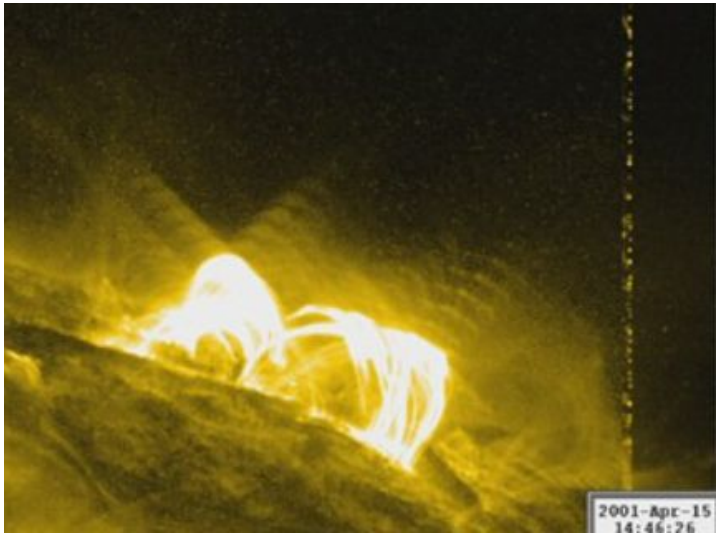
1. Dark spots present on the photosphere that are ~4200 K and each sunspot has two regions: Umbra(central) and Penumbra.
2. There are strong magnetic fields in them and are caused by outcrop of the magnetic lines in the loop rising from inside.
3. The number of sunspots indicates the “solar activity”.
4. Galileo was one of the first who saw sunspot using a telescope.





What is a SOLAR FLARE?

1. A solar flare is a sudden release of energy during which magnetic energy is converted to kinetic energy of fast particles, mass motions, and radiation across the entire electromagnetic spectrum.
2. Energy released upto 10^{25} J in the largest flares. Many more much smaller flare-like events(e.g. micro-flares) occur down to ~ 10^{17} J(10*a nano flare, the observational limit). [nano=10^{-9}]



Solar spacecraft observing solar flares

1. GOES(Geostationary Operational Environmental Satellites)
2. RHESSI(Ramaty High Energy Solar Spectroscopic Imager)
3. SOHO(SOlar and Heliscopic Observatory)
4. TRACE(Transition Region And Coronal Explorer)
5. STEREO
6. SDO(Solar Dynamics Observatory)

Fundamental questions in Flares

Where and How is the energy stored?

The location of the stored energy is unobservable- it is presumed to be in a non-potential magnetic field region

Why is the energy released?

It is widely assumed that magnetic reconnection results in a sudden release of energy in the way observed.

It is practically impossible to determine where the energy is released- it appears that energetic particles are accelerated at the energy release site

What happens after the energy is released?

There are burss of hard X-rays followed by a gradual increase of soft X-rays and radio emission which is well observed.

As the magnetic energy is being released, particles, including electrons,protons, and heavy nuclei, are heated and accelerated in the solar atmosphere. The energy released during a flare is typically on the order of 10^{27} ergs per second. Large flares can emit up to 10^{32} ergs of energy. This energy is ten million times greater than the energy released from a volcanic explosion. On the other hand, it is less than one-tenth of the total energy emitted by the Sun every second.

https://youtu.be/q2kDvrs2VEs

Stages of Flare

There are typically three stages to a solar flare.

First is the ***precursor*** stage, where the release of magnetic energy is triggered. Soft x-ray emission is detected in this stage.

In the second or ***impulsive*** stage, protons and electrons are accelerated to energies exceeding 1MeV. During the impulsive stage, radio waves, hard x-rays, and gamma rays are emitted.

The gradual build up and decay of soft x-rays can be detected in the third, ***decay*** stage.