The Leonids are Coming! The Leonids are Coming!

A memorable light show or just a bracing shower?

By RON COWEN

Eric Young

Modern drawing of what the 1883 meteor strorm may have looked like to the Sioux tribe in North Dakota.

The night of Nov. 12, 1833, might as well have been July 4. The skies over the United States were ablaze with bursts of light surpassing the most extravagant display of fireworks.

It was, one eyewitness said, as if "a tempest of falling stars broke over the Earth. . . . The sky was scored in every direction with shining trails and illuminated with majestic fireballs." Even some souls asleep in their beds were awakened by the silent light show streaking through their windows—an unusually intense display of shooting stars called the Leonid meteor storm.

Every year in mid-November, Earth encounters the Leonid storm, so named because it was thought to come from the constellation Leo. In fact, this storm originates from a tenuous stream of dusty debris expelled by Comet 55P/ Tempel-Tuttle during centuries of passes near the sun. These particles, known as meteoroids, spread out along the comet's orbit.

As the meteoroids from this comet or others burn up in Earth's atmosphere, some 100 streaks of light an hour may grace the skies. Such events, known as meteor showers, are common; our planet travels through about 12 a year, each from a meteoroid stream spewed by a different comet.

A more intense downpour, strong enough to qualify as a meteor storm, is rarer. A Leonid storm occurs roughly every 33 years, when the planet passes through a dense trail of debris that lies close to the comet (SN: 6/14/97, p. 371).

Chinese astronomers reported seeing the first storm in 902 A.D. The last one, in 1966, rivaled the spectacle of 1833 and was so intense that viewers likened the profusion of shooting stars to snowflakes in a snowstorm. This November 17, and perhaps the same time next year, the planet will once again plunge into a dense concentration of the Leonid stream.

Earth will pass three times farther from the comet than it did during the 1966 blockbuster. It's not known whether this year's passage will generate a mild storm, with thousands of shooting stars an hour, or just an intensified shower, with the streaks of light appearing at perhaps one-tenth to one-hundredth that rate.

Either way, East Asia is the prime location for witnessing the peak of the encounter, predicted to occur about 2:20 p.m. eastern standard time on Nov. 17 and to last at most a few hours. While it will be a moonless night in East Asia, daylight will render even the most intense fireworks invisible in North America. Sky watchers in the United States, however, might still be treated to a better-than-average spectacle in the wee hours of the morning on both Nov. 17 and Nov. 18, says Brian G. Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. (see sidebar).

There's a good chance the light show in 1999 will be at least as lavish as the one this year, says Peter Brown of the University of Western Ontario in London, Ontario. After that, thanks to Jupiter's tug on Tempel-Tuttle, the comet won't get close to Earth for another century.

That's one reason why Brown and his colleagues are setting up shop next month in Australia and in the Gobi desert in Mongolia. By bouncing radar beams off the meteoroids and using optical TV monitors to track the streaks of light that the particles produce, the researchers hope to gauge accurately the number of meteoroids striking Earth's atmosphere and to test how well computer models have predicted the intensity of the event.

A close encounter between Earth and Tempel-Tuttle happens to occur just before or just after the icy comet passes closest to the sun's warming rays, forcing the comet to vent fresh debris. Because it takes time for the meteoroids to drift away from the comet, most of the debris encountered by Earth is in fact composed of material spewed by the comet during previous passes.

A. Scott Murrell/New Mexico State Observatory

The Leonid meteor shower, photographed on Nov. 17, 1966.

The models developed by Brown and his colleagues, in which they simulate the release of debris from Tempel-Tuttle and track its path over several hundred years, suggest that the material Earth will plow through this year comes from dust expelled by the comet in 1899 and 1932. The team also finds that the 1999 event, best visible from western Europe, might be about 50 percent stronger than the one this November.

In contrast, Donald K. Yeomans of NASA's Jet Propulsion Laboratory in Pasadena, Calif., and his collaborators used a historical approach to predict that the Leonids will be equally intense this year and next.

"We looked at all the showers from 902 A.D. through 1966 and asked, When were major storms witnessed?" says Yeomans. Factoring in such information as the proximity of the comet to Earth during a storm and the time lag between the comet's closest approach to the sun and the occurrence of a downpour, the team predicts that the events of 1998 and 1999 may be the most spectacular showers since 1966.

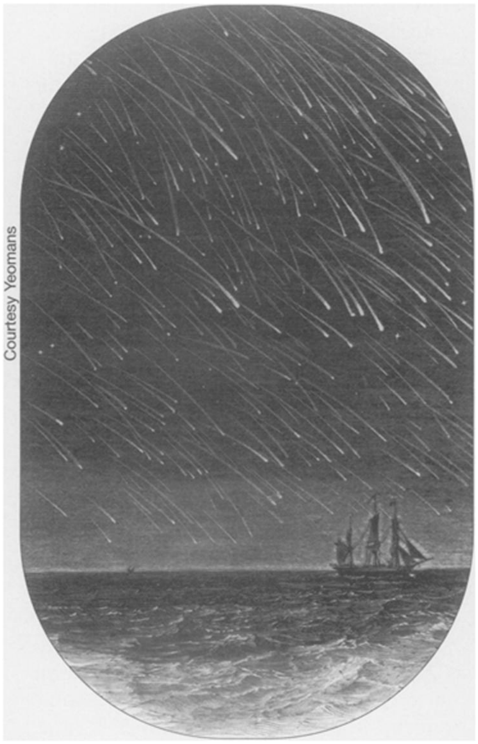
The historical record suggests that the passages this year and next have characteristics in common with two previous sets of encounters—those in 1866 and 1867, in which observers saw a maximum of 5,000 shooting stars, or meteors, an hour, and those of 1931 and 1932, in which viewers counted at most about 200 meteors an hour. Yeomans thus estimates that observers this year will see somewhere between 200 and 5,000 meteors an hour.

That's an admittedly wide range, he notes. "Nobody can predict these things well, so it's a bit of a crapshoot," says Yeomans. "There's nothing precise about predicting meteor storms."

Such uncertainties are proving particularly frustrating for technology companies, the U.S. military, NASA, and others who own or operate any of the 650 or so satellites in space. Researchers estimate that each craft's chance of getting hit by a Leonid meteoroid is only about 0.1 percent.

The debris is mostly tiny, and scientists don't think any particles will punch holes in satellites. They are worried, however, about the electrical damage that may be wrought by these high-speed meteoroids. Traveling at 72 kilometers per second relative to Earth, more than 200 times the speed of a 22-caliber bullet, Leonid particles have the highest speeds of any group of meteoroids. That's because Earth and the debris plow headlong into each other.

When a meteoroid no bigger than a grain of dust slams into a satellite at such speeds, the kinetic energy it delivers can generate a cloud of highly charged gas, or



Courtesy Yeomans

Woodcut of the 1833 Leonid meteor storm, as seen off the Florida coast.

plasma. Depending on where the meteoroid hits and the construction of the satellite, the plasma may generate an electromagnetic pulse that could short-circuit or destroy delicate electronic parts.

"It really comes down to our lack of understanding about what happens when something the width of a human hair hits a satellite 30,000 km from Earth at 72 km/second," says Brown. "The simple answer is that we have only a vague idea. You can't accelerate particles [this large] on Earth to that velocity."

The uncertainty breeds both apprehension and debate. The upcoming Leonids "will represent the largest meteoroid threat to spacecraft in history," claims David K. Lynch of the Aerospace Corp. in Los Angeles.

That assertion is "just nonsense," says Yeomans. "That's just Chicken Little stuff."

Some scientists are quick to point out that during the 1966 Leonid storm, not a single satellite was damaged. However, there are more than 10 times as many craft in space today as in 1966. In 1993, a European Space Agency satellite spun out of control due to an electrical disturbance generated by the impact of a particle from the Perseid meteor shower (SN: 10/2/93, p. 217).

This year "is the the first time . . . since we have had a large number of satellites that we've had a major, predicted meteor storm, and this is likely the largest one since 1966," says S. Pete Worden of the U.S. Air Force in Arlington, Va.

"If you're the owner of a spacecraft that's worth $500 million up there, even if the probability of being hit is less than 0.1 percent, which it is, you may want to [take precautions]," Yeomans notes. To that end, NASA will not launch the space shuttle in mid-November, and the Hubble Space Telescope will point its mirror away from the Leonid meteoroids. Other satellites will be aligned edge on to the storm so that the smallest possible surface area will be exposed to the debris.

In a few cases, says Worden, the military may shut power to components of satellites, such as antennae, that may be particularly susceptible to an electrical discharge. Some satellites might be switched off entirely during the peak of the Leonid activity.

The craft that are at the greatest risk are those that reside in extremely distant orbits, where Earth's tug balances that of the sun. In such an orbit, about 1 million km closer to the sun than Earth is, a craft is far more likely to plow into a concentrated part of the Leonid trail. Ironically, these devices include the Solar and Heliospheric Observatory, which just recovered from an unrelated episode in which it lost power and spun out of control in June.

The only people in space, the cosmonauts in the Mir space station, are planning to ride out the height of the storm in Mir's escape vehicle, the Soyuz capsule. In an emergency, the crew could fire up Soyuz to return to Earth.

Looking on the bright side, says Worden, "this is a really unique opportunity to test out all the satellites" a few years in advance of the solar maximum, a time when outbursts from the sun can hurl clouds of high-speed, charged particles toward Earth and generate global electrical storms. Astronomers predict that a solar maximum will occur in 2000.

As the Leonid shower proceeds, observations by several teams, including Brown's, will guide government agencies and businesses concerned with the health of satellites. "The idea is to give an early indicator if it [turns out to be] a bad storm," says Brown. "This is the first real-time warning system" in place for a meteor storm.

Radar observations by Brown and his collaborators may test an intriguing, and somewhat disturbing, hypothesis that suggests the coming Leonids could pose a greater threat to orbiting satellites than expected. In the October Astronomy and Geophysics, Duncan Steel of Spaceguard Australia in Adelaide proposes that the number of Leonid meteoroids in 1998 or 1999 could be 10 times greater than other estimates.

Steel suggests that many of the freshest Leonid meteoroids are composed entirely of organic, tar-like compounds—key constituents of comets. In contrast to compounds rich in silicates or iron, organic compounds burn at relatively low temperatures high in Earth's atmosphere and are therefore not detected.

Some of the radar systems that Brown uses to detect meteoroids do have frequencies low enough to begin to detect Steel's proposed population, Brown says. "I think, in broad terms, what Steel says is probably true." He notes, however, that Steel's hypothesis holds true only if the composition of meteoroids is 100 percent organic. Even trace amounts of silicates would cause a meteoroid to vaporize lower down in the atmosphere, where it could easily be detected by standard equipment.

"My own feeling is that it's not nearly as severe a problem as he's presenting, but it underscores how much we don't understand," Brown concludes. Come mid-November, sky watchers will have a chance to find out how stormy the Leonids will be. □

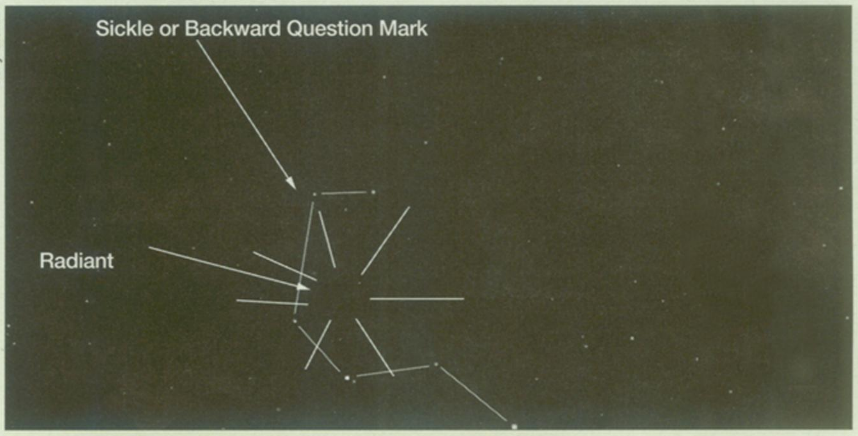
Looking at the Leonids

Although astronomers aren't at all sure that Earth's passage through the Leonid meteor stream this November will prove a blockbuster, it's a good bet that the annual light show will be more intense than usual—even in North America, where viewers won't see the peak of activity that sky watchers in East Asia will witness.

Instead of staying up late, it's probably wiser to wake up early on Nov. 17 and 18. That's because the radiant—the point in the sky from which the Leonids appear to originate—doesn't rise until about 12:30 a.m. local time and the show will be best at about 3:00 a.m., when the radiant is about 30 degrees above the horizon. The radiant lies within the constellation Leo's western portion, a group of stars referred to as the sickle or backwards question mark.

The Leonid meteors are visible to the naked eye, and binoculars would only cut down the field of view, notes Brian G. Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Lie down on a reclining chair, pointing your feet toward the east. For the best view, don't gaze directly at the radiant; instead, look 30 or 40 degrees above or west of that point. The meteors should be visible, weather permitting, through sunrise. Dress warmly and remember, if the 1998 event proves a dud, you'll have a second chance in 1999. *—R.C.*

Gary Kronk



This computer-generated image represents the view that observers at mid-northern latitudes will have of the Leonid meteors at about 3:00 a.m. local time on Nov. 17.