October skies

by Bob Riddle

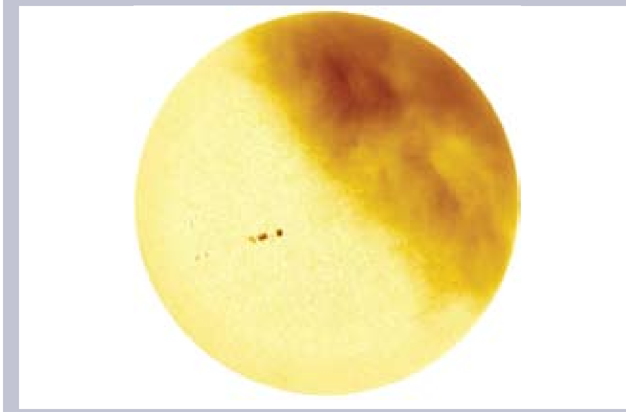
For many years, students and I regularly kept records of our observations of sunspots as we followed the solar cycle from its minimum to its maximum during the last decade. Students made two sketches of the sunspots: one showing the location, and the other showing a more detailed sketch of a sunspot or sunspot group of their choosing. Students would then follow their sunspot daily, as long as possible.

For viewing the Sun, we typically used the projection method where the Sun's image is projected through the eyepiece of a telescope and then focused onto a sheet of white paper fastened to the inside of a cardboard box. This is by far the safest and easiest method for a small group to view the Sun. In addition, there are a variety of commercially available products for safe solar viewing.

By following sunspots, students were able to observe the changes that take place over time in the appearance of a sunspot or group. Students often remark that a sunspot looks like a cell with a dark nucleus, and that when a sunspot splits, it reminds them of cell division (see Sunspot Animation in Resources). Students can also recreate what Galileo did approximately 400 years ago as he observed the Sun and used the motion of sunspots to determine the rotation rate of the Sun. When sunspots from various solar latitudes are used, students will see that the rotation of the Sun is not the same, but varies by latitude. The Sun is not solid, and because of this, sunspots at different latitudes rotate around the Sun at different lengths of time. There are many variations for measuring the rotation rate of the Sun; however, they all involve determining the speed of the sunspot by measuring how far it travels in a given time period. The Solar Rotation Activity provides links to a sequence of daily images of the Sun and the supporting materials to do the activity. Additionally, students may use Galileo's drawings of sunspots for this activity (see Resources for activities and drawings).

At the time of this writing, we are somewhere within the 11-year sunspot cycle during which there should be an increase in the number of sunspots. However, for reasons not fully understood, sunspots have been very infrequent during the current cycle. Perhaps by the time you are reading this, there will be sunspots to observe.

FIGURE 1 Close-up detailed image of a sunspot (10 mm = 10,000 km)



Stars are very hot and burn for a very long time

Our Sun is an incredible fusion machine that has been churning out energy for around the last 5 billion years, and will continue to do so for approximately that same length of time before things start to change. This change occurs somewhere toward the end of the stage of stellar development when the internal temperature of a star begins to change, upsetting a balance between thermal pressure pushing outward, and the force of gravity pushing inward on the star. But that's the end of the story more or less (and material for a future column), not how it all came about.

Our Sun was formed like other stars, as a result of the collapsing of a cloud of dust and gases. As these clouds collapse or contract, the material making up the cloud moves inward, releasing gravitational potential energy in the form of thermal energy, some of which is radiated outward and some that adds to the steadily increasing temperature within the collapsing cloud. At some point, the internal pressure of the collapsing cloud has raised the temperature enough to sustain fusion. At this point, the outward flowing thermal radiation is balanced by the inward push from gravity and the star is at thermal equilibrium—a state of balance whose duration is determined by the star's mass.

The bottom line for a star is its mass, as it is the mass of the material making up a star that determines the life span of that star. As mass increases, the rate at which a star fuses increases, giving a star of high mass less time than a star of lower mass. As long as there is thermal equilibrium, the star fuses at a constant rate, providing a steady and constant release of energy that is equal to the rate of fusion. Slight variations in the rate may occur during the course of a star's lifetime; however, for the most part, these events are self-correcting. For example, if the rate of fusion were to speed up, then the amount of thermal energy released would also increase, causing an imbalance and allowing the star to expand. As the star expands, it cools, lowering the temperature and decreasing the rate of fusion. The opposite would happen if the core were to cool—the rate of fusion would decrease, allowing pressure from gravity to increase, which would cause an increase in temperature that would return the rate of fusion back to what it was prior to the event.

Our Sun, as an average-sized star, has fused through approximately one-half of its life span of approximately 10 billion years, as determined by its mass. It is calculated that every second, the Sun fuses around 600 million tons of hydrogen into 596 million tons of helium. The remaining 4 million tons is released as solar energy in various wavelengths of electromagnetic radiation. In space, the Sun is a white-colored star based on its surface temperature. Viewed from the Earth's surface, the light from the Sun is filtered, in a sense, as some of the wavelengths (blue and violet) are absorbed, causing the Sun to appear yellow. But this is only the part of the spectrum that is visible to our eyes. What about the parts of the electromagnetic spectrum we cannot see? For this, special equipment can be used or software or websites such as the Space Weather Viewer (see Resources).

October

4	Full Moon
6	Mercury at greatest west elongation
8	Mercury near Saturn
9	LCROSS impact with lunar south pole
11	Last quarter Moon
12	Moon near Mars
	Cassini spacecraft flyby of Titan
13	Venus near Saturn
	Moon at perigee: 369,067 km
16	Moon near Venus and Saturn
18	New Moon
25	Moon at apogee: 404,166 km
26	First quarter Moon
	Spring equinox on Mars
27	Moon near Jupiter

Visible planets

Mercury will be visible before sunrise for the first few weeks of the month, and will have a close conjunction with Saturn on October 8.

Venus will be very visible over the eastern horizon before sunrise, and will have a close conjunction with Saturn on October 13.

Mars will rise around midnight and will be visible the rest of the night over the southern horizon.

Jupiter will rise before sunset and will be visible all night, setting before sunrise.

Saturn will be visible over the southeastern horizon at sunrise and will have a conjunction with both inner planets this month.

Questions for students

1. It is said that the Sun will burn for billions of years. What is incorrect about that statement? (The statement is incorrect because the Sun does not really burn, but gives off radiation by a process known as nuclear fusion. To burn is a chemical reaction, involving oxygen to release energy.)
2. When we say that we see sunspots on the Sun's surface, does this mean that there is actually a surface on the Sun? (The Sun is a gaseous mass, and as such has no solid surface. When astronomers refer to the Sun's surface, they are referring to the part of the Sun where the temperature radiates radiation in wavelengths that our eyes can see—the photosphere.)
3. Student research: Use sunspots to determine the rotation rate of the Sun. (See Resources for an activity suggestion.)

Resources

Cassini Mission—*http://saturn.jpl.nasa.gov*

Galileo's sunspot drawings—*http://galileo.rice.edu/sci/observations/sunspot_drawings.html*

International Year of Astronomy—*http://iya09.org*

LCROSS—*www.nasa.gov/lcross*

Solar and Heliospheric Observatory—*http://sohowww.nascom.nasa.gov*

Solar rotation activity— *http://btc.montana.edu/ceres/html/Faces/faces1.html*

Space weather—*www.spaceweather.com*

Space weather viewer—*http://sunearthday.nasa.gov/2009/index.php*

Sunspot animation—*http://ds9.ssl.berkeley.edu/LWS_GEMS/6/secef_2.htm*

Sunspot in detail—*www.ucar.edu/news/releases/2009/sunspots.jsp#mediaterms*

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