Aurora on Other Planets?

Objectives

This activity is designed to allow students to understand that there are common phenomena that unify our study of the planets. They will discover that if certain minimum conditions are met, then the same thing will occur regardless of the planet. At the conclusion of this activity, they will be able to:

1. Describe the requirements for a planet to have an aurora.
2. Use these requirements and planetary data to predict which planets or moons will show an aurora.
3. Discuss a special case involving the planet Venus and what makes it unique.

With our study of the aurora here on Earth, a natural question is whether aurora exist on other planets or even moons of our solar system. In this activity students will brainstorm just what planetary characteristics are essential for creating aurora. They will then analyze data from the solar system and find likely candidates for aurora. Students can search for images of extraterrestrial aurora and discuss the curious case of Venus.

Preparation

Prepare copies of the planetary data tables for the students, or make an overhead transparency for the whole class to see. [Master on page 4.] If you plan on including the section on searching for extraterrestrial auroral images, you should make arrangements for computers with Internet access to be accessed by the students.

Materials

- **Planetary data tables: one for each pair of students and/or one overhead transparency for the whole class. [Master on page 4.]**

In Class

1. What are the Ingredients for Making an Aurora?

Brainstorm with your students the requirements for making aurora. The list should include a solar wind of charged particles, a magnetic field, and an atmosphere. For older students a brief discussion of what causes a magnetic field can also be a good learning experience. Planetary magnetic fields are caused by the slightly different rotation of different layers of a planet as well as effects of molten cores. At least one of these layers must be a conducting liquid or gas. In general, the faster a planet rotates, the stronger the magnetic field, but there are exceptions to this rule, depending on internal dynamics of the body. The Earth has a magnetic field because there are currents flowing in the conducting liquid of the Earth's outer core. If a terrestrial planet rotates and shows a magnetic field, this is one means by which astronomers infer that it has a molten interior.

2. Predicting Aurora: Which Planets or Moons?

With a table of planetary characteristic and our previous discussion of requirements for an aurora, compile a list of possible places to look for aurora throughout the solar system.

Make the planetary data table available to the students, either as handouts or overhead transparency. Ask them to predict which planets or moons would be likely to have aurora. The students' predictions should include all the gas giants. For older students you may like to point out the relationship between the rapid rotation rates and strong magnetic fields of the gas giants.

Planet Data

Planet or Major Satellite	Radius (km)	Atmospheric Composition	Rotation Rate (Days)	Magnetic Field
Mercury	2,440	None	58.6	Weak
Venus	6,052	Carbon Dioxide	243**	Negligible
Earth	6,371	Nitrogen/Oxygen	1.0	Moderate
Moon	1,737	None	27.0	Negligible
Mars	3,390	Carbon Dioxide	1.0	Negligible
Jupiter	69,911	Hydrogen/Helium	0.4	Extremely Strong
Io	1,821	Sulfur Dioxide	1.8	Weak
Europa	1,565	Oxygen (Very Thin)	3.5	Weak
Ganymede	2,634	Oxygen (Very Thin)	7.1	Weak
Callisto	2,403	Oxygen (Very Thin)	16.7	Weak
Saturn	58,232	Hydrogen/Helium	0.4	Extremely Strong
Titan	2,575	Nitrogen/Methane	16.0	Negligible
Uranus	25,362	Hydrogen/Helium	0.7	Strong
Neptune	24,624	Hydrogen/Helium	0.7	Strong
Triton	1,352	Nitrogen/Methane	5.9	Negligible
Pluto	24,624	None	6.4	Negligible

**Venus Rotation is RETROGRADE, or backwards compared to other planets.

3. Solar System Aurora Hunt.

Now that you have your predictions about which planets and/or moons have the correct conditions to generate aurora, it is time to research if scientists have found evidence to support your predictions.

Using the available resources, try to find evidence through images or written reports to support or reject your hypotheses.

This portion can be optional depending on your access to computers and the Internet. A good place to begin an Internet search is at www.nasa.gov. If this part of the activity is difficult due to lack of facilities, another option is to find some images of aurora on planets such as Jupiter and Saturn, and discuss these images with your students. In addition, aurorae have been photographed on the Jovian moons Io and Ganymede.

If you have found some images of the aurora on other planets, can you share some common features these aurora share with the aurora from here on Earth?

Responses should indicate that satellite imagery of the aurora on other planets shows the aurora is located near the poles of the planet and that it forms a ring, similar to the form it takes here on Earth.

4. The Case of the Ashen Light of Venus

From your investigations, it should be clear that we should not expect to see an aurora on the planet Venus. Venus doesn't have a magnetic field, partially because of its very slow rotation rate. Yet, there is something mysterious going on with Venus. In 1643, Giovanni Riccioli reported seeing a mysterious glow on the night side of Venus. Since then, there have been many reports of such a glow on the night side of Venus. Amateur astronomers report most of these observations, but professional astronomers have corroborated some of them. So what could cause such a glow?

One idea is intense lightning discharges, but the recent flyby of Venus by the Cassini spacecraft seems to rule this out. Another possibility is that it could be something akin to the aurora here on Earth. Spacecraft have noted an emission of light similar to the emission of auroral light caused by oxygen. Could it be that Venus has its own, unique type of aurora? In this case it would not be an auroral ring caused by the concentration of solar wind particles near the magnetic poles, but a more diffuse glow as these particles are spread out through the atmosphere. There is some limited evidence that this ashen glow is more intense during higher levels of solar activity. Some difficulties with this explanation are that these glows require oxygen, which Venus does not have in a free form in its atmosphere. Also, the light is seen on the night side of Venus, and we have to explain how the solar particles reach the "back side" of Venus.

What do you think?

Students may have some ideas to express on this subject. Some possible explanations are that the oxygen needed is formed in small quantities by solar energy interacting with the atmosphere on the day side, and then is slowly recombined on the night side. The particles can be shunted to the night side by a weak magnetic charge Venus picks up from the sun. This is comparable to the weak magnetism a nail picks up when rubbed against a magnet.

Going Further

1. Discuss how scientists use the Earth as a model to look for evidence of other processes that occur on other planets. By comparing how a volcano looks on Earth, we can understand that Olympus Mons on Mars is a shield volcano similar to the volcanoes of the Hawaiian Islands. Other phenomena that can be found on Earth as well as other planets or moons include storms, craters, ice flows, geysers, and the greenhouse effect.
2. Make a simple paper model of the magnetic field (magnetosphere) around the Earth. The template for this model can be found at:

   http://www-spof.gsfc.nasa.gov/Education/Intro.html

   as well as a good summary of how magnetic fields around planets are formed as well as the history of the science of magnetic fields.
3. Have students research the Ashen Light in more detail and write a position paper giving their reasons whether they believe it is a real phenomenon or just a figment of the imagination of telescope observers.

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