Astronomy **Summary Knowledge Organiser** – Chapter 9 (Topic 10) **Solar astronomy (i)**

The Sun, eclipses and transits can be observed safely using **PINHOLE PROJECTION** (see images below) but the most detailed images of the Sun's surface can be seen using **TELESCOPIC PROJECTION** or a telescope with an **H-ALPHA FILTER**.

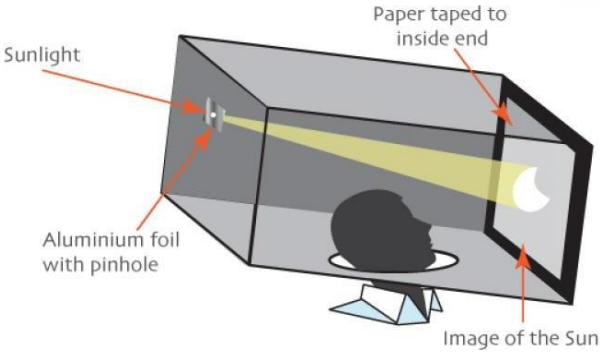
Telescopic projection involves using a '**baffle**' (a piece of card with a small hole in it) to absorb most of the solar radiation before it enters the telescope, this reduces the brightness of the image formed to a safe level for viewing.

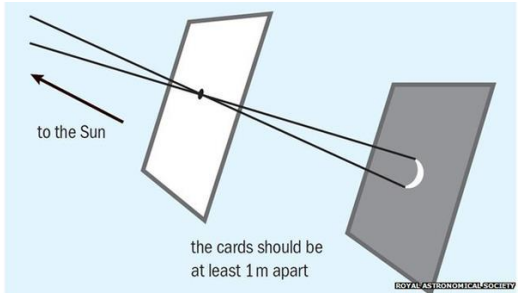
An **H-alpha filter absorbs** all sunlight except for a **narrow band of wavelengths (close to 656 nm)** that are emitted from Hydrogen.

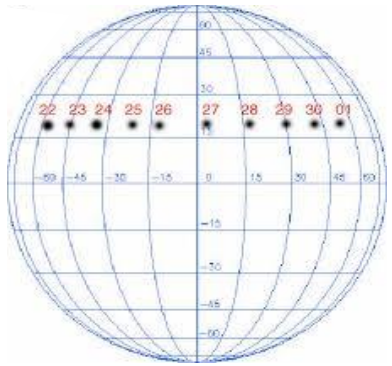
WARNING

If you look directly at the Sun, even briefly, without wearing *solar viewers*, you will permanently damage your vision. (Sunglasses give no protection.)

Even *during* the eclipse, the bright part of the Sun will be just as bright as usual.







The Sun is **not a solid body** so its **ROTATIONAL PERIOD** is **different at different latitudes**. The time it takes for the Sun to spin at different latitudes is found by **observing sunspots move across the surface** of the photosphere and **recording the position of the same sunspot at the same time every few days**. The changing position of the sunspot on different dates can then be found by overlaying the solar disc image with a transparent overlay showing longitude.

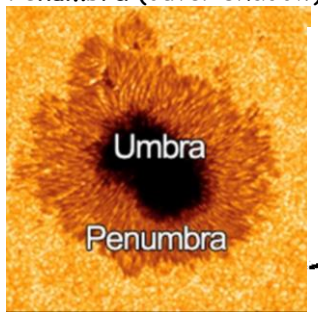
After repeat observations are completed for sunspots at the same latitude the **rotation period** of that latitude can be calculated using the following **formula**;

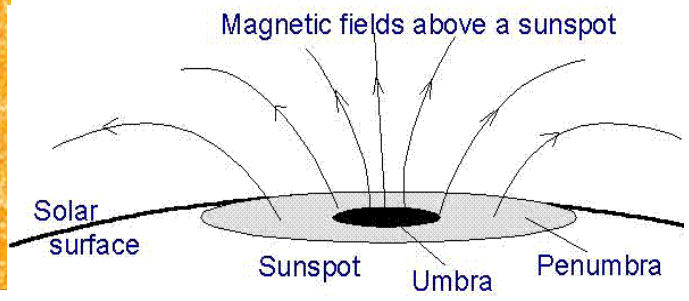
$$\frac{T}{t} = \frac{360^{o}}{L}$$

where **t** is the 'time interval' between the observations, **L** is the 'change in longitude' of the sunspot and **T** is the rotational period at that latitude. So, you simple observe the sunspots, fill in 't' and 'L' and then calculate 'T'.

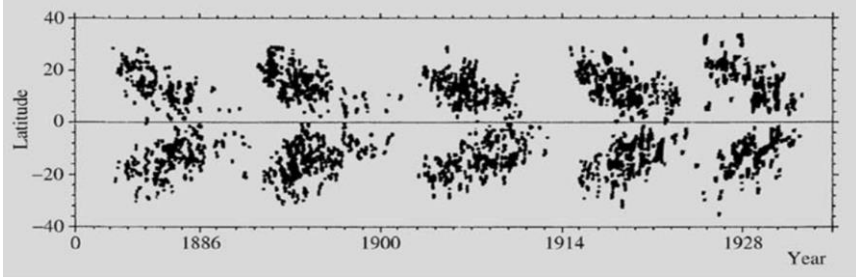
Sunspots appear as **darker regions** on the Sun's surface (called the **photosphere**). They appear darker because they are **relatively cooler** to the surrounding surface, but they are definitely **not cold**! Sunspots are caused when **strong magnetic fields** in that area of the Sun **restrict the flow of hot plasma to the surface**, making it cooler than the surrounding surface (see below). The **photosphere** has a temperature of approx. **5800K**.

Penumbra (outer shadow) – **5600K** **Umbra** (inner shadow) – **3800K**

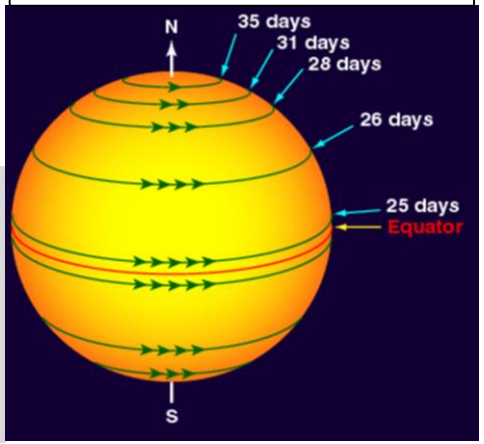




Individual sunspots can last for a few days up to a month. However, the **numbers of sunspots** always follow a regular **11 year SOLAR CYCLE**. During each 11 year period the number of sunspots will be very few, then rise to a maximum, before falling back to very few again. During the cycle sunspots will initially form at **high latitudes**, then form **closer to the solar equator**. If plotted on a graph (below), the **Butterfly Diagram** is formed.

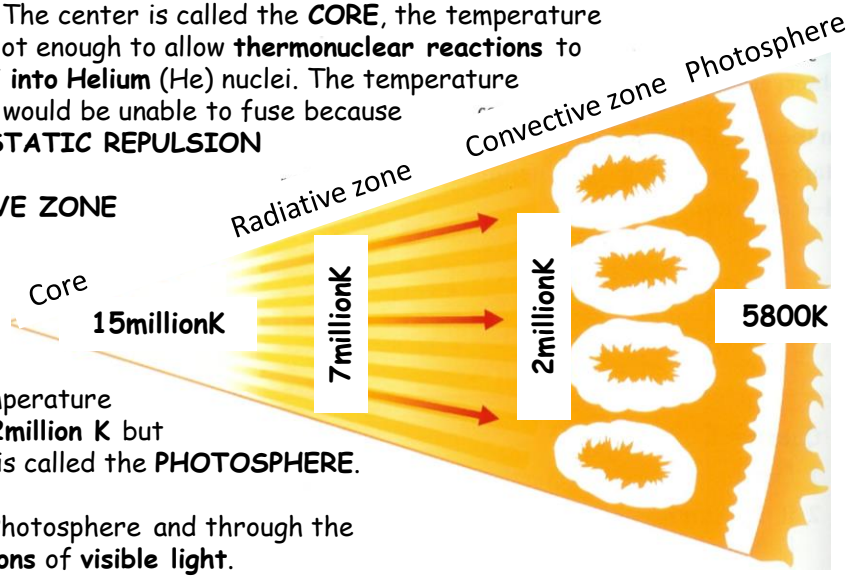


The **rotation period** is **25 days at the equator & 36 days close to the poles**



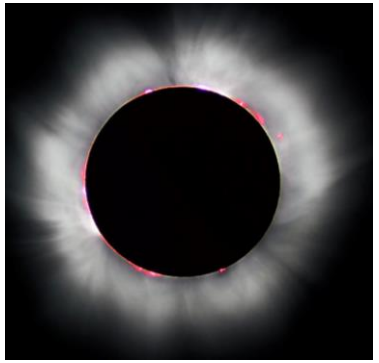
Astronomy **Summary Knowledge Organiser** – Chapter 9 (Topic 10) **Solar astronomy (ii)**

The Sun's interior is made of 4 layers. The center is called the **CORE**, the temperature here is about **15 million Kelvin** and is hot enough to allow **thermonuclear reactions** to happen that **FUSE Hydrogen** (H) nuclei **into Helium** (He) nuclei. The temperature must be this high otherwise the nuclei would be unable to fuse because they couldn't overcome the **ELECTROSTATIC REPULSION** of their positively-charged nuclei.
Above the Sun's core is the **RADIATIVE ZONE** where energy is transferred outwards by **Gamma photons**.
Next, the **200,000km** wide **CONVECTIVE ZONE** transports **hot plasma** up to the Sun's surface in rising **convection currents**. The temperature at the base of the convective zone is **2million K** but cools to **5800 K** at the surface which is called the **PHOTOSPHERE**.

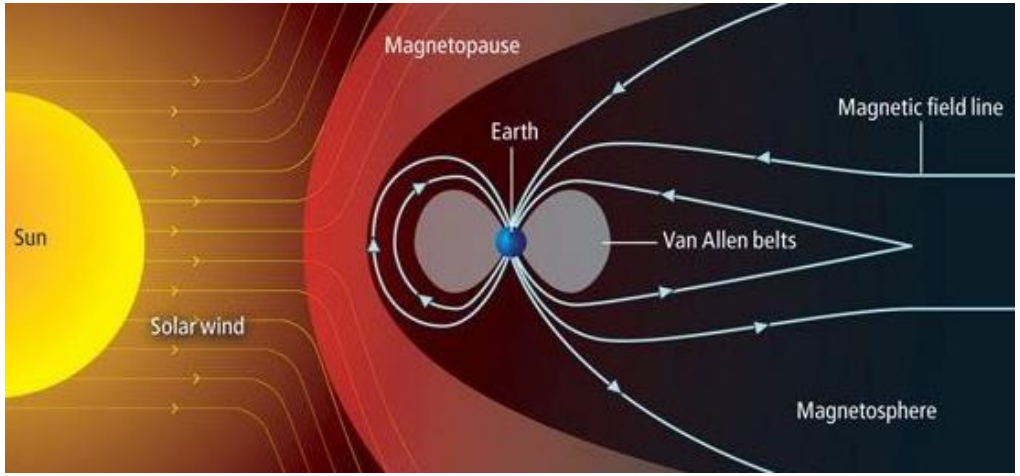


Energy is transferred away from the Photosphere and through the **CHROMOSPHERE** & **CORONA** by **photons** of **visible light**.

Above the Photosphere the Sun's atmosphere consists of **2 more layers**. Directly above is the **CHROMOSPHERE,** a very thin spherical shell of gas surrounding the Sun that can **only be seen** during a **solar eclipse**. Its <u>temperature</u> <u>ranges</u> from **4000K** just above the Sun's surface to **100,000K** at its top!
Finally, the tenuous, **even less dense CORONA** extends out into space for **millions of km** and is so **remarkably HOT** (**2million K**) that it **<u>emits X-rays</u>** . Again, the **Corona is only visible during a solar eclipse**, at all other times they are 'drowned out' by the brightness of the Photosphere!



The Earth would have a **magnetic field** similar in shape to that of a bar magnet but the force of the **solar wind** emitted from the Sun compresses it. The actual magnetic field created is called the **MAGNETOSPHERE**.



The Sun's **CORONA** emits both a **SLOW** and a **FAST solar wind**.
The <u>slow solar wind</u> is a **400 km/s outflow of plasma containing <u>CHARGED PARTICLES</u>**. It is made up of mainly **PROTONS** & **ELECTRONS**.
The <u>fast solar wind</u> is **intermittent gusts of <u>RADIATION</u>** emitted **from coronal holes** and is linked to **coronal mass ejections** and **solar flares**.
The solar wind **<u>causes</u>** the **ion tails of comets** to form, the **aurora** and **geomagnetic storms**. These storms can overload power lines and cause blackouts, interfere with radio transmissions, damage electronic instruments on satellites and increase the risks from radiation for air passengers and astronauts!
The **Van Allen Belts** (pictured above) are **doughnut shapes rings of charged particles** (inner belt contains mainly protons, outer belt mainly electrons).
Van Allen **radiation** belts are zones where the **energetic charged particles** of the solar wind are captured & held by the Earth's magnetic field. Astronauts <u>safely</u> passed through these high radiation zones during the Apollo missions to the Moon.

<u>Nuclear FUSION – the proton-proton chain</u>
Fusion takes many forms but the most common series of reactions involves Hydrogen nuclei being fused in stages to form Helium nuclei that are then fused themselves to form more Hydrogen and Helium nuclei and a **vast amount of energy!** The stages of the <u>proton-proton chain</u> are <u>shown to the right</u>.
With each stage of fusion **MASS (*m*) is <u>converted</u> into ENERGY (*E*)**. The amount of energy released can be calculated using **Einstein's equation;**

$$E = mc^2$$

(**c** is the speed of light in **m/s**).

$$H_1^1 + H_1^1 \rightarrow H_1^2 + e_1^0 + \nu_0^0$$

$$H_1^2 + H_1^1 \rightarrow He_2^3 + \gamma_0^0$$

$$He_2^3 + He_2^3 \rightarrow He_2^4 + H_1^1 + H_1^1$$