Classroom activities: The Sun and the Sun-Earth connection

www.sunearthplan.net

The online version of this booklet is available at:
www.sunearthplan.net/media/9984_IHY_activities.pdf

Keeping safe in the Sun

Objectives

- To learn that scientists are studying the Sun during a special year called International Heliophysical Year.
- To learn that the light from the Sun can be dangerous. We need to block this light using suntan lotion.

Resources required

- Colour change beads
- 2-3 different sunscreens
- 1 baby lotion
- Clear plastic bags
- Cotton buds
- UV light source (the Sun!)
- Stop watch
- Coloured pencils

Teaching activities

Introduction

International Heliophysical Year (IHY) runs from 2007 to 2009. During IHY scientists around the world are studying how the Sun affects us here on Earth.

One way the Sun affects us here on Earth is through the ultraviolet (UV) light it emits. The UV from the Sun is what gives you a suntan but it also causes sunburn, which can lead to skin cancer. If you snowboard, you will be high up in the mountains, hopefully in the sunshine. This UV light is stronger in the mountains than on a beach. The snow also reflects UV light onto your face. You can even get sunburnt while it is snowing.

This means that when you are out in the Sun you want to take a very good sunscreen to block the UV light, and to keep you safe. You’ve bought some sunscreen, but the labels have rubbed off the bottles.

You have some beads that change colour in ultraviolet light. You decide to create an experiment to test which is the best sunscreen to use on your trip snowboarding.

Activity

The aim of this activity is to encourage the students to come up with their own investigation. There are many ways to carry out this investigation. We recommend placing the beads into the plastic bags, and checking that they change colour under UV light. You can then sort the beads into different colours, if you think this might make a difference.

Let the beads return back to white.

Then you can try thinly smearing the outside of a bag with sunscreen (imagine the bag is your skin, you don’t normally put a thick layer of cream on). We suggest providing cotton buds for this – it suggests that you don’t need much cream! Try several different bags, with different sunscreens/lotions.

You can try timing how long it takes for different beads to change colour. Try making a colour chart, as the beads do get deeper in colour with more exposure to UV. Which cream or lotion gives the best protection from the UV light?

Safety

The UV beads will change colour outside, even if it is cloudy. However, you may wish to use UV LED torches, or black lights, if you do not have easy access to an outside space.

These should be used with care, not point into eyes, and following any other manufacturer’s recommendations. Also, NEVER LOOK DIRECTLY AT THE SUN.

Students could explore:

- Does glass block UV light?
- Do the different colour beads react in the same way/time?
- How does clothing protect you from UV radiation?
- How long does sunscreen last?
- How easy is it to wash sunscreen off?

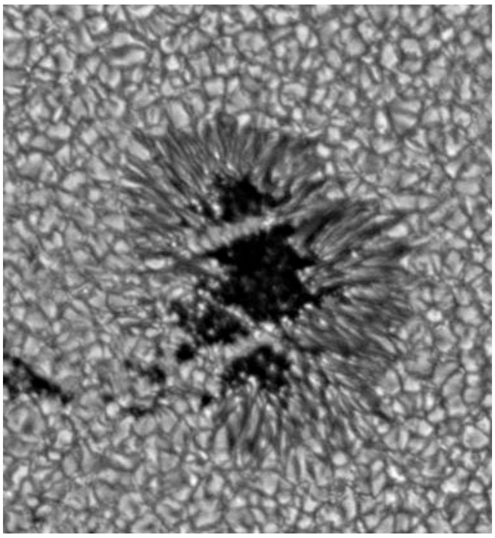
Web links

UV colour change beads are easy to source, one suggested provider is

- http://www.mutr.co.uk and search for ‘UV beads’ (approx. £4.00 for 100 beads)

Sun spotting

The Sun gets spots!



Sunspots are huge dark areas on the Sun. They are typically the size of a planet! They are cooler than the surrounding Sun.

They have been observed for thousands of years and recorded since 1610!

Warning

Never look directly at the Sun. This can result in permanent damage to your eyes

The number of sunspots on the Sun changes over time. New sunspots form, and old ones disappear. Sometimes there may be 100 spots, and sometimes none at all.

They are usually found in pairs and are associated with strong magnetic fields.

Things to do

- Make a large graph showing the number of sunspots counted every year since 1700.
    - Give each person or pair a set of sunspot numbers and graph paper.
    - Plot the number of sunspots counted each year.
- Label the peaks, the maxima, P1, P2 etc
- Label the troughs, the minima, T1, T2 etc
- Measure the length of time between two neighbouring peaks (P-P) several times.
- Measure the length of time between two neighbouring troughs (T-T) several times.

Peak-to–peak (P – P)		Trough-to-trough (T – T)	
P1 – P2	_________years	T1 – T2	_________years
P2 – P3	_________years	T2 – T3	_________years
Average		Average	

What is the average length of time of the sunspot cycle?

Sunspot numbers by year

1700	5
1701	11
1702	16
1703	23
1704	36
1705	58
1706	29
1707	20
1708	10
1709	8
1710	3
1711	0
1712	0
1713	2
1714	11
1715	27
1716	47
1717	63
1718	60
1719	39

Sunspot numbers by year

1720	28
1721	26
1722	22
1723	11
1724	21
1725	40
1726	78
1727	122
1728	103
1729	73
1730	47
1731	35
1732	11
1733	5
1734	16
1735	34
1736	70
1737	81
1738	111
1739	101

Sunspot numbers by year

1740	73
1741	40
1742	20
1743	16
1744	5
1745	11
1746	22
1747	40
1748	60
1749	80.9
1750	83.4
1751	47.7
1752	47.8
1753	30.7
1754	12.2
1755	9.6
1756	10.2
1757	32.4
1758	47.6
1759	54

Sunspot numbers by year

1760	62.9
1761	85.9
1762	61.2
1763	45.1
1764	36.4
1765	20.9
1766	11.4
1767	37.8
1768	69.8
1769	106.1
1770	100.8
1771	81.6
1772	66.5
1773	34.8
1774	30.6
1775	7
1776	19.8
1777	92.5
1778	154.4
1779	125.9

Sunspot numbers by year

1780	84.8
1781	68.1
1782	38.5
1783	22.8
1784	10.2
1785	24.1
1786	82.9
1787	132
1788	130.9
1789	118.1
1790	89.9
1791	66.6
1792	60
1793	46.9
1794	41
1795	21.3
1796	16
1797	6.4
1798	4.1
1799	6.8

Sunspot numbers by year

1800	14.5
1801	34
1802	45
1803	43.1
1804	47.5
1805	42.2
1806	28.1
1807	10.1
1808	8.1
1809	2.5
1810	0
1811	1.4
1812	5
1813	12.2
1814	13.9
1815	35.4
1816	45.8
1817	41
1818	30.1
1819	23.9

Sunspot numbers by year

1820	15.6
1821	6.6
1822	4
1823	1.8
1824	8.5
1825	16.6
1826	36.3
1827	49.6
1828	64.2
1829	67
1830	70.9
1831	47.8
1832	27.5
1833	8.5
1834	13.2
1835	56.9
1836	121.5
1837	138.3
1838	103.2
1839	85.7

Sunspot numbers by year

1840	64.6
1841	36.7
1842	24.2
1843	10.7
1844	15
1845	40.1
1846	61.5
1847	98.5
1848	124.7
1849	96.3
1850	66.6
1851	64.5
1852	54.1
1853	39
1854	20.6
1855	6.7
1856	4.3
1857	22.7
1858	54.8
1859	93.8

Sunspot numbers by year

1860	95.8
1861	77.2
1862	59.1
1863	44
1864	47
1865	30.5
1866	16.3
1867	7.3
1868	37.6
1869	74
1870	139
1871	111.2
1872	101.6
1873	66.2
1874	44.7
1875	17
1876	11.3
1877	12.4
1878	3.4
1879	6

Sunspot numbers by year

1880	32.3
1881	54.3
1882	59.7
1883	63.7
1884	63.5
1885	52.2
1886	25.4
1887	13.1
1888	6.8
1889	6.3
1890	7.1
1891	35.6
1892	73
1893	85.1
1894	78
1895	64
1896	41.8
1897	26.2
1898	26.7
1899	12.1

Sunspot numbers by year

1900	9.5
1901	2.7
1902	5
1903	24.4
1904	42
1905	63.5
1906	53.8
1907	62
1908	48.5
1909	43.9
1910	18.6
1911	5.7
1912	3.6
1913	1.4
1914	9.6
1915	47.4
1916	57.1
1917	103.9
1918	80.6
1919	63.6

Sunspot numbers by year

1920	37.6
1921	26.1
1922	14.2
1923	5.8
1924	16.7
1925	44.3
1926	63.9
1927	69
1928	77.8
1929	64.9
1930	35.7
1931	21.2
1932	11.1
1933	5.7
1934	8.7
1935	36.1
1936	79.7
1937	114.4
1938	109.6
1939	88.8

Sunspot numbers by year

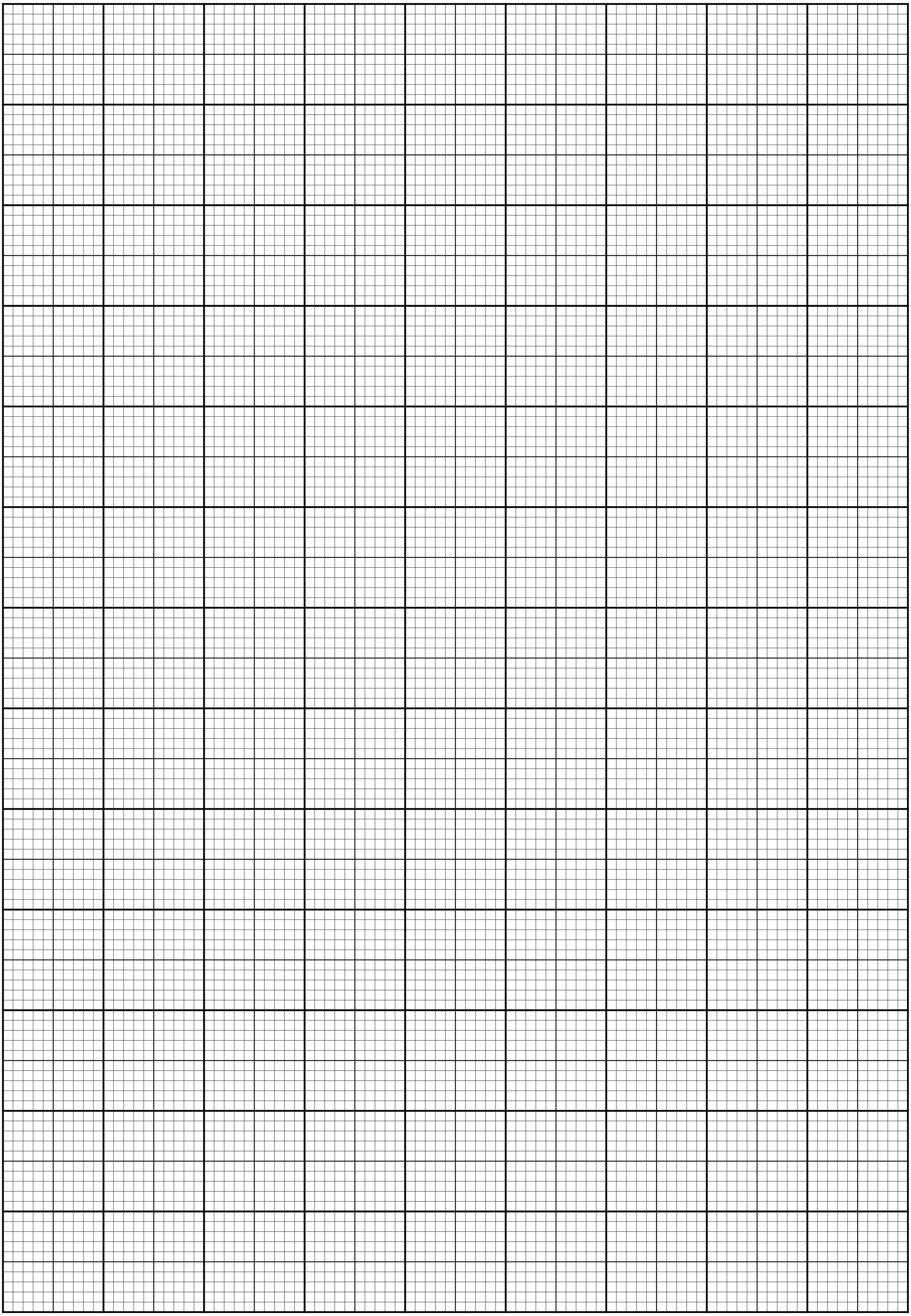
1940	67.8
1941	47.5
1942	30.6
1943	16.3
1944	9.6
1945	33.2
1946	92.6
1947	151.6
1948	136.3
1949	134.7
1950	83.9
1951	69.4
1952	31.5
1953	13.9
1954	4.4
1955	38
1956	141.7
1957	190.2
1958	184.8
1959	159

Sunspot numbers by year

1960	112.3
1961	53.9
1962	37.6
1963	27.9
1964	10.2
1965	15.1
1966	47
1967	93.7
1968	105.9
1969	105.5
1970	104.5
1971	66.6
1972	68.9
1973	38
1974	34.5
1975	15.5
1976	12.6
1977	27.5
1978	92.5
1979	155.4

Sunspot numbers by year

1980	154.6
1981	140.5
1982	115.9
1983	66.6
1984	45.9
1985	17.9
1986	13.4
1987	29.2
1988	100.2
1989	157.6
1990	142.6
1991	145.7
1992	94.3
1993	54.6
1994	29.9
1995	17.5
1996	8.6
1997	21.5
1998	64.3
1999	93.3
2000	119.6
2001	111
2002	104
2003	63.7
2004	40.4
2005	29.8
2006	15.2



Space storms

15th July 2000

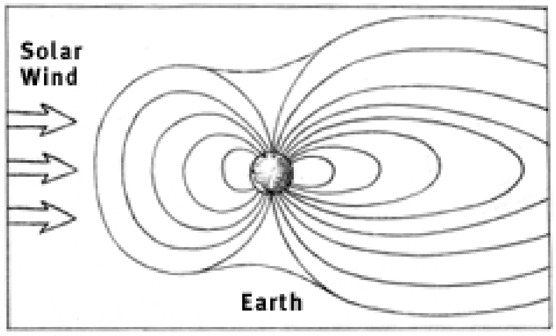
News alert! Millennium space storm approaching Earth!

A space satellite called ACE has made some measurements of the Solar Wind.

Scientists have spotted a fast stream of Solar Wind heading towards Earth. They can use data from the satellite to predict when the fast and dense Solar Wind will reach the Earth.

Fact box

The Solar Wind is a stream of ionised gas (plasma) that travels from the Sun into outer space. The plasma is made of ions and electrons and can travel at over 400 kilometers every second (that's millions of miles an hour!).



Can you help?

When a fast, dense portion of Solar Wind meets the Earth, it squashes the Earth's magnetic field and can cause aurora.

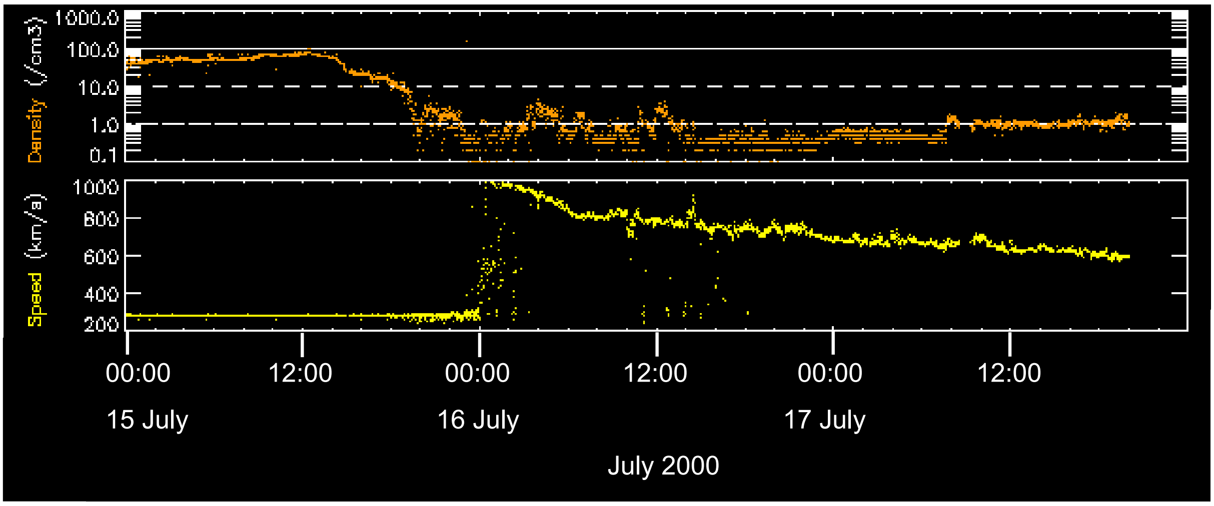
Can you help the scientists to predict what time the fast, dense solar wind will arrive?

Things to find out

- How far from Earth was the ACE satellite on 15 July 2000? (Use website http://son.nasa.gov/tass/magnetosphere/sat_ace.htm to learn about ACE)
- This graph shows the Solar Wind travelling at 2 speeds. What speed does the slow Solar Wind travel at?
- What speed does the fast Solar Wind travel at?
- What time did the Solar Wind change speed?

Plot of the Solar Wind density and speed

Density (orange) is plotted in particles per cm^3 and speed (yellow) is plotted in km/s.



What time do you think the fast Solar Wind will reach the Earth?

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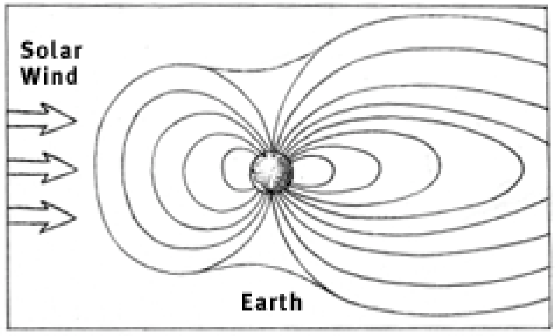

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Things to find out

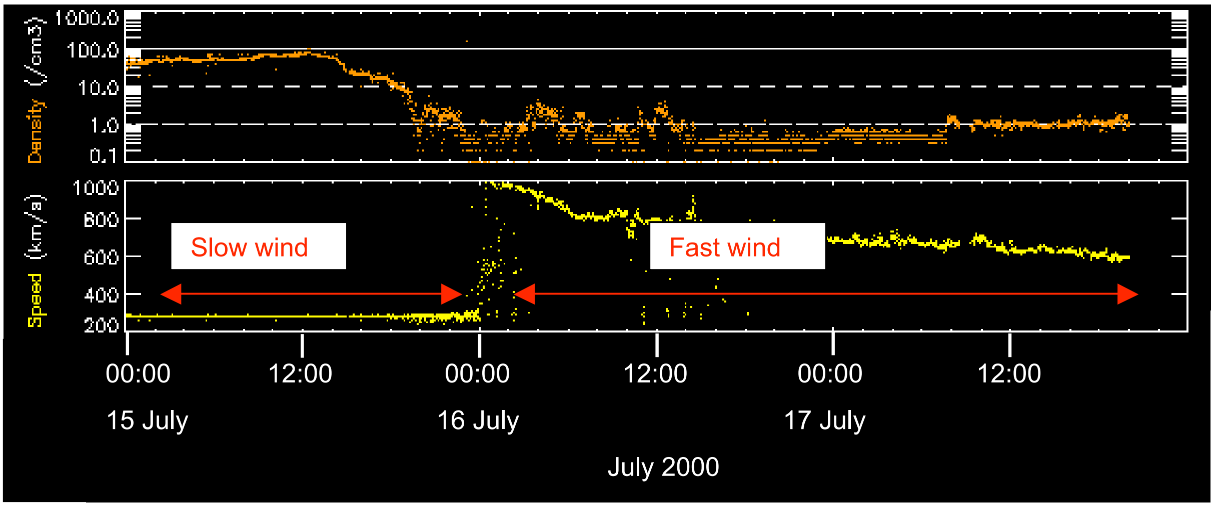
- How far from Earth was the ACE satellite on 15 July 2000? (Use website http://son.nasa.gov/tass/magnetosphere/sat_ace.htm to learn about ACE)

  1.5 million km or 1 million miles

- This graph shows the Solar Wind travelling at 2 speeds. What speed does the slow Solar Wind travel at? 300 km/s
- What speed does the fast Solar Wind travel at? 1000 km/s (or you could take an average speed)
- What time did the Solar Wind change speed? 00:00 on 16 July

Plot of the Solar Wind density and speed

Density (orange) is plotted in particles per cm^3 and speed (yellow) is plotted in km/s.



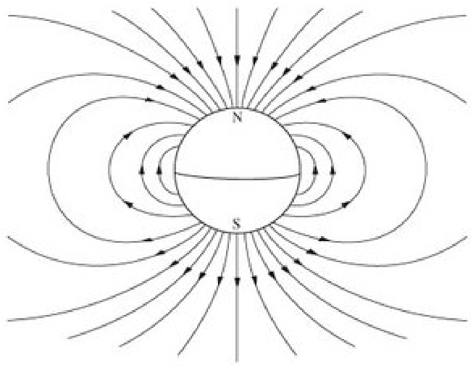
What time do you think the fast Solar Wind will reach the Earth?

Travelling 1.5 million km to Earth at 1000 km/s, the fast wind would arrive around 00:25 am on 16th July 2000.

Spotting magnetic storms

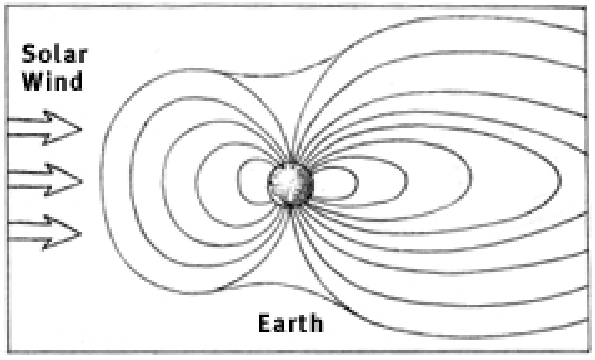
News alert! The Earth’s magnetic field CHANGES SHAPE!

Yes, it’s true. The Earth’s magnetic field doesn’t always look the same. You may have seen a picture of the Earth’s magnetic field looking like this:



But did you know that the Solar Wind, which streams from the sun at 100s of kilometres every second (that’s a million miles per hour), squashes the Earth’s magnetic field, so that it looks like this

:



You can see this happening, if you measure the direction of the magnetic field. If you are very lucky, you might see it changing very dramatically, and that is a sign that an aurora could be happening!

How to make and use your own magnetic storm spotter

The magnetic storm spotter is a very simple piece of equipment. It measures changes of the magnetic field at the Earth's surface.

Equipment

A clear (and clean!) plastic 2-litre pop bottle with its label removed and a plastic lid

Thread

A bar magnet shorter than the width of the bottle

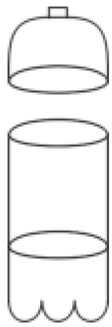
A small craft mirror, mirrored sequin or piece of mirror-card

A piece of card

Rice to stop the bottle falling over

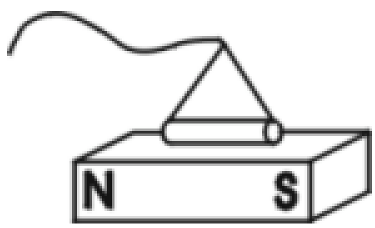
A drinking straw

Sticky tape, scissors, glue and blu-tac



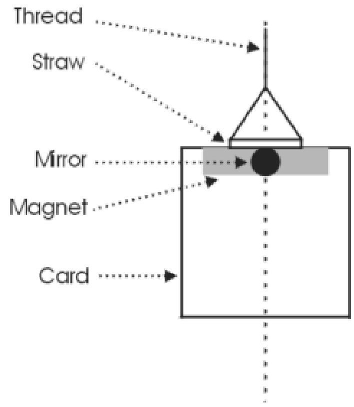
Instructions

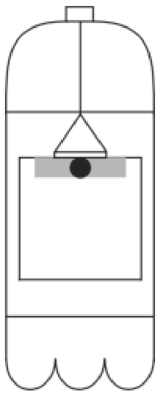
- Carefully cut around the pop bottle to remove the top 1/3.
- Fill approximately the bottom 1/3 of the bottle with sand or rice.



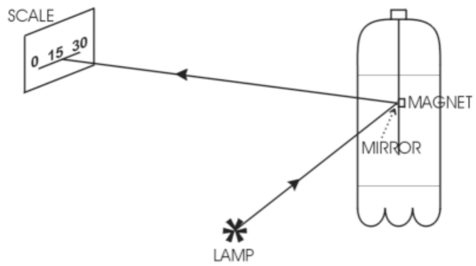
- Cut the straw slightly shorter than the magnet and stick it to the magnet using glue or sticky tape.
- Cut a 50cm length of thread and thread this through the straw.
- Make a triangular loop of this thread keeping the long piece of thread attached to this triangle.

- Cut a rectangular piece of card. It must be able to move freely within the bottle when hanging vertically. Use glue to stick the magnet to the middle of the top edge of this.
- Stick the mirror to the middle of the other side of the magnet. Make sure this is in line with the thread from which the magnet is hanging.
- It is important to make sure that the magnet hangs horizontally. If the magnet isn't quite horizontal stick a small piece of blu-tac to the cardboard to rebalance it.





- Make a small hole in the centre of the bottle top and screw the top back on.
- Feed the thread through the hole and adjust the length of the thread so that it does not scrape on the sand. Also, the mirror should be at least 2cm below the cut edge of the bottle. Secure the thread to the top of the bottle to stop it slipping. Use sticky tape or glue, or tie the thread to a matchstick laying across the hole.
- Tape the top of the bottle to the bottom.



Now you have a magnetometer ready to use!

You now need to reflect a narrow light source off the mirror and onto white card. This should be 1-2m away from the bottle. T the angle between the lamp and the mirror should be between 10 and 20°.

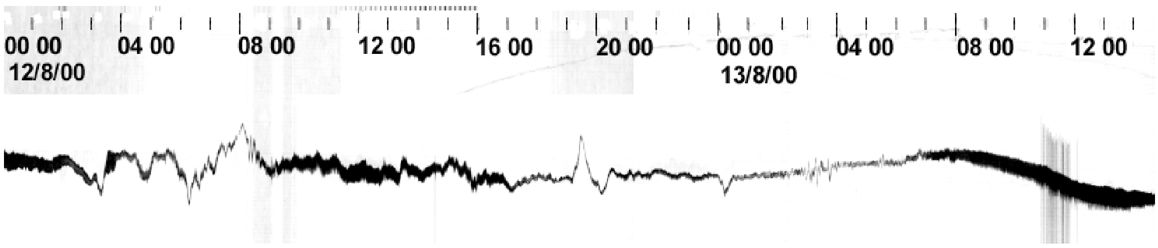
You can mark where you see the light on a scale on the card (or along a metre rule). Mark the position of the light spot every one-two hours. You should see the spot moving during the day. If the spot moves a lot – you may be observing a magnetic storm. **Beware metal objects and trains!**

If you think there might be an aurora, then look north in the sky, and see if you can see any strange lights. Or you could visit Aurorawatch to see if they think there will be an aurora tonight. http://www.dcs.lancs.ac.uk/iono/aurorawatch/

What to look out for

You will find that some days are quiet and some are busy. If you can leave the detector running for a long period of time (tens of hours) then you will start to notice a regular daily cycle which is due to the Earth's rotation causing the detector to go through the squashed (sunward) side and extended (night-time) side of the Earth's magnetic field once a day. You will see that the bottom of the dip in the signal is around midday, when the Sun is directly south, so at this point the Sun switches from being on the east side to being in the west.

On a busy day your results will be all over the place with troughs and peaks. A scanned in version of the plot from a pop-bottle detector is shown below. This plot was made used using a light following plotter called a PhotoDyne.



If you want to see some results from a magnetometer at Lancaster University see http://www.dcs.lancs.ac.uk/iono/aurorawatch/detectors/results.html