Reports

Voyager 1 Encounter with the Saturnian System

Abstract. *An overview of the Voyager 1 encounter with Saturn is presented, including a brief discussion of the flight, trajectory, science plan formulation, and highlights of the results described in the subsequent reports.*

The Voyager 1 encounter with Saturn marked the successful accomplishment of the third step in the NASA Voyager program to explore the interplanetary and planetary environments of the outer solar system (*1*). The Voyager spacecraft was described in detail by Draper *et al.* (*2*). Voyager 1, launched on 5 September 1977, had its closest approach to Jupiter on 5 March 1979, during a 98-day period of intensive acquisition of science data on the Jovian system and its environs (*3*). Voyager 2 was not far behind Voyager 1, with closest approach to Jupiter on 9 July 1979 (*4*). With assistance from Jupiter's gravity and a post-encounter trajectory correction maneuver, Voyager 1 continued on toward Saturn.

During its cruise from Jupiter to Saturn, at a velocity of nearly 15 km/sec (34,000 miles per hour), Voyager 1 explored the interplanetary medium and selected celestial sources of interest. In addition, each of its science instruments was recalibrated in preparation for the Saturn observations. During this 20-month cruise period, Voyager personnel developed and tested the detailed spacecraft sequences needed to perform the planned scientific studies during the 4-month encounter with the multiringed planet.

The Voyager 1 scientific investigations are listed in Table 1. The locations of the instruments and essential subsystem hardware are shown in the Voyager 1 Jupiter report (*3*). All instruments functioned nominally with the exception of the photopolarimeter, which developed anomalous behavior during the Jupiter encounter and has remained inoperable since then.

The trajectory of Voyager 1 was chosen to provide (i) a close encounter with Titan before Saturn closest approach so that atmospheric occultations, high-resolution imaging, Titan magnetic field studies, and solar wind and magnetospheric wake studies could be accommodated; (ii) optimum geometry for radio occultation studies of the rings; (iii) radio and ultraviolet occultation studies of Saturn's atmosphere; and (iv) spacecraft passage through the ring plane at Dione's orbit in order to minimize hazards from impinging ring particles. The actual Voyager 1 trajectory and the planned Voyager 2 trajectory also provide complementary sets of satellite close-approach distances (Table 2).

Voyager 1 encounter activities began on 22 August 1980, when the spacecraft was 109,000,000 km (68,000,000 miles) from Saturn. Closest approach, at a distance of 126,000 km (78,000 miles) above Saturn's cloud tops, occurred at 2346 UTC (coordinated universal time) on 12 November 1980. Titan closest approach occurred before that of Saturn, at 0541 UTC on 12 November 1980. A view of the Voyager 1 trajectory through the Saturnian system is shown in Figs. 1 and 2. Figure 3 depicts the planned complementarity of latitude coverage by Voyagers 1 and 2.

Design of the spacecraft sequences was complicated by several factors. Saturn's greater distance necessitated a factor of 3 reduction in the rate of data transmission (44,800 bits per second at Saturn compared to 115,200 bits per second at Jupiter). Furthermore, Saturn's satellites and rings provided twice as many objects to be studied at Saturn as at Jupiter, and the close approaches to these objects all occurred within a 24-hour period, compared to nearly 72 hours at Jupiter.

Scientific studies included investigation of the ring system, satellites, and magnetosphere of Saturn and of the atmospheres of Saturn and Titan. Studies of the planetary atmosphere focused on dynamics, composition, structure, and magnetospheric effects (auroras). Studies of Titan were designed to determine the diameter of the solid surface, atmospheric temperature and pressure profiles, and atmospheric composition and to search for an intrinsic magnetic field of Titan. The other satellites of Saturn were studied to determine their size, density, surface geology, temperature structure, and reflective properties. Ring studies included radial structure, temperature, and particle size determinations and searches for azimuthal differences and for a ring atmosphere. Magnetospheric studies addressed the source of Saturnian radio emissions, motions and other variations within the magnetosphere, and interactions between the magnetosphere and the rings and satellites.

Some highlights from the following detailed reports are summarized below.

Table 1. Voyager science investigations.

Investigation	Abbreviation	Principal investigator
Imaging science	ISS	B. A. Smith, University of Arizona (team leader)
Infrared radiation	IRIS	R. A. Hanel, Goddard Space Flight Center
Photopolarimetry	PPS	A. L. Lane, Jet Propulsion Laboratory
Ultraviolet spectroscopy	UVS	A. L. Broadfoot, University of Southern California, Space Sciences Institute
Radio science	RSS	G. L. Tyler, Stanford University (team leader)
Magnetic fields	MAG	N. F. Ness, Goddard Space Flight Center
Plasma particles	PLS	H. S. Bridge, Massachusetts Institute of Technology
Plasma waves	PWS	F. L. Scarf, TRW Defense and Space Systems Group
Planetary radio astronomy	PRA	J. W. Warwick, Radiophysics, Inc.
Low-energy charged particles	LECP	S. M. Krimigis, Johns Hopkins University, Applied Physics Laboratory
Cosmic-ray particles	CRS	R. E. Vogt, California Institute of Technology

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All of these studies benefited from the prior ground-based observations of Saturn and from the Pioneer 11 Saturn results (*5*).

Saturn's atmosphere. One principal objective of the Voyager mission was a comparative study of the dynamics of the atmospheres of Saturn and Jupiter. Because Saturn is colder, the cloud layers are deeper in the atmosphere than at Jupiter and are blander in appearance (*5*). Alternating dark belts and light zones are visible in the clouds of Saturn and extend to much higher latitudes than on Jupiter.

The velocities of the clouds have been measured with respect to the motion of the interior of Saturn, as indicated by the 10 hour 39.4 minute rotational period of the magnetic field. Eastward wind speeds in Saturn's near-equatorial clouds of up to 480 m/sec (1100 miles per hour) are four times the highest speed measured in Jupiter's clouds. These winds, which are not strongly correlated with the belt and zone boundaries, decrease smoothly to nearly zero at latitudes near 40°N and 40°S.

The nighttime face of Saturn is illuminated by ring light, degrading the threshold of visual detection of lightning or auroras compared to that at Jupiter. Ultraviolet auroras were, however, detected in a polar ring near 80°S. Auroralike emissions from molecular hydrogen were also seen near the sunlit edges of the planet at very low latitudes.

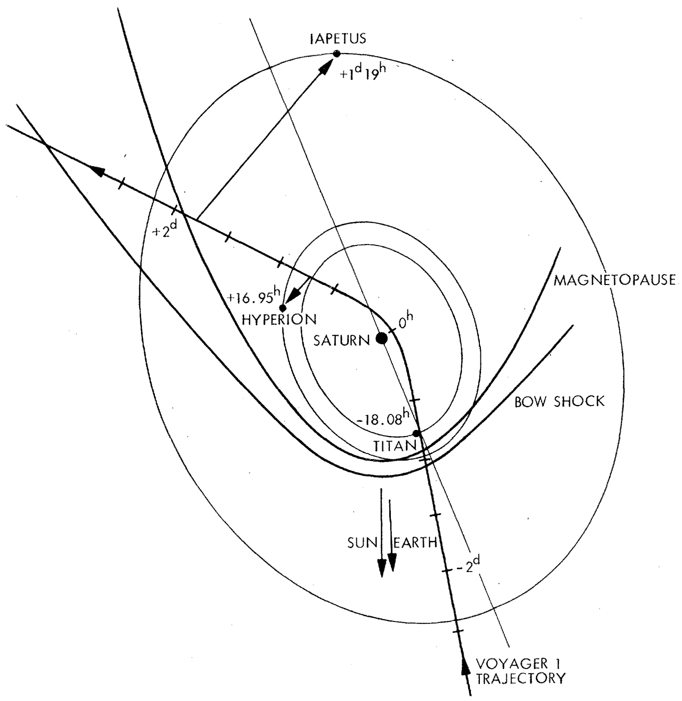
The bulk of Saturn's atmosphere is hydrogen. Helium accounts for only about 11 percent of the mass of the atmosphere above the clouds of Saturn compared to 19 percent in the same region on Jupiter. This difference is consistent with a gravitational separation of helium and hydrogen in Saturn's interior, which could generate the excess energy radiated by Saturn over that which it receives from the sun. Methane, ammonia, ethane, acetylene, and phosphine are also detected in the atmosphere, although there was relatively little gaseous ammonia due to the low atmospheric temperature. Temperatures decrease from ~ 150 K in the upper atmosphere to a minimum of ~ 85 K at a pressure of 100 mbar and increase to ~ 160 K at 1.4 bars. Temperatures in the southern hemisphere are warmer, apparently a seasonal effect.

Rings. Since first seen by Galileo in 1610, Saturn's primary distinguishing characteristic has been its rings. The distinct, broad A, B, and C rings, which are easily observable from Earth, were found to be of distinctive character. The outermost ring, A, is probably closest to the pre-Voyager concept of Saturn's rings. Its rather uniform appearance is marked by a few narrow features that correspond to orbital resonances with satellites 1980S1 and 1980S3. There is evidence for satellite-driven density waves in the region of the Encke division. Radio transmission through the rings indicated that the effective diameter of A ring particles is 10 m. The small satellite 1980S28 is just beyond the outer edge of the A ring.

The A and B rings are separated by the Cassini division, which contains five broad rings that have additional structure. The effective particle diameter from radio transmission is about 8 m.

The middle, or B, ring is strikingly different, consisting of numerous narrow ringlets with no apparent large-scale order. It is possible that the ringlets are formed by the action of a large number of moonlets embedded within the ring. The B ring region is also characterized by sporadic radial markings or "spokes," perhaps the result of levitation of small particles above the ring plane. The possible importance of electrostatic charging effects in spoke formation and dynamics is suggested by the detection at radio wavelengths of electrostatic discharges from the rings. These discharges are loosely correlated with Saturn's rotation.

The C ring, which is just inside the B ring, is more transparent than the A and



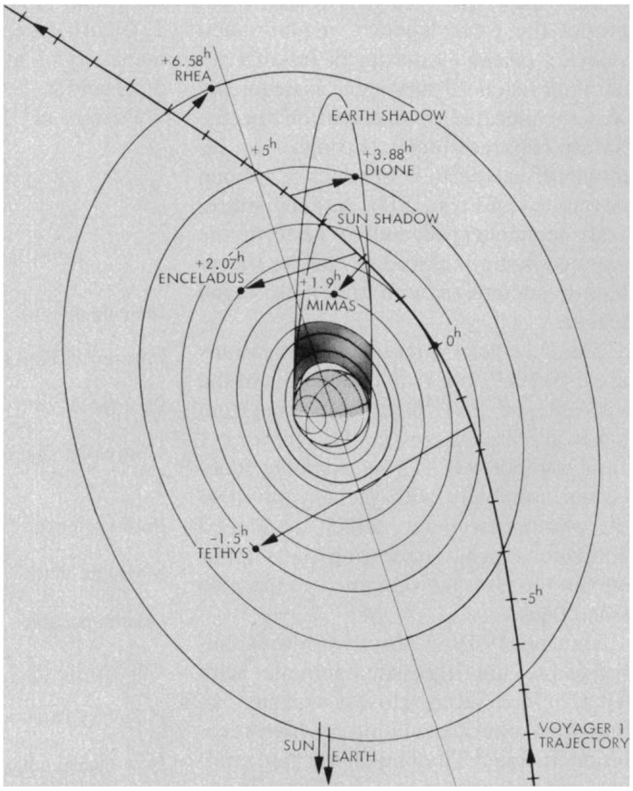


Fig. 1 (left). Voyager 1 path through the Saturn system shown in the plane of the spacecraft trajectory. The projected orbits of Iapetus, Hyperion, and Titan are shown along with the positions of these satellites at the times (labeled) when Voyager 1 was closest to them. The average positions of Saturn's bow shock and magnetopause are also shown. Time ticks along the trajectory mark Voyager's position at 12-hour intervals. Fig. 2 (right). Voyager 1 path through the orbits of the inner satellites from Mimas through Rhea. Positions of the satellites are shown at the times of Voyager's closest approach to them. The limits in the plane of the spacecraft trajectory of the sun and Earth "shadows" are shown. Time ticks mark Voyager's position at 1-hour intervals.

B rings and contains a number of dense ringlets whose locations are regular but evidently unrelated to orbital resonances with the larger satellites. Radio transmission through the C ring indicated an effective particle diameter of 2 m. A still fainter D ring, also comprised of numerous narrow features, was found between the inner edge of the C ring and the planet.

An atmosphere of neutral hydrogen extends 60,000 km (36,000 miles) above and below the main rings and somewhat beyond the outer edge of the A ring. Water ice in the ring material is a potential source for the cloud of hydrogen, which has an estimated number density of 600 atoms per cubic centimeter.

Beyond the A ring are three additional rings. The F ring was discovered by Pioneer 11, which also disclosed a complex distribution of material in this region (*5*). Voyager 1 images showed a very narrow ring that has local concentrations in some regions and a multicomponent braided appearance. Satellites 1980S26 and 1980S27 provide the gravitational shepherding that maintains the narrow ring of very small particles. The other rings are noted in Table 3.

Icy satellites. The total number of known satellites of Saturn has reached 15 with the discovery of three by Voyager 1. Characteristics of the 15 satellites are given in Table 2. All but Phoebe were observed by Voyager 1. With the exception of Titan, which is discussed separately, the satellites are covered with water ice and in some cases are composed mainly of water ice. At least some of the newly discovered satellites appear to be nonspherical, perhaps an indication of past collisions and fragmentation. 1980S1 and 1980S3 are in nearly the same orbit, with 1980S1 leading by about 105° and 1980S3 closing at the time of the Voyager 1 Saturn encounter. At the present closing rate, 1980S3 will overtake 1980S1 in early 1982, but orbital dynamicists predict that they will exchange orbits without colliding (*6*).

All the icy satellites, with the possible exception of Enceladus, are heavily cratered, although the density of cratering varies considerably on several of these bodies, suggesting either a nonuniform distribution of impacting particles or subsequent surface modification. Mimas has one large impact crater almost one-third the diameter of Mimas itself, as well as numerous smaller, bowl-shaped craters and long, narrow grooves.

Enceladus is the most reflective of Saturn's moons, perhaps a consequence of geologically recent surface-forming events. No craters have been seen on Enceladus. It orbits Saturn in precisely half the orbital period of Dione, and its surface may be repeatedly flexed by gravitational forces from Dione in a manner similar to tidal heating processes on Io and Europa. Saturn's E ring particles are most concentrated near the orbit of Enceladus, suggesting that Enceladus may be the source of particles for this ring.

Tethys, like Mimas, has deep, bowl-shaped craters. A 750-km-long valley suggests that some form of internal stress was present at one time, perhaps

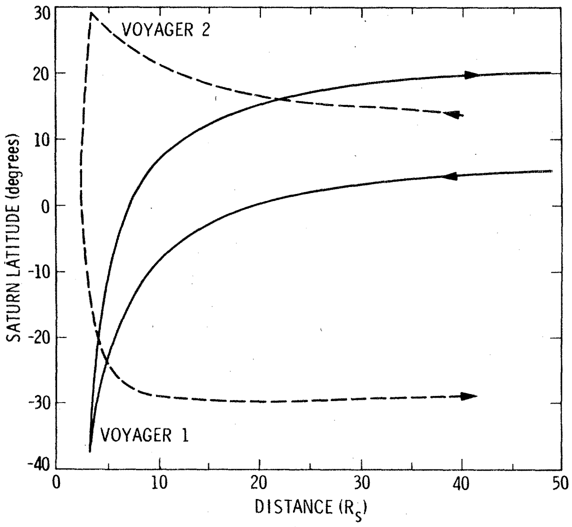


Fig. 3. Planetocentric latitudes of Voyager 1 (actual) and Voyager 2 (planned) as a function of spacecraft distance from the center of Saturn in units of Saturn radii (R_S = 60,330 km). Inbound and outbound directions are indicated with arrows. Note that Voyager 1 crossed the equator (ring plane) twice, once near the orbit of Titan and once near the orbit of Dione. Voyager 2 will cross the ring plane only once.

Table 2. Saturn satellite data.

Satellite	Diameter (km)	Distance (km)	Distance (R_S)*	Period (hours)	Closest approach (km)	
					Voyager 1	Voyager 2
1980S28	30†	137,300†	2.276†	14.446†	219,000	287,000
1980S27	220†	139,400†	2.310†	14.712†	300,000	247,000
1980S26	200†	141,700†	2.349†	15.085†	270,000	107,000
1980S3	90 × 40†	151,422†	2.510†	16.664†	121,000	147,000
1980S1	100 × 90†	151,472†	2.511†	16.672†	297,000	223,000
Mimas	390†	188,224	3.120	23.139	88,440	309,990
Enceladus	500†	240,192	3.981	33.356	202,040	87,140
Tethys	1,050†	296,563	4.916	45.762	415,670	93,000
1980S6	~160	378,600†	6.275†	65.738†	230,000	270,000
Dione	1,120†	379,074	6.283	66.133	161,520	502,250
Rhea	1,530†	527,828	8.749	108.660	73,980	645,280
Titan	5,140†	1,221,432	20.246	382.504	6,490	665,960
Hyperion	290†	1,502,275	24.901	521.743	880,440	470,840
Iapetus	1,440†	3,559,400	58.999	1901.820	2,470,000	909,070
Phoebe	~160	10,583,200	175.422	9755.679	13,537,000	1,473,000

*Here 1 R_S is defined as 60,330 km (37,490 miles). †From Voyager 1 data in this issue; distances and periods are for 1 October 1980. The remaining entries were provided by the Voyager navigation team.

Table 3. Saturn ring data.

Feature	Distance (km)	Distance (R_S)*	Period (hours)	Comments
Cloud tops†	60,330	1.000	10.657	Near 100-mbar level
D ring inner edge	~67,000	1.11	4.91	Extremely small optical depth
C ring inner edge	73,200‡	1.21	5.61	
B ring inner edge	92,200‡	1.95	7.93	
B ring outer edge	117,500‡	1.53	11.41	Inner edge of Cassini division
A ring inner edge	121,000‡	2.01	11.93	Outer edge of Cassini division
Encke division	133,500‡	2.21	13.82	About 200 km wide
A ring outer edge	136,200‡	2.26	14.24	
F ring	~140,600	2.33	14.94	Three narrow components
G ring	~170,000	2.8	19.9	Seen only in forward-scattered light
E ring inner edge	~210,000	3.5	27.3	
E ring maximum	~230,000	3.8	31.3	Near orbit of Enceladus
E ring outer edge	~300,000	5.0	46.6	

*Here 1 R_S is defined as 60,330 km (37,490 miles). †Distance at equator from Saturn's center; the period is the rotation rate of the planet. ‡From Collins *et al.* (*9*).

associated with the expansion or freezing of the nearly pure water ice of which Tethys is composed.

Dione is almost a twin of Tethys in size, but has a density corresponding to a 60:40 mixture of ice and rock. Extensive white, wispy regions are evidently large fractures in the crust through which water has escaped and formed frost. There is also evidence for extensive resurfacing of some areas, although the source of energy for such geologic activity is not understood.

Rhea is a somewhat larger ice and rock satellite that also exhibits bright, wispy regions, dense cratering, linear grooves and troughs, and evidence for resurfacing. Its temperature was measured at 98 K just before it entered the shadow of Saturn. Inside the shadow, measurements yielded a temperature of about 75 K for part of the surface materials and substantially less for the remainder.

The masses of Hyperion and Iapetus are poorly known, so their densities are uncertain; it is likely that both are composed mainly of water ice. The two faces of Iapetus are very different in brightness, with the leading face only one-fifth as reflective as the trailing face. The observed distribution of surface brightness is remarkably consistent with the model proposed by Morrison *et al.* (*7*) on the basis of telescopic observations of brightness variations of Iapetus.

Titan. As the only satellite in the solar system known to have a substantial atmosphere, Titan was an important target for study. Before the Voyager 1 flyby of Titan, estimates of the atmospheric pressure at the cloud-obscured surface were uncertain by a factor of 100, ranging from 20 mbar to 2 bars, and estimates of surface temperature ranged from 80 to 200 K. Pioneer 11 found the diameter of Titan to be 5680 and 5760 km in red and blue light, respectively, but saw no markings in the clouds or haze (*5*).

Voyager 1 also saw a thick haze that completely obscured Titan's surface. A somewhat brighter southern hemisphere may be an atmospheric seasonal effect (Titan and Saturn entered a 7½-year-long southern autumn early in 1980). A dark hood was observed over Titan's north polar region. The highest resolution images, and nearly concurrent ultraviolet measurements of the sun's apparent brightness as Voyager 1 passed into Titan's shadow, indicated several detached haze layers up to 500 km above the more opaque atmospheric haze. The upper haze layers appear to be due to absorption of ultraviolet light by molecules; the lower visible haze contains particles about 1 μm in diameter. Voyager 1 radio signals penetrated the obscuring haze and revealed a solid surface 5140 km (3194 miles) in diameter. Combined with Titan's mass, this means that the density of Titan is nearly twice that of water, indicating a 50:50 mix of rock and water ice.

The atmospheric pressure at Titan's surface is 1.6 bars (60 percent more than at Earth's surface) and the temperature is ~ 93 K. The bulk of the atmosphere is nitrogen, with less than 10 percent methane at the surface and about 1 percent methane in the upper atmosphere. In addition to the known products of methane chemistry, such as acetylene, ethylene, and ethane, there is a measurable amount of hydrogen cyanide. That the hydrogen cyanide can be produced from nitrogen and methane by energetic electron chemistry is evidenced by ultraviolet dayglow of N_2, N^+, and N.

The surface temperature of Titan is near the triple point of methane, so that solid, liquid, or gaseous methane may be present, depending on season and latitude. The temperature decreases to a minimum of ~ 70 K about 40 km (25 miles) above the surface, ensuring the formation of methane clouds if there is more than 1 percent methane in the lower atmosphere. At higher altitudes the temperature increases to 160 K.

Titan has no intrinsic magnetic field and therefore does not have a liquid, electrically conducting core. Its atmosphere may be a source of the neutral hydrogen atoms that form a torus of particles encompassing the orbits of Titan and Rhea.

Magnetosphere. Pioneer 11 discovered that Saturn's magnetosphere was distinctly different from the magnetospheres of Earth and Jupiter. Voyager 1 first observed Saturn's magnetosphere in January 1980, when bursts of radio emission were detected with an average recurrence period of 10 hours 39.4 minutes and ascribed to rotation of the planetary magnetic field (*8*). The emission occurs when there is a specific orientation with respect to the sun and is further modulated with a 2.7-day period, the latter suggesting that Dione interacts strongly with the magnetosphere. Other discrete, low-frequency emissions suggest that other satellites may be involved in generation of radio emissions.

Although there was no detectable torus of ultraviolet-emitting ions, as discovered at Jupiter, there is a disk of plasma (hydrogen and possibly oxygen) extending almost out to Titan's orbit. The plasma is in nearly full corotation with Saturn's magnetosphere, with a speed of ~ 150 km/sec (330,000 miles per hour) at a distance of 17 R_S (Saturn radii; 1 R_S = 60,330 km) from the planet. Beyond 8 R_S the magnetic field was altered by the presence of large-scale electric currents flowing in an azimuthal direction.

On the outbound leg of its trajectory, Voyager 1 penetrated Saturn's magnetic tail, which has a diameter of about 80 R_S and is relatively devoid of plasma at higher latitudes. The field lines in the traversed region are closed, and copious fluxes of low-energy electrons are present. Higher-rigidity particles (for instance, protons with energies in excess of 2 MeV) are not stably trapped in the outer regions of the magnetosphere, however.

The close Titan flyby was designed to permit detailed study of the Venus-like interaction between the corotating magnetosphere and Titan. This interaction results in Titan having an induced magnetic field and a dipolar magnetic tail. The plasma turbulence resulting from the interaction may generate radio waves and contribute to the energetic particle chemistry in Titan's atmosphere. In the wake there is evidence for a plume of material (ionized hydrogen and nitrogen) stripped from the top of Titan's atmosphere. The Titan interaction may also contribute to the complex character of the region outside 18 R_S.

Shadowing and absorption effects by Titan were also observed in the energetic particle fluxes during the close Titan flyby. The source of the energetic particles is in the outer edges of the magnetosphere, and an underabundance of helium indicates that the source material is not of solar-wind origin. Energetic molecular hydrogen is also present, presumably accelerated from Saturn's or Titan's atmosphere.

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References and Notes

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10. Without the dedicated and enthusiastic efforts of a large number of Voyager Project personnel, many of whom spent untold amounts of personal time during evenings and weekends to meet deadlines in a crowded sequence preparation schedule, the successful Saturn encounter of Voyager 1 would have been impossible. Special thanks are due to J. Diner for her efforts as Saturn Science Coordinator and for her contributions to this overview paper. The Voyager Program is one of the programs of the Planetary Division of NASA's Office of Space Science. The Voyager Project is managed by the Jet Propulsion Laboratory of the California Institute of Technology under NASA contract NAS 7-100.

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Encounter with Saturn: Voyager 1 Imaging Science Results

Abstract. *As Voyager 1 flew through the Saturn system it returned photographs revealing many new and surprising characteristics of this complicated community of bodies. Saturn's atmosphere has numerous, low-contrast, discrete cloud features and a pattern of circulation significantly different from that of Jupiter. Titan is shrouded in a haze layer that varies in thickness and appearance. Among the icy satellites there is considerable variety in density, albedo, and surface morphology and substantial evidence for endogenic surface modification. Trends in density and crater characteristics are quite unlike those of the Galilean satellites. Small inner satellites, three of which were discovered in Voyager images, interact gravitationally with one another and with the ring particles in ways not observed elsewhere in the solar system. Saturn's broad A, B, and C rings contain hundreds of "ringlets," and in the densest portion of the B ring there are numerous nonaxisymmetric features. The narrow F ring has three components which, in at least one instance, are kinked and crisscrossed. Two rings are observed beyond the F ring, and material is seen between the C ring and the planet.*

Saturn is one of the five planets that were known to the ancients. The modern exploration of the system of rings and satellites about this planet began in July 1610 with Galileo's initial telescopic observations (*1*, *2*). Many additional discoveries were made in the 17th century, including Huygens' realization that Saturn was encircled by rings and his discovery of its largest satellite, Titan. The astronomer Cassini discovered Iapetus, Rhea, Dione, and Tethys and first observed the division in the rings that is named after him. He also correctly concluded that the leading hemisphere of Iapetus is much darker than the trailing hemisphere.

Three centuries later, the unmanned U.S. spacecraft Voyager 1 examined the Saturn system at close range with an imaging system (*3*) that is a direct descendant of the early telescopes of Galileo, Huygens, and Cassini. During its closest approach to Saturn in November 1980, Voyager 1 made observations of the planet and its rings and satellites. Some of the satellites were observed with resolutions approaching 1 km, an improvement of almost three orders of magnitude over ground-based observations and two orders of magnitude over Pioneer 11 images (*4*). Voyager recorded surface detail for the first time on eight satellites. It discovered several new satellites and revealed hundreds of components of the ring system, perhaps six of which were known previously. In addition, the images revealed many new phenomena in Saturn's atmosphere. In all, several tens of billions of imaging bits were returned in the few days around closest approach to Saturn—more information than was obtained in the entire previous history of human exploration of this system. This has enabled the greatest leap forward since the 17th century in knowledge about the Saturn system.

Saturn's atmosphere. Imaging Saturn is more difficult than imaging Jupiter, both because of the lower intrinsic contrast of features and because of the lower light levels at Saturn's greater distance from the sun (9.5 versus 5.2 AU). Visually, Saturn's atmosphere differs from Jupiter's in that it has lower contrast and fewer conspicuous features (Fig. 1). Winds are about four times stronger on Saturn, reaching two-thirds the speed of sound near the equator (Fig. 2). Its eastward and westward (zonal) jets are two to four times wider and, unlike Jupiter's jets, bear little relation to its overall banded cloud structure. The external parameters that govern both atmospheres are generally similar; only a few are substantially different. By comparing the dynamics of Jupiter and Saturn's atmospheres we hope to better understand the relative importance of the parameters that influence atmospheric characteristics.

Figure 2 shows measured zonal velocity as a function of planetographic latitude. The measurements were made with the AMOS interactive computing system at Jet Propulsion Laboratory (*5*) and the MCIDAS system at the University of Wisconsin (*6*); similar results were obtained at University College London. In generating the Saturn wind profile of Fig. 2 both systems employed user-identified cloud features. Feature position was measured in two frames separated by a known time interval, and the displacement interpreted as a wind vector. Although the possibility of misidentifying wave phase velocities as mass motions (wind vectors) clearly exists, for Jupiter there is no difference between motions of features 50 km in size and those 100 times larger (*7*). Since atmospheric waves tend to be highly dispersive (phase speed tends to depend on wavelength), this agreement indicates that actual mass motions are being observed. For Saturn we base this assertion on far

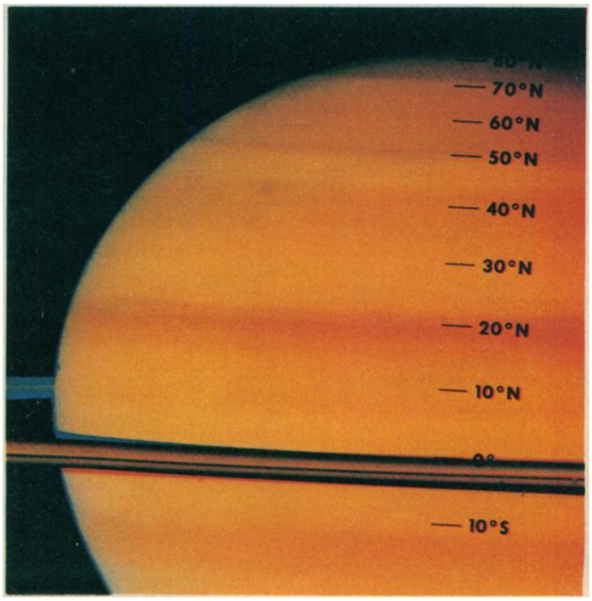

Fig. 1. Color image of Saturn's northern hemisphere. The low contrast is evident when one considers that the part of the planet in the center of the image has more features than any other region on Saturn. The dark North Equatorial Belt is located near 20°N, the more active North Temperate Belt at 40°N. The rings obscure the equator and the region southward. Latitudes are planetographic in all figures.

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