A Passion for the Little Things Among the Planets

If mass were the only criterion, asteroids, satellites, and the smallest planet, Pluto, would not rate much attention. But they often held center stage early this month when planetary scientists gathered in Providence, Rhode Island, for the annual meeting of the Division of Planetary Science of the American Astronomical Society. Here is a selection of the news about the lesser bodies that so many researchers hold dear.

The Poor Man's Grand Tour of the Solar System

Planetary scientists might have felt a certain sense of loss last August as Voyager 2 headed out of the solar system without a look at Pluto. A pass by the tiny planet had been cut for budgetary reasons from the originally planned Grand Tour of all five of the outer planets, but the scientists' pain will have been somewhat assuaged by the new evidence Voyager found as it flew by Triton—this satellite of Neptune is another Pluto . . . sort of.

What Voyager's finding did was buttress the apparent resemblance between Neptune's moon Triton and Pluto. Both seem to be examples of the chunks of ice and rock that, in the early solar system, formed the comets and parts of the other four outer planets. If so, Triton will serve as a surrogate for the one planet made directly from the solid stuff of the early solar system, possibly making it a bit easier to decipher the secrets of the solar system's origins.

Planetary scientists had long suspected that Triton originated as a wandering member of the early solar system's swarm of primordial bodies. Most major satellites orbit in the plane of their planet's equator because both satellite and planet formed from the same swirling disk of dust and gas. But Triton's orbit is steeply inclined to Neptune's equator, suggesting that the planet captured its satellite after Triton formed directly from the solar nebula, just as the comets did.

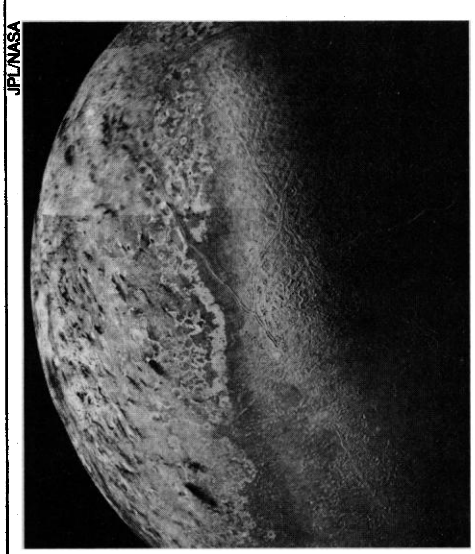
New Voyager data tend to support this idea, says mission scientist Leonard Tyler of Stanford University. Triton's gravitational effect on the spacecraft's motion revealed that the moon has a relatively high density of 2.066 grams per cubic centimeter. That makes Triton two-thirds rock—just as Pluto is. In contrast, the major satellites of the other outer planets are largely made of ice.

If Triton and Pluto were both made from the same stuff of the early solar system, Voyager observations should tell researchers something about how Pluto and planetary building blocks in general were put together. There are no new answers yet, but the new view of Triton is already raising some interesting questions.

For starters, researchers are asking themselves, where is Triton's fair share of carbon monoxide? This compound is abundant throughout the universe. It should have been far more abundant in the solar nebula than methane, and there is plenty of methane on Triton. And carbon monoxide behaves much like molecular nitrogen, which is also present on the moon's surface. Yet Voyager scientists found very little if any carbon monoxide on Triton. The question then becomes, if Triton formed directly from the solar nebula, what aspect of its formation discriminated against carbon monoxide in favor of methane and nitrogen?

Figuring out just why their peek at Triton at the end of the abbreviated Grand Tour did not reveal more carbon monoxide should keep planetary geochemists wondering a while. They no doubt hope that they will not have to wait for an answer until a probe actually reaches Pluto. None is currently planned and the wait could extend decades into the next millennium.

JPL/NASA



A little bit of Pluto. *Neptune's moon Triton is made of the same stuff as the smallest planet.*

First Direct View of Solar System Chaos

When the first iconoclast attacked our precious notion that the solar system behaves like clockwork, the obvious question was: Where is the direct proof? Computer simulations of chaos in the solar system are nice, but where can you see it for yourself?

Astronomer James Klavetter of the University of Maryland in College Park is the first to answer that question. He has direct observations of Saturn's 150-kilometer satellite Hyperion that prove it is gyrating wildly, just as predicted by those who see chaos in their computer simulations.

Other astronomers had been trying to detect chaos in Hyperion's rotation for several years, but Klavetter succeeded because of his persistence and ingenuity. As a graduate student at the Massachusetts Institute of Technology, Klavetter spent a summer traveling to three telescopes on two continents to try to pin down the question of Hyperion's rotation.

He chose this target because Jack Wisdom of MIT and his colleagues had predicted in 1984 that Hyperion would be found to be twisting, turning, and tumbling so wildly that its behavior would be unpredictable in any detail (*Science*, 29 July 1983, p. 448). The cause of Hyperion's chaotic rotation, they said, is the combination of its irregular shape—it looks something like a ragged hamburger bun—and the stretching of its orbit by the gravitational tugs of Saturn's larger satellite Titan.

The prediction of chaos seemed sound enough, but no one was confirming the prediction. No wonder. As Klavetter found when he began his effort, trying to accurately observe the moon, what with the glare of its giant parent planet (which is almost half a million times brighter), bouts of bad weather, and unforeseen technical problems, was challenging enough. But he also discovered he would have to watch Hyperion almost every clear night for months on end to show that its rotation is chaotic.

Klavetter had the will to overcome such obstacles, but at first he had no way. Like his competitors, he had been unable to garner that much observation time from the committees that control the 1-meter telescopes needed to observe Hyperion. Klavetter prevailed by sharing the allotted observing time of other astronomers in return for making observations for them. In the end, he had 37 useful nights of observations of the brightness of Hyperion over a period of 53 days. That was enough, he told the meeting. If its brightness varied chaotically from day to day—if it changed without any regular, predictable pattern—then the moon must be tumbling rather than spinning like a top.

Klavetter saw "nothing even close to regular behavior. With my data you can say with absolute certainty that Hyperion's behavior is chaotic." With more subtle chaos showing up in simulations of the behavior of asteroids, Pluto, and perhaps other planets (*Science*, 14 April 1989, p. 144), the computer jockeys should rest easier now that astronomers are "absolutely certain" they have at least one example of chaos in the solar system.

Largest Radar Detects Dumbbell in Space

The more asteroids radar astronomer Steven Ostro sees, the stranger they look. Now he has seen one that looks for all the world like a dumbbell, albeit a slightly squashed dumbbell. How could that be? Perhaps it formed when two chunks of rock gently collided and never came apart.

The existence of such bizarre asteroids may provide an explanation for an observation made here on Earth that has long puzzled geologists. They have found a few pairs of closely spaced impact craters that seem to have formed simultaneously. Ordinary comets or asteroids are thought to be too strong to break up just before they hit, so they should produce only one crater on striking Earth.

But in 1979, William Hartmann of the Planetary Science Institute in Tucson, Arizona, predicted in a paper that some of today's asteroids might have formed by the gentle fusion of two smaller chunks of rock. Being only weakly joined to each other, these chunks might break apart as they entered Earth's atmosphere and form a pair of separate but closely spaced craters such as the Soviet Union's Kara and Ust-Kara craters in the Arctic. Now Ostro appears to have bagged the first such fused asteroid.

Ostro, who works at the Jet Propulsion Laboratory in Pasadena, California, and his colleagues made their discovery with the world's largest radio telescope, the 300-meter Arecibo dish, which is nestled in a bowl-shaped valley in Puerto Rico. Their target was 1989 PB, an asteroid that had been discovered in early August by Eleanor Helin, also of JPL. 1989 PB has a diameter of only 1 kilometer, which is tiny by asteroid standards. But at a distance of 2.4 million kilometers, it was also relatively close to Earth and therefore a prime candidate for imaging.

So, just 10 days after Helin found the asteroid, Ostro and company bounced microwave signals from the Arecibo dish off 1989 PB. The returning signals were formed into a radar image, the first ever of such a small body. At this point in the image analysis, Ostro sees 1989 PB as two rough, highly irregular bodies stuck together at what more strictly resembles a short, narrow waist than the bar of a dumbbell. With that shape, it may well have formed by the fusion of two smaller asteroids, just as Hartmann predicted. He envisioned two similarly sized asteroids that were on a collision course but traveling at extremely low speeds relative to each other. Such bodies might simply fall together and then be held in an embrace by their own feeble, but sufficient, gravitational attraction.

Rare as fused asteroids like 1989 PB may be, Ostro foresees finding other exotically shaped asteroids. After all the "normal" satellites that have become familiar, future close looks at "asteroids are going to startle us," he predicts.

Which Way is North? Ask Right-Handed Astronomers

Astronomers do not often draw applause in the middle of their talks, but David Tholen of the University of Hawaii did it by simply pointing out the south pole of Pluto on a diagram he had made of the planet. To a biologist, this might sound innocuous—even arcane—but Tholen's gesture sounded a battle cry of quiet rebellion in the ranks of planetary astronomers.

The International Astronomical Union, the ruling body of astronomy, has decreed that the north pole of every planet and moon is the one lying on the solar system's "top" side. This has been the IAU standard since 1976. But whole subspecialities of planetary astronomy want nothing to do with that convention. "We simply ignore the IAU," notes one Pluto observer. Says Tholen: "I really don't see any advantage at all [in the IAU convention]." Not all astronomers agree, but Tholen would have them hew to the approach used by physicists for decades, one that makes consistent sense when physicists talk among themselves about spinning bodies.

For more than a century, physicists have invoked the so-called right-hand rule in designating poles—if you curl your fingers of your right hand, making a fist, and if you align those fingers with a planet's rotation, your thumb will be at what physicists—and now the planetary rebels—say is the true north pole of the planet.

As some planetary scientists will tell you, the problems produced by using the IAU convention are numerous. For example, a body whose poles are aligned near the plane that divides top from bottom in the solar system might slowly wobble, bringing the poles across the plane and flipping the pole designations. And following the convention can also wreak havoc with the physics of several planets. "If we used the IAU convention," says astronomer Philip Nicholson of Cornell University, "everything would go 'backwards' on Venus, Uranus, and Pluto," including the weather. The winds would not care about whose convention was being followed; they would still blow around a low-pressure center in opposite directions in opposite hemispheres, as they do on every rotating body. But anyone discussing a northern hemisphere cyclone on Venus would have to find out which convention was being used in order to decide whether the wind was blowing clockwise or counterclockwise.

Yet another problem is the confusion that can arise when scientists who use the IAU convention have to cooperate with those using the right-hand rule, as during Voyager's encounter with Uranus. The physicists navigating the spacecraft followed the right-hand rule because their computers had always been programed that way, but the results of their calculations had to be converted to the IAU convention for the Voyager planetary scientists, who as a group had decided to abide by the convention.

So why such a troublesome convention? "It's really a question of tradition rather than logic," says Merton Davies of the Rand Corporation in Santa Monica, who is chairman of the IAU committee that voted in the convention. "The primary reason for the convention was the preparation of [planetary] maps once we got high-resolution data, and all the mapmakers at the U.S. Geological Survey in Flagstaff abide by the convention." The mapping began back in the early 1970s with Mars, for which there is no conflict between conventions, and it has been continued since.

So far at least, the two sides in the convention controversy have refrained from open warfare. But that could change if journal editors try to enforce the IAU convention, as some planetary scientists feel they should. If editors take a stand on the issue, they are likely to find themselves in the front lines of a shooting war. ■ RICHARD A. KERR