

Sunspots

Part I: Sunspots

In this activity we will determine the cause of sunspots. The most defining characteristic of sunspots is that they appear as dark spots on the surface of the Sun.

1) Why do sunspots appear dark?

2) Two students are discussing their answers to question 1.

Student 1: Sunspots are dark because they don't give off any light.

Student 2: I disagree, sunspots give off light, just not as much as the rest of the Sun. It's like trying to see the light from a flashlight being held right next to a search light. The search light drowns out the light from the flashlight.

Do you agree or disagree with either or both of the students? Why?

3) According to the Stefan-Boltzmann law, how does the intensity of light given off by an object relate to its temperature?

What does this tell us about sunspots?

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Part II: The Cause of Sunspots

Figure 1a shows a magnetic field line running from north to south across the Sun. Five points are indicated on the magnetic field line; the one in the middle lies on the equator.

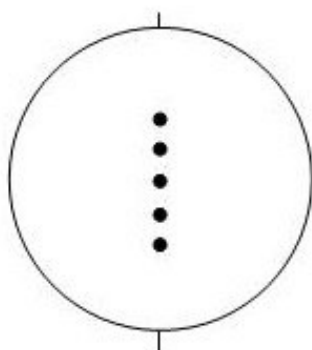


Figure 1a

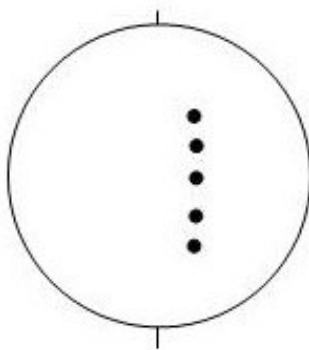


Figure 1b

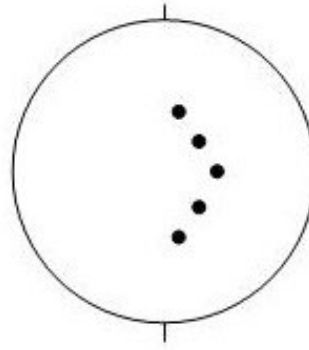


Figure 1c

4) Which of the figures (Fig. 1b or Fig. 1c) accurately depicts the positions of the same five points at a later date? Explain your reasoning.

5) Two students are discussing their answers to question 4.

Student 1: The Sun rotates like a solid object, so the spots should always stay in a straight line. Therefore, I believe that Figure 1b is correct.

Student 2: The Sun is not solid. It is composed mostly of hydrogen gas. Therefore, it doesn't have to rotate like a solid object. I believe that Figure 1c is correct and that the spots will spread out over time.

Do you agree or disagree with either or both of the students? Why?

Magnetic field lines stay tied to the surface due to the presence of charged particles. As the surface moves, the magnetic field lines move with it.

6) Draw in the magnetic field line for Figure 1c (it should intersect the north and south pole of the Sun). Based on the explanation given by student 2, how would this affect the magnetic field lines over the course of time?

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The Sun is a differential rotator. Because it is not solid, different latitudes of the Sun are allowed to rotate at different rates.

- 7) Looking at Figure 1c, compare the rate of rotation at the equator to the rotation rates at higher latitudes (north or south). Which rotates faster? Explain your reasoning.

As the Sun rotates, the magnetic field lines get pulled along with the surface. Over time, this causes the magnetic field lines to become wrapped around the Sun tighter and tighter. As they become more tightly wound, the magnetic field lines begin “popping” out of the surface of the Sun. Where the magnetic field lines cross the surface of the Sun, sunspots are formed.

Figure 2a depicts a profile view of the surface of the Sun, with a magnetic field line extending out of it. Figure 2b depicts the Sun at a point when its magnetic field is tightly wound about it. In some instances, you can see the magnetic field extending out of the surface of the Sun.

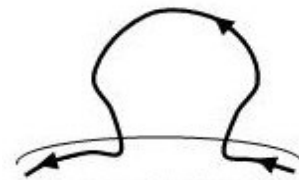


Figure 2a



Figure 2b

- 8) Indicate the position(s) of any sunspots that would appear at this instance.

- 9) The direction of the magnetic field lines are indicated by arrows. For each sunspot, indicate whether the magnetic field running through it is pointing up out of the surface, or pointing down into the surface.

- 10) If this figure is typical of the creation of sunspots in general, do we ever expect to find a single sunspot all by itself? Explain your reasoning.

