THE UNIVERSE IN THE CLASSROOM

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Special Issue: Seeing in the Dark

Seeing in the Dark, a dramatic new PBS special by award-winning journalist and author Timothy Ferris, premieres at 8 p.m. September 19th on most PBS stations (check local listings for exact dates and times.) It explores the delights and rewards of amateur astronomy and chronicles the contributions that amateurs are making to the science and art of astronomy. The program was produced in state-of-the-art high definition and features many great images and animations that you and your students are likely to enjoy.

The Astronomical Society of the Pacific has been working with Timothy Ferris to provide educational materials for the interactive web site accompanying the show (see below) and to let educators know about the program and the educational opportunities that go with it. We thus devote this special issue of *The Universe in the Classroom* to *Seeing in the Dark*. We hope you enjoy the materials from and about the show, and encourage you to write to us if you find interesting ways to use it in your classroom.

Image credit: Francis Kenny

A conversation with the filmmaker, Timothy Ferris

An award-winning author, journalist, filmmaker, and an avid amateur astronomer for more than 50 years, Ferris has presented two other PBS specials—*The Creation of the Universe* and *Life Beyond Earth*.

Seeing in the Dark filmmaker Timothy Ferris

Image credit: Mark Andrews

Q: Why do humans gaze at the stars and take up amateur astronomy?

TF: I think it's healthy for people to understand their wider environment. The world's a lot less troubling when you understand the systems that it's part of, in the huge scope of space and time in which human life exists. People ask, "Doesn't this make you feel insignificant, that everything out there is so big?" But I really think the reverse is true, that

one feels much better about the human condition when one understands it in its natural context. That context extends out through the stars and the wider universe. It's all nature, and it's always good for the mind and heart to understand nature and our place in nature. That's what stargazing is all about.

Q: What inspired you to put so much effort and thought into producing *Seeing in the Dark*?

TF: Stargazing's a beautiful subject. I don't know any sight in nature that's more inspiring than a dark, star-filled night sky, and I wanted to make a film that would do justice to the aesthetics of stargazing. I don't believe it's ever been done. We had to enlist a lot of technical leverage to try to give you something of the feeling of being out there. One of my ambitions, from early on in the film, was to create scenes in which the sights, sounds and ambiance would give you a sense of what it's like to be out stargazing at night.

Q: Is astronomy accessible to the general population?

TF: One of the great things about stargazing is that it's immediately at hand for so many people. The stars are always up there. Even from a light-polluted location, using a little effort with binoculars or a small telescope, there's usually something you can see—even if it's only the rings of Saturn or the moons of Jupiter. And kids can get into it. You can enjoy stargazing just by going out and learning a couple constellations with your kids. It is a genuinely infinite subject in which there is no limit to how much one can learn.

Q: How far, on a clear night, can you see out into space?

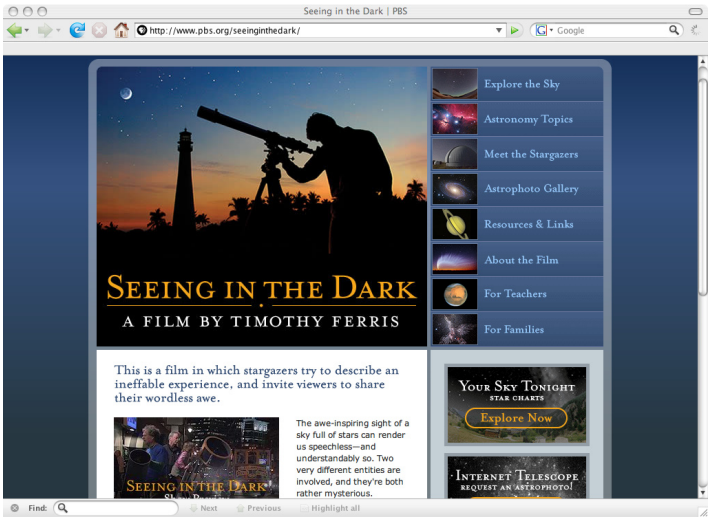
TF: On a clear night, you can see pretty much forever. You can see quasars five billion light years away; that's light that's older than the Earth. It's easy to image and also to see galaxies that are hundreds of millions of light years away. To get from the middle of a city—from Times Square in Manhattan to a site that's dark enough that you can have a lot of fun and see stuff with a small telescope—is often less than an hour's drive. So it is possible to get out there, and there's tremendous happiness and satisfaction in taking advantage of this fact and having a look at nature on the big scale.

The *Seeing in the Dark* Web Site

Accompanying the show is a new interactive web site which can be found at: http://www.pbs.org/seeinginthedark/

Among the many things you can do at the web site are:

1. view or print "Your Sky Tonight", a chart of any part of the sky, showing planets, stars, and deep space objects, as seen from any location and time you wish to set



The *Seeing in the Dark* interactive website

2. watch introductory "how-to-videos" with Timothy Ferris on getting started with the hobby of astronomy

3. take a photo of any object in the northern sky using the *Seeing in the Dark* Internet Telescope and have it sent to you by e-mail (restricted to students)

4. read more about the astronomers featured in the show and get basic background information about the astronomy it covers (including such topics as planets around other stars, the exploration of Mars, and how light serves as a cosmic time machine) [One of these essays, on Saturn, is reprinted below in this issue.]

5. explore a series of class-room tested, hands-on activities for students in grades 2 through 12, ready for teachers to use

6. browse through a gallery of beautiful color images of the cosmos, taken by the astronomical photographers who contributed to the show

7. find a star whose light left on its journey toward us in the year you were born [see the activity section of this issue]

8. discover some fun projects and games for families who want to do astronomy together (both indoors and outdoors)

9. watch the amazing special effects videos from *Seeing in the Dark* on your computer

10. browse through links to some of the best web sites for learning more about astronomy, and finding an astronomy club near you.

(The web site was made possible through generous support from the National Science Foundation.)

Saturn and Its Rings

By Andrew Fraknoi

This is one of several essays available on the Seeing in the Dark *website*.

Perhaps the most imposing sight you can see through a telescope is the planet Saturn, with its magnificent system of rings. Many dedicated amateur astronomers say they were turned on to stargazing by seeing Saturn through a telescope. And Saturn is impressive in more ways than just its looks.

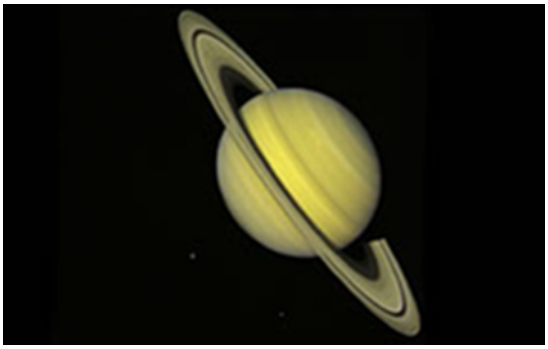
One of the giant planets in the outer solar system, Saturn contains enough material to build 95 Earths. Its diameter is 75,000 miles—large enough to fit more than nine Earths across it. Yet for all its bulk, Saturn is a lightweight planet. Made mostly of the simplest gases in the universe, its average density is less than that of water—so if you had a bathtub big enough, Saturn would float in it.

The giant planet takes only about 10 hours to spin once—a day less than half of our much smaller Earth's. This rapid spin plus heat rising from its interior create powerful and complex weather systems in Saturn's atmosphere. The storms get particularly intense every 30 years—one Saturnian year—when summer comes to the ringed planet's northern hemisphere. In 1990, the largest of the season's storms could be seen even with modest telescopes. It was amateur astronomers who first alerted professional scientists that a huge storm was brewing. It eventually spread to encircle the Saturn globe.

These days, a sophisticated spacecraft called Cassini is conducting close-up observations of the Saturn system, orbiting the planet and recording images and data about the atmosphere, the rings, and Saturn's moons. You can see some of the pictures it is sending back at: saturn.jpl.nasa.gov/multimedia/images/index.cfm

Saturn has a swarm of moons that interact with the rings. As of mid-2007, 59 moons had been identified, most of them relatively small. One moon, however, called Titan, is the second largest in the solar system, and bigger than Mercury, Eris, and Pluto. It has a smoggy atmosphere and rivers of liquid swamp gas (methane) appear to flow on its cold surface. Bright and rather ruddy looking, Titan can be readily discerned out beyond the rings; it looks like a star in smaller telescopes, while larger ones show it is a disc.

Saturn's rings are made up of billions of icy pieces, organized by their mutual gravity and the interfering gravity of nearby moons into thousands of strands and ringlets. The ring particles range in size from smoke particles to the bulk of a small truck. Occasionally, an especially strong interaction between a moon and the ring particles will produce a noticeable gap in the rings; some of the gaps appear in the pictures on this page. When the edge of a ring or gap is especially sharp, there is a good chance that a shepherd moon is responsible. Just as shepherds and shepherd dogs keep flocks of sheep from straying, shepherd moons keep ring particles from moving away from the orbit they mark out, leaving a clear ring edge in their wake.



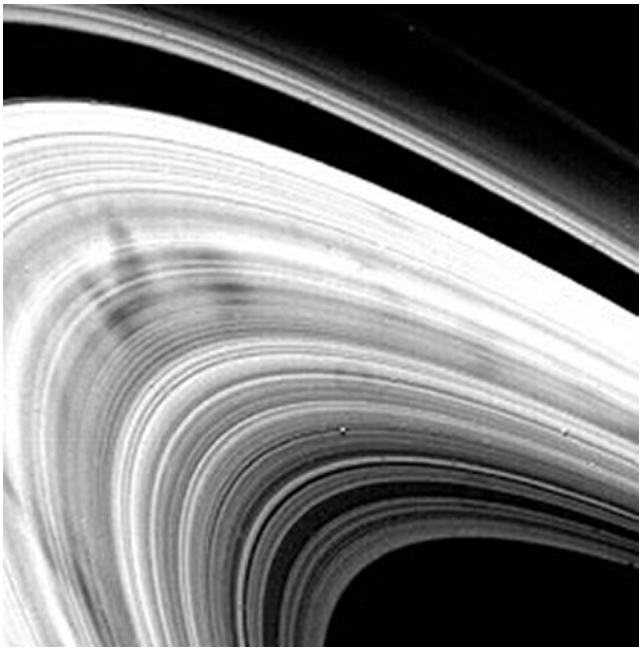
Voyager 2 true-color picture of Saturn, taken on July 21, 1981, 21 million miles away.

Image credit: JPL/NASA

As described on *Seeing in the Dark*, in the mid-1970s, Stephen O'Meara, a young amateur astronomer with phenomenal observing skills, noticed dark radial features on the rings of Saturn that reminded him of spokes in a bicycle wheel. Although they had been spotted by a few earlier observers, the consensus was that they had to be optical illusions. Scientists reasoned as follows: Every chunk of ice in the rings orbits Saturn at its own rate, with inner bodies—which, being closer to Saturn, experience a stronger force of gravity—moving faster than the outer ones. If you flew a spaceship over the rings and painted a radial line across them, the inner part of the line would move ahead while the outer part lagged behind, and the line would quickly disappear. So O'Meara was unable to get his drawings of the spokes published. Nobody took them seriously.

Then, in 1979, the Voyager 1 spacecraft flew by Saturn and took close-up pictures of its rings with unprecedented detail. Clearly visible on some of the pictures were long straight spokes across the rings, much like the ones O'Meara had sketched.

No one fully understands the reason these spokes exist, but the fact that they do NOT drift apart means they must be connected with the spin of Saturn and not with the motion of the many ring chunks. One theory, mentioned in the film, is that Saturn's magnetic field captures any small pieces of icy dust that have an electric charge and levitates them above the rings while stringing them out into straight marks that trace lines in the magnetic field. Magnetically lifted above the main rings, such particles respond to the rotation rate of Saturn's magnetic field rather than of the rings themselves.



Voyager 2 image of the spokes in Saturn's B Ring

Image credit: JPL/NASA

The evidence suggests that spokes appear mainly during certain seasons of the long Saturn year, perhaps in response to the changing angle at which sunlight hits the rings. This may explain why the Cassini space probe, unlike Voyager, found only a few, dim spokes. The facts are hard to pin down, but what is clear is that the patient observations of a young amateur astronomer helped generate an intriguing new branch of Saturn ring science, and that the Lord of the Rings is very likely nowhere near finished spinning puzzles for Earth's observers.

On the *Seeing in the Dark* website, you can read more essays like this one, as well as see special effects videos of Saturn and other astronomical objects.

Classroom Activity: Birthday Stars

When astronomers look out into space, they are also looking back in time. Because the speed of light is only VERY fast (but not infinite), it takes a while for the light from the stars to get to us. The farther away a star is, the longer the journey that its light must make on its way to Earth.

The units astronomers use make calculating this "light delay time" rather easy. A *light year* is defined as the distance light travels in one year. So, if a star is 15 light years away, its light takes 15 years to reach us. That means the light we see tonight left that star 15 years ago, before any of our elementary school or middle-school students were even born. Read more about light as a cosmic time machine on the *Seeing in the Dark* website.

Students, once they understand the concept of light years and light delays, often wonder if there is a star whose light takes exactly the same time to reach us as their current age. For *Seeing in the Dark*, Timothy Ferris put together a list of stars visible from the Northern Hemisphere for a wide range of ages. You can find the listing at: http://www.pbs.org/seeinginthedark/explore-the-sky/birthday-stars.html

An interesting activity would be to get your students to:

1. find the star that corresponds to their ages;

2. find out more about that star, using some of the references recommended on the web site or other sources in the library or on the Web;

3. find another star at the same distance, if possible.

An add-on activity might ask them to research what was happening on Earth in the year they were born and the light of the stars they selected first left.

You can find many more activities like this one on the *Seeing in the Dark* website.

***Seeing in the Dark* premieres on Wednesday, September 19 on PBS stations around the United States. Most stations will show the film at 8 p.m., but check your local listings for the exact time and date.**