11.E: The Giant Planets (Exercises)

For Further Exploration

Articles

Jupiter

Aguirre, Edwin. “Hubble Zooms in on Jupiter’s New Red Spot.” *Sky & Telescope* (August 2006): 26.

Beatty, J. “Into the Giant.” *Sky & Telescope* (April 1996): 20. On the Galileo probe.

Beebe, R. “Queen of the Giant Storms.” *Sky & Telescope* (October 1990): 359. Excellent review of the Red Spot.

Johnson, T. “The Galileo Mission to Jupiter and Its Moons.” *Scientific American* (February 2000): 40. Results about Jupiter, Io, Ganymede, and Callisto.

Simon, A. “The Not-So-Great Red Spot.” *Sky & Telescope* (March 2016): 18. On how the huge storm on Jupiter is evolving with time.

Smith, B. “Voyage of the Century.” *National Geographic* (August 1990): 48. Beautiful summary of the Voyager mission to all four outer planets.

Stern, S. “Jupiter Up Close and Personal.” *Astronomy* (August 2007): 28. On the New Horizons mission flyby in February 2007.

Saturn

Gore, R. “The Riddle of the Rings.” *National Geographic* (July 1981): 3. Colorful report on the Voyager mission.

McEwen, A. “Cassini Unveils Saturn.” *Astronomy* (July 2006): 30. A report on the first two years of discoveries in the Saturn system.

Spilker, L. “Saturn Revolution.” *Astronomy* (October 2008): 34. On results from the Cassini mission.

Talcott, R. “Saturn’s Sweet Surprises.” *Astronomy* (June 2007): 52. On Cassini mission results.

Uranus and Neptune

Cowling, T. “Big Blue: The Twin Worlds of Uranus and Neptune.” *Astronomy* (October 1990): 42. Nice, long review of the two planets.

Gore, R. “Neptune: Voyager’s Last Picture Show.” *National Geographic* (August 1990): 35.

Lunine, J. “Neptune at 150.” *Sky & Telescope* (September 1996): 38. Nice review.

Websites

Jupiter

NASA Solar System Exploration: http://Solarsystem.nasa.gov/planets/jupiter

Nine Planets Site: http://nineplanets.org/jupiter.html

Planetary Sciences Site: http://nssdc.gsfc.nasa.gov/planetary...piterpage.html

Saturn

NASA Solar System Exploration: http://Solarsystem.nasa.gov/planets/saturn

Nine Planets Site: http://nineplanets.org/saturn.html

Planetary Sciences Site: http://nssdc.gsfc.nasa.gov/planetary...aturnpage.html

Uranus

NASA Solar System Exploration: http://Solarsystem.nasa.gov/planets/uranus

Nine Planets Site: http://nineplanets.org/uranus.html

Planetary Sciences Site: http://nssdc.gsfc.nasa.gov/planetary...ranuspage.html

Neptune

NASA Solar System Exploration: http://Solarsystem.nasa.gov/planets/neptune

Nine Planets Site: http://nineplanets.org/neptune.html

Planetary Sciences Site: http://nssdc.gsfc.nasa.gov/planetary...ptunepage.html

Missions

Cassini Mission Site at the Jet Propulsion Lab: http://saturn.jpl.nasa.gov/index.cfm

Cassini-Huygens Mission Site at European Space Agency: http://sci.esa.int/cassini-huygens/

NASA Galileo Mission Site: http://Solarsystem.nasa.gov/galileo/

NASA's Juno Mission to Jupiter: http://www.nasa.gov/mission_pages/ju...ain/index.html

Voyager Mission Site at the Jet Propulsion Lab: http://voyager.jpl.nasa.gov/

Videos

Cassini: 15 Years of Exploration: https://www.youtube.com/watch?v=2z8fzz_MBAw. Quick visual summary of mission highlights (2:29).

In the Land of Enchantment: The Epic Story of the Cassini Mission to Saturn: https://www.youtube.com/watch?v=Vx135n8VFxY. An inspiring illustrated lecture by Cassini Mission Imagining Lead Scientist Carolyn Porco (1:37:52).

Jupiter: The Largest Planet: http://www.youtube.com/watch?v=s56pxa9lpvo. Produced by NASA's Goddard Space Flight Center and Science on a Sphere (7:29).

Collaborative Group Activities

1. A new member of Congress has asked your group to investigate why the Galileo probe launched into the Jupiter atmosphere in 1995 survived only 57 minutes and whether this was an example of a terrible scandal. Make a list of all the reasons the probe did not last longer, and why it was not made more durable. (Remember that the probe had to hitch a ride to Jupiter!)
2. Select one of the jovian planets and organize your group to write a script for an evening news weather report for the planet you chose. Be sure you specify roughly how high in the atmosphere the region lies for which you are giving the report.
3. What does your group think should be the next step to learn more about the giant planets? Put cost considerations aside for a moment: What kind of mission would you recommend to NASA to learn more about these giant worlds? Which world or worlds should get the highest priority and why?
4. Suppose that an extremely dedicated (and slightly crazy) astronomer volunteers to become a human probe into Jupiter (and somehow manages to survive the trip through Jupiter's magnetosphere alive). As she enters the upper atmosphere of Jupiter, would she fall faster or slower than she would fall doing the same suicidal jump into the atmosphere of solid Earth? Groups that have some algebra background could even calculate the force she would feel compared to the force on Earth. (Bonus question: If she were in a capsule, falling into Jupiter feet first, and the floor of the capsule had a scale, what would the scale show as her weight compared to her weight on Earth?)
5. Would you or anyone in your group volunteer for a one-way, life-long mission to a space station orbiting any of the gas giants without ever being able to return to Earth? What are the challenges of such a mission? Should we leave all exploration of the outer solar system to unmanned space probes?

Review Questions

1. What are the main challenges involved in sending probes to the giant planets?
2. Why is it difficult to drop a probe like Galileo? How did engineers solve this problem?
3. Explain why visual observation of the gas giants is not sufficient to determine their rotation periods, and what evidence was used to deduce the correct periods.
4. What are the seasons like on Jupiter?
5. What is the consequence of Uranus' spin axis being 98° away from perpendicular to its orbital plane?
6. Describe the seasons on the planet Uranus.
7. At the pressures in Jupiter's interior, describe the physical state of the hydrogen found there.
8. Which of the gas giants has the largest icy/rocky core compared to its overall size?
9. In the context of the giant planets and the conditions in their interiors, what is meant by "rock" and "ice"?
10. What is the primary source of Jupiter's internal heat?

11. Describe the interior heat source of Saturn.
12. Which planet has the strongest magnetic field, and hence the largest magnetosphere? What is its source?
13. What are the visible clouds on the four giant planets composed of, and why are they different from each other?
14. Compare the atmospheric circulation (weather) of the four giant planets.
15. What are the main atmospheric heat sources of each of the giant planets?
16. Why do the upper levels of Neptune's atmosphere appear blue?
17. How do storms on Jupiter differ from storm systems on Earth?

Thought Questions

1. Describe the differences in the chemical makeup of the inner and outer parts of the solar system. What is the relationship between what the planets are made of and the temperature where they formed?
2. How did the giant planets grow to be so large?
3. Jupiter is denser than water, yet composed for the most part of two light gases, hydrogen and helium. What makes Jupiter as dense as it is?
4. Would you expect to find free oxygen gas in the atmospheres of the giant planets? Why or why not?
5. Why would a tourist brochure (of the future) describing the most dramatic natural sights of the giant planets have to be revised more often than one for the terrestrial planets?
6. The water clouds believed to be present on Jupiter and Saturn exist at temperatures and pressures similar to those in the clouds of the terrestrial atmosphere. What would it be like to visit such a location on Jupiter or Saturn? In what ways would the environment differ from that in the clouds of Earth?
7. Describe the different processes that lead to substantial internal heat sources for Jupiter and Saturn. Since these two objects generate much of their energy internally, should they be called stars instead of planets? Justify your answer.
8. Research the Galileo mission. What technical problems occurred between the mission launch and the arrival of the craft in Jupiter's system, and how did the mission engineers deal with them? (Good sources of information include *Astronomy* and *Sky & Telescope* articles, plus the mission website.)

Figuring for Yourself

1. How many times more pressure exists in the interior of Jupiter compared to that of Earth?
2. Calculate the wind speed at the edge of Neptune's Great Dark Spot, which was 10,000 km in diameter and rotated in 17 d.
3. Calculate how many Earths would fit into the volumes of Saturn, Uranus, and Neptune.
4. As the Voyager spacecraft penetrated into the outer solar system, the illumination from the Sun declined. Relative to the situation at Earth, how bright is the sunlight at each of the jovian planets?
5. The ions in the inner parts of Jupiter's magnetosphere rotate with the same period as Jupiter. Calculate how fast they are moving at the orbit of Jupiter's moon Io (see Appendix G). Will these ions strike Io from behind or in front as it moves about Jupiter?