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Nicholas Panagakos  
Headquarters, Washington, D.C.  
(Phone: 202/755-3680)

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Frank Bristow  
NASA Jet Propulsion Laboratory, Pasadena, Calif.  
(Phone: 213/354-5011)

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## VOYAGER ENCOUNTERS SATURN: SCIENTIFIC HIGHLIGHTS

The following is a summary of the major scientific discoveries, observations and theories generated by the recent encounter of Voyager 1 with Saturn:

### The Planet

• The basic appearance of Saturn's atmosphere is similar to that of Jupiter, with alternating dark and light cloud markings. The features in the Saturnian atmosphere, however, are muted by the presence of a much thicker haze layer above the visible clouds. The belt/zone structure on Saturn also extends to much higher latitudes than on Jupiter.

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- Wind speeds in the atmosphere are not closely tied to the belt/zone boundaries as was apparently the case for Jupiter. The greatest wind speeds (more than 1,600 kilometers or 1,000 miles per hour) occur at the equator and are four to five times stronger than Jupiter wind speeds.

- Temperatures near the cloud tops range from 86 degrees Kelvin (-305 degrees Fahrenheit) to 92 K (-294 F), with the coolest temperatures noted near the center of the equatorial zone.

- Auroral emissions were seen near the poles of Saturn; auroral-type emissions in the ultraviolet were also noted near the illuminated limbs of the planet.

- The dark face of Saturn receives a substantial amount of light from the rings, especially in that hemisphere above the illuminated face of the rings.

- Lightning bolts have not been observed in the images of Saturn's dark face, but radio emissions typical of lightning discharges have been noted. These discharges are believed to emanate from Saturn's rings rather than from its atmosphere.

- Radio emissions, primarily from the north polar region and near 90 degrees longitude, indicate that the body of Saturn and its magnetosphere rotate with a period of 10 hours 39 minutes 26 seconds.

### The Rings

- The classically known A, B and C rings were observed by Voyager 1 to consist of hundreds of ringlets, a few of which are elliptical in shape.

- The F ring, first discovered by Pioneer 11, is composed of three separate ringlets which appear to be intertwined. The inner and outer limits of the F ring seem to be controlled by two shepherding satellites, S-13 on the outside and S-14 on the inside. The outer edge of ring A is similarly shepherded by S-15. All three of these satellites were discovered by Voyager 1.

- The existence of a D ring inside the C ring was confirmed by observations during Voyager 1's passage through the shadow of Saturn. The tenuous E ring, previously observed only from Earth during periods when Saturn's rings could be viewed edge-on, was also observed during shadow passage.

- Measurements show that the D, E and F rings have a large population of particles less than 1/10,000 of an inch in diameter. Radio measurements of the C ring yield an effective particle size of about 1 meter (3 feet), but also suggest a wide distribution of particle sizes.

- The existence of a thin ring just inside the co-orbital moons S-10 and S-11 was first inferred from the passage of its shadow across one of the moons, and later detected directly in the Voyager image of the E ring mentioned above.

- The spokes in the B ring are dark in approach pictures and bright in forward-scattered light in post-closest approach pictures, and may be a result of electrostatic forces lifting fine particles above the face of the optically thick B ring. These spokes appear to corotate with Saturn's magnetic field.

The New Moons: S-10, S-11, S-12, S-13, S-14, S-15

- Each of the recently discovered moons of Saturn was photographed, but only S-10 and S-11 had large enough angular diameters in the images to determine their shapes. Both are irregular in shape with their long axes pointed toward the center of Saturn. S-11, the trailing satellite of this co-orbital pair is about 135 km (80 mi.) long by 70 km (40 mi.) wide. S-10 is somewhat larger with an average diameter of about 200 km (120 mi.). Both bodies are apparently composed of water ice, and both orbit the planet at a distance of 91,000 km (57,000 mi.) above the cloud tops of Saturn.

- Little is know about S-12 through S-15 other than their orbits. S-12 (sometimes referred to as Dione B) orbits at the same distance from Saturn as Dione, slowly oscillating about a point 60 degrees ahead of Dione. As mentioned earlier, S-13, S-14 and S-15 were discovered by Voyager 1 and orbit just outside the F ring, just inside the F ring, and just outside the A ring, respectively.

- Other satellites may be discovered as Voyager 1 scientists examine the voluminous data returned from the encounter, or from photos to be returned in the summer of 1981 by Voyager 2.

The Inner Moons: Mimas, Enceladus, Tethys, Dione, Rhea

● Each of these five inner moons of Saturn is approximately spherical in shape. Their densities and surface brightness indicate that they are composed mainly of water ice. Tethys, in particular, seems to be almost pure ice, whereas Dione may range from 30 to 70 percent rock.

● All five of these moons represent a size of body not previously explored by space probes, intermediate in size between Phobos and Deimos (Mars' moons) and Amalthea (Jupiter), and the terrestrial-sized bodies -- Mercury, Moon and the Galilean satellites of Jupiter. Their measured diameters, accurate to about 20 km (12 mi.), are: Mimas, 390 km (240 mi.); Enceladus, 500 km (310 mi.); Tethys, 1,050 km (650 mi.); Dione, 1,120 km (695 mi.); and Rhea, 1,530 km (950 mi.).

● With the exception of Enceladus, all of these moons have heavily cratered surfaces, reminiscent of the Moon and Mercury. Mimas has one very prominent crater which has a diameter almost one fourth that of Mimas itself. Stretching for 750 km (470 mi.) across the surface of Tethys is a 60 km (40 mi.) wide valley, which appears to be a fracture in the crust of the moon. Several sinuous valleys, some of which appear to branch, are visible on Dione's surface.

Both Dione and Rhea have brighter wispy streaks which stand out against an already high reflective surface. These are probably the result of relatively fresh ice ejecta thrown out of more recent (on a geologic time scale) impact craters.

Of these five inner moons, only Enceladus shows no evidence at a scale of 12 km (7 mi.) of any impact craters.

- Because the maximum intensity of the E ring occurs near the orbit of Enceladus, it is speculated that Enceladus may serve as a source for E ring particles. Enceladus was not a prime target for Voyager 1, but Voyager 2 will fly closer and return higher resolution images than Voyager 1.

### Titan

- Titan, Saturn's largest moon and the only moon in our solar system known to possess any substantial atmosphere, was thought to be the largest satellite in the solar system. It is now known to be smaller than Ganymede, largest of Jupiter's Galilean satellites. Its precise diameter is not yet known, but is less than 5,120 km (3,180 mi.), compared with Ganymede's 5,270 km (3,275 mi.). This implies a density twice that of water ice for Titan, requiring it to be an equal amount of rock and ice, as is Ganymede.

- The surface cannot be seen because it is hidden by a dense haze at least 280 km (175 mi.) thick.

- The atmospheric pressure near Titan's surface is 50 percent greater than that of Earth.

The atmosphere of this unique moon contains methane, ethane, acetylene, ethylene and hydrogen cyanide, but the bulk of the atmosphere is now believed to be composed of nitrogen, the main constituent of Earth's atmosphere.

- Lakes of liquid nitrogen may exist near the poles of this strange world, whose surface temperature is probably 90 K (-300 F), only slightly warmer than the boiling point of liquid nitrogen.

- Titan has no intrinsic magnetic field, and therefore possesses no large liquid conducting core. Titan does serve as a source of charged particles in Saturn's magnetosphere, but only in the amount of about one ounce per second.

- A thick haze obscures all surface features, and a total of three distinct detached haze layers are apparent above the main haze layer. The three layers merge into a darkened hood over the north pole of Titan. Titan's southern hemisphere is somewhat brighter than its northern hemisphere, perhaps as a result of seasonal effects.

#### The Outer Moons: Hyperion and Iapetus

- The masses of Hyperion and Iapetus are poorly known, so their densities are quite uncertain. However, it is very likely that they too are mainly water ice. Their surfaces are somewhat less reflective than the inner moons, but still much more reflective than our own Moon, which reflects only 4 percent of the light it receives from the Sun.

- Iapetus is peculiar in that it has one bright and one dark hemisphere. The dark side, which faces in the forward direction as Iapetus circles Saturn, reflects only one-fifth as much as the bright trailing side.

Hyperion has a diameter of about 310 km (190 mi.), Iapetus a diameter of about 1,440 km (890 mi.).

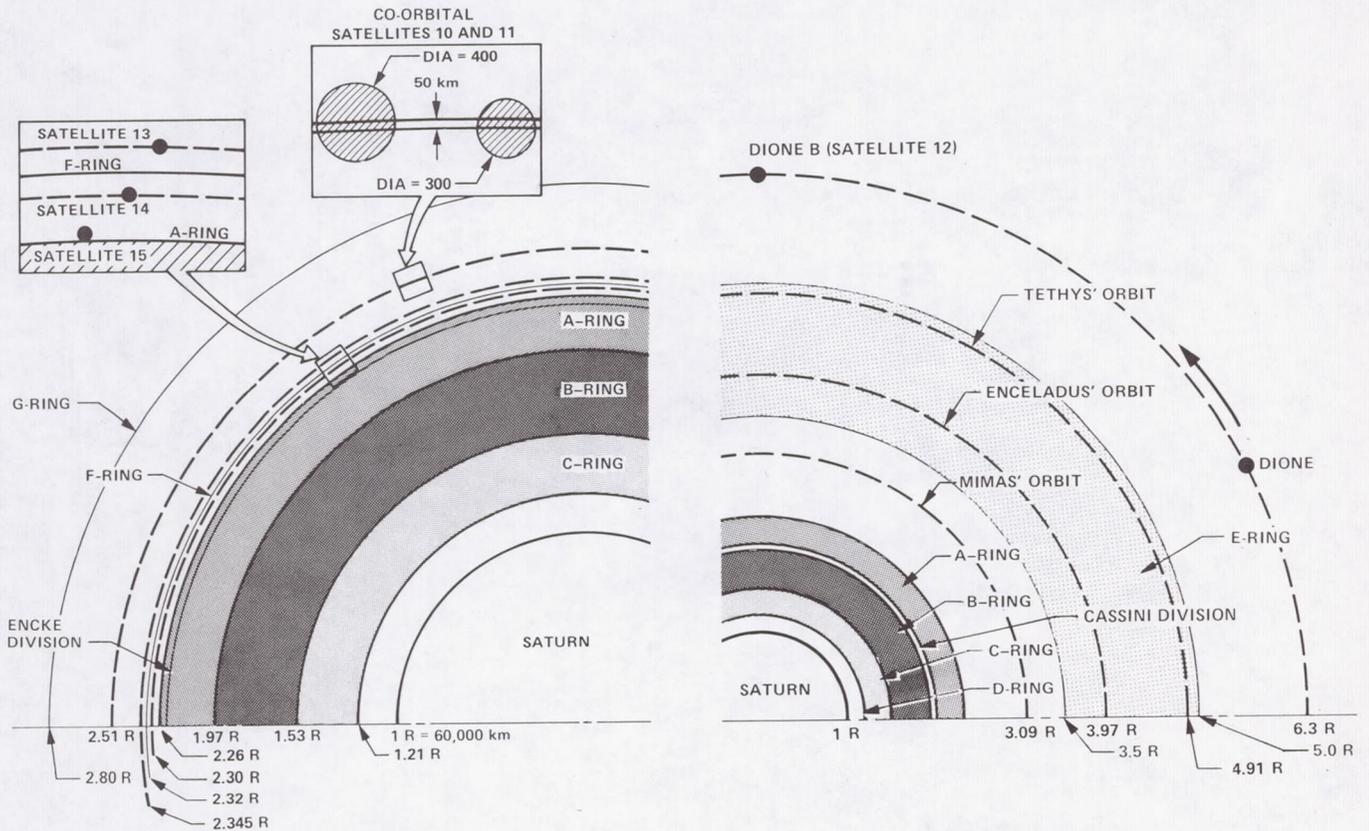
### The Magnetosphere

- Although it is only about one-third the size of Jupiter's magnetosphere, the magnetosphere of Saturn is nevertheless an enormous structure, extending nearly a million miles inward from the planet toward the Sun before the flow of charged particles in the solar wind overcomes the effects of Saturn's magnetic field. As in the case of Jupiter's magnetosphere, charged particles in Saturn's magnetosphere are dragged along by the magnetic field and circle Saturn once every 10 hours 39 minutes. At the orbital distance of Titan, these charged particles speed by Saturn's largest moon at more than 193 km (120 mi.) per second.

- The size of the magnetosphere fluctuates rhythmically as the solar wind increases or decreases in intensity, with the result that at times Titan finds itself outside of Saturn's magnetosphere altogether.

- Surrounding Titan and its orbit and extending inward to the orbit of Rhea is an enormous cloud of uncharged hydrogen atoms forming a torus or ring, of ultraviolet-emitting particles. Because they are uncharged, these atoms are not dragged along by Saturn's magnetic field as it rotates, but rather orbit as countless miniscule moons around Saturn.

● The rings of Saturn act as an effective shield or absorber of charged particles close to the planet, but in the process apparently are substantially affected, as evidenced by the "spokes" of fine particles and lightning-like electrical discharges in the rings.



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