Sunspots

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1 Introduction

In September 1859 spectacular aurora were seen all around the Earth. Unusually, they were seen as far south as Mexico, Cuba and Hawaii. In the Rocky Mountains the aurora were so bright that gold miners got up and started preparing breakfast because thinking it was morning. At the same time the largest geomagnetic storm ever recorded played havoc with compass bearings, and induced large currents in telegraph wires (which were then spreading over continents): sparks flew from morse keys and fires started.

Prior to this point unusually large numbers of sunspots had been observed on the surface of the Sun and seventeen and a half hours before the first aurora, the English amateur astronomers Richard Carrington and Richard Hodgson made the first observations of a solar flare, and later published descriptions in the Monthly Notices of the Royal Astronomical Society. (This is now generally known, perhaps unfairly to Hodgson, as the *Carrington Event*.)

A similar event today would probably cause large scale disruption to our electronically connected society. Communications and weather satellites would be damaged, radio communications disruptions and electricity grids might fail. (In 1989 large parts of the electricity grid in Quebec were put out of action by a smaller event.) In 2012 a solar superstorm created a similarly sized coronal mass ejection that fortunately missed the Earth.

Hence, sunspots, the *solar wind* and *space weather* remain extremely important subjects of study in astronomy, with an unusually direct relevance to our life on Earth, and some physics graduates can now claim the unusual profession of 'space weather forecasters'. Sunspots also have a great deal of intrinsic scientific interest: they tell us much about what is going on inside the Sun

The purpose of this project is to investigate the scientific and practical importance of sunspots observations and learn how to observe them with equipment available at school.

2 Seeing Spots

2.1 Safety

It is extremely important that you *never* look directly at the Sun, even though ordinary sunglasses, and you should never look at the Sun through a telescope unless it has been equipped with a specially designed safe solar viewing filter that cannot be accidentally removed. (Such filters are available for small telescopes at fairly modest cost - about 40 for a 100mm objective. They protect the telescope from excessive heat as well as protecting your eyes.)

2.2 Projection

In fact, there is generally little need to look through telescopes when observing sunspots: you may get a better view (especially when working in groups) by projecting the Sun's image onto a card behind the telescope as shown in Figure 2.2 on page 3. (The device on the left is described at in the Sky at Night magazine website at http://www.skyatnightmagazine.com/feature/how-guide/how-make-solar-projection-screen.)

Note that when working with larger telescopes there is a risk of damaging the eyepiece of the telescope through the concentrated heat of the Sun (especially when the instrument has plastic lenses) so it is normal to reduce the effective aperture (say with a cardboard over the objective lens with a small cut-out). Lack of light is not a problem when looking at the Sun. There are many alternative designs and commercial accessories which can be found via Googling something like 'sunspot observation by projection'.

The configuration of sunspots can be recorded either by photographing the card or by simply drawing on the card with a pencil. When recording observations remember to record the exact time, and be sure to mark the circular image with the correct solar orientation.

3 Investigation

Try to answer these questions by observing sunspots over an extended period (you will need regular observations over several weeks). You are, of course, likely to miss observations on cloudy days, especially in winter. There are, however, a number of 'space weather' websites that regularly post current images of the Sun.

- What is the Rotation Period of the Sun?

Figure 1: Some of the many ways of doing Solar Projection

- Does the Sun rotate as a solid body? Can you produce evidence one way or the other?
- Look up the 'space weather' websites, and see if reports of aurora correlate with the sunspot numbers that you see.
- Have you seen any solar flares while observing the Sun? (They appear as sudden increases in brightness over of parts of the solar disk.)
- How do sunspots relate to solar flares?
- How can solar flares affect the Earth's magnetic field?
- What is the cause of aurora?
- How can magnetic storms bring down electricity grids?

You may not get a chance to attack all of these questions - but they are all related. You may also find that your investigations take you off in directions not identified above that appear to you to be more interesting. This is fine, as long as you can explain *why* it is more interesting.