Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this *The Solar Cycle*.

The first thing you notice in reviewing the literature about the solar cycle is that the math doesn't work. Here in 2010 we are just a year into cycle number 24 and each cycle has a duration of around 11 years - and isn't the Sun like 5 billion years old?

A Swiss astronomer named Rudolf Wolf introduced the cycle numbering scheme as well as a sunspot index and the so-called Cycle 1 started from 1755 and went until 1766. Cycle 23 which ended in December 2008 was a slightly unusual one, with a duration of 12.6 years – ending with a prolonged solar minimum extending across the whole of 2008. And then Cycle 24, which we are in now, itself got off to a slow start – showing almost no sunspots over 2009. So 24 is shaping up to be a relatively quiet cycle – predicted to hit its maximum in May 2013, although as with the unusual cycle 23, these predictions are quite often wrong.

Anyway, it's all about magnetism. The Sun's magnetic field arises from the same phenomenon seen in plasma you can create in a laboratory – where a gas is heated to a point where electrons dissociate from atoms and you are left with a mix of negatively charged electrons and positively charged nuclei which are all in very energetic motion due to the temperature they've been heated to.

The Sun is a bit like a dipole magnet with north and south poles and lines of magnetic force extending out from high latitudes of each hemisphere - not unlike the Earth's magnetic field, except with the Sun, this magnetic field is a whole lot stronger and much more violent. The reasons for the cyclic strengthening and weakening of the Sun's magnetic field remain unclear. It might be a consequence of the Sun's rotation and large scale plasma convection currents – or it might have something to do with the planets, at least the big ones like Jupiter and Saturn.

If you've seen the lines of magnetic force that are shown up by iron filings spread out on a piece of paper with a bar magnet underneath it – that's kind of what we are dealing with. The lines of force that shape the Sun's magnetic field are always there, but in a solar minimum they run beneath the surface – while as the Sun trends towards a solar maximum, these magnetic lines of force start to break through the Sun's surface.

Sunspots are generally found in pairs which may represent the exit and re-entry points of a particularly energetic line of magnetic force - sticking out beyond the Sun's surface in a small loop. Sunspots are slightly cooler and hence look darker than the rest of the Sun's surface – but are more than balanced by magnetically associated bright spots, called faculae. During a solar maximum there are certainly more dark sunspots, but a whole lot more bright faculae – so the nett effect is a slight increase in the Sun's overall luminosity.

Solar maxima also see a lot more dramatic and short-lived events like solar flares – which are bright flashes seen on the Sun's surface – and are really intense bursts of radiation across the whole electromagnetic spectrum, including intense bursts of X and gamma rays. Solar flares are actually concentrated explosions – and when seen side-on, it's apparent that they often throw up plasma up from the Sun's surface – which is either dragged back down in a parabolic loop by the Sun’s gravity or may be thrown right out into space – which we call a coronal mass ejection.

At the start of a solar cycle, sunspots first appear above 45 degree latitudes in both the northern and southern solar hemispheres. Then they begin to appear progressively closer to the equator over a 5-6 year period, steadily increasing in number as they do so. So at a solar maximum you generally have lots of sunspots on both sides of the equator - as well as flares, faculae and coronal mass ejections. Then, everything begins to quieten down again, over a 5 to 6 year period, often with long periods where you see no sun spots at all. And then - a new set of high latitude sunspots start to appear, heralding the commencement of a new solar cycle.

What's even more interesting, is that sunspot pairs have a particular magnetic polarity, where one has a north polarity and the other one has a south. Within one solar cycle, sunspot pairs in one hemisphere of the sun have the same polarity - while sunspot pairs in the other hemisphere have the opposite polarity. And then in next solar cycle - the new sunspots appearing in high latitudes of one hemisphere have the opposite polarity to the previous cycle’s sunspots in that same hemisphere.

And one more layer of complexity - there is a slow and continuous conveyor-belt-like flow of solar plasma from the solar equator towards each solar pole and a deeper sub-surface flow of material from the poles back to the equator. We have noticed a relationship between the speed of this plasma flow and the solar cycle.

The flow is significantly faster around solar minima than solar maxima - and a prolonged solar minimum like the one over the extended end of Cycle 23 and the start of Cycle 24 is associated with an even faster flow of plasma than the average speed seen in the minima of most other cycles. But whether it’s the increased plasma flow suppressing magnetic activity - or increased magnetic activity impeding the plasma flow is not immediately clear.

Of course this variable behaviour of the Sun has an impact on the rest of the solar system and particularly on the inner solar system. We are already making big investments into what we call space weather – which involves both trying to monitor it and to develop reliable space weather prediction services. These services will be of increasing importance as we continue to get more spacecraft and more people into space.

Solar maxima do have an effect on the Earth's atmosphere - though, in terms of temperature change, there's only a 0.1% increase in total solar irradiance – or maybe 0.3% in very active maxima. Of more concern are the solar flares which create a sudden gusts of solar wind and powerful bursts of X rays and gamma rays.

Dramatic solar maxima include the Carrington Event of 1859, where a large solar flare caused electrification of telegraph cables, set telegraph offices on fire and apparently produced nightly auroras you could read the newspaper by. A solar flare in 1989 overloaded Quebec’s electricity grid. Another big one in 2003 sent astronauts racing to the middle of the ISS for maximal shielding and completely wrote off the $450 million Midori 2 satellite.

In solar minima, there’s less dramatic activity, less solar wind and less violent radiation bursts. However, there are some drawbacks with minima, since a weaker solar wind means fewer cosmic rays are diverted away from Earth. You also get an increased accumulation of space junk – since the junk is most often de-orbited during solar maxima when the extra heating of Earth's atmosphere expands it outwards, creating extra drag on low orbiting junk.

Also, in a solar minimum, the auroras aren’t as good.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website that helps keep your costs to a minimum. No ads, no profit, just good science. Bye.