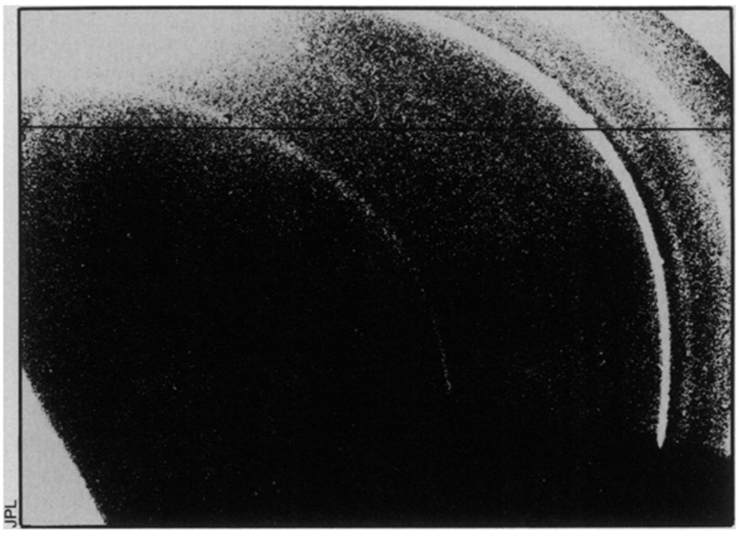
Voyager 1: Titan and other wonders

The scientists who met recently at the NASA Ames Research Center in California to discuss the Voyager 1 spacecraft's long-awaited findings about Saturn's big moon Titan (SN: 12/13/80, p. 375) were a frustrated lot. For still missing from their new treasure trove of data, they believed, were perhaps the most eagerly awaited results of the entire encounter: the surface pressure and temperature of the only substantial atmosphere known to exist around a planetary satellite. Radio measurements had initially shown a maximum pressure of 1,500 millibars — half again greater than earth's — at a temperature of about −181°C (assuming a pure nitrogen atmosphere, although Titan's would include a few percent of methane). But that initial batch of data was so "noisy" at the higher pressures that it was hard to tell whether the radio beam had really reached the surface or simply been absorbed by the dense gas at some unknown altitude. It would take additional data to be sure, and the researchers expected to face weeks of impatient waiting.

Yet, unknowingly, they already had their answers. Mere days after the meeting, the new data arrived, and although details of the atmosphere's vertical structure remain to be analyzed, it was immediately clear that the earlier probing had "struck bottom" after all. And just as readily, pieces of the Titan puzzle began to fall into place.

Its radius, hidden by the atmosphere from optical measurement, turns out to be 2,560 kilometers, indicating (from its mass effect on Voyager 1's flightpath) a density of 1.92 grams per cubic centimeter — barely a third that of earth and almost identical with that of Jupiter's moon Ganymede (which also seems to be the only larger moon in the solar system). This gives Titan only about 14 percent of earth's gravity, says Stanford University's Von R. Eshelman, which means that an atmosphere with 1.5 times earth's surface pressure is also more than five times as dense.

Particularly intriguing is the atmospheric surface temperature, which lies almost exactly at the "triple point" of methane — the temperature at which methane can exist as a solid, a liquid or a gas. The data so far leave room for as much as 10 percent methane at the surface, says Tobias Owen of the State University of New York at Stony Brook, and 7.8 percent methane, according to Eshelman, would place the triple point only 1.3°C below the calculated "pure-nitrogen" temperature. This, Owen notes, could mean that Titan is "locked" to its present temperature, since considerable changes in the amount of energy reaching the surface would go into changing the methane from one state to another before the temperature shifted appreciably. And even actual temperature changes could be "self-limiting": A slight warming, for example, could turn some liquid methane to gas, which would rise and freeze into a crystalline "ice fog" in the cooler atmosphere overhead, in turn keeping more sunlight from the surface and lowering the temperature again.



Saturn's D-ring, conclusively shown for the first time in this Voyager 1 photo, extends from the inner edge of the brighter C-ring (upper right) at least halfway to the planet (lower left). Saturn's shadow crosses D-ring at lower right.

Given the small day-night and equator-to-pole temperature differences likely in the dense gas, plus the limited seasonal variations at such a great distance from the sun, winds in Titan's lower atmosphere are probably slow at most. As for clouds and such, says Owen, methane is likely to be the whole show (except for whatever organic molecules may form at the top of the atmosphere and drift to the bottom). It's too warm for liquid nitrogen, he says, even at the roughly 30-to-60-km altitudes where Eshelman sees temperatures down to −202°C (again calculated for pure nitrogen but probably not very different with the maximum 2 percent methane possible at those levels), and too cold for ammonia (presumably the early source of the nitrogen) to do anything but lie frozen on the ground.

Titan, however, is not Saturn's only surprising satellite. Dione, reports Frederick L. Scarf of TRW Inc., shows signs that it may be acting as an on-off switch for some of Saturn's radio emissions, possibly in a way similar to the imperfectly understood process by which some of Jupiter's powerful emissions seem to be controlled by the position of Io. Signals intermittently detected by Voyager 1's instruments at frequencies of 50 to 60 kilohertz, says Scarf, seem to occur primarily when Dione is facing Saturn's "dawn quadrant" — the sunward portion of the hemisphere that faces ahead in the planet's orbital movement. In fact, he says, the "signature" of Dione's 66-hour orbital period shows up as clearly in those emissions as does Saturn's own rotational period in its higher-frequency signals.

Such an effect would strongly suggest Dione to have an ionosphere, and data from the Pioneer 11 spacecraft's Saturn flyby of 16 months ago show a peak in the density of Saturn's charged-particle "plasma" at the radial distance of Dione's orbit, as if Dione could be a source of the particles. (Another peak was reported at the orbit of Tethys, and a few of the 50-to-60-kHz radio bursts fail to match exactly with Dione's orbital period. Scarf has not yet sought a Tethys link.) Scarf also notes the "wispy" features seen on part of Dione's surface and tentatively linked by other researchers with possible "outgassing" of volatile material from the satellite's interior, implying a possible mechanism for providing particles to an ionosphere.

Then, of course, there are the rings. A lately noted Voyager 1 photo has turned out to confirm the existence of the controversial "D-ring" inside the more visible ring structure. Earth-based observers have been citing various evidence for its existence for more than a decade, but the photo, says Richard J. Terrile of Jet Propulsion Laboratory, shows it to be so faint that "it's very *very* unlikely that this ring was ever seen from the ground." Even so, the image reveals thin "ringlets" and other details in the D-ring, which extends from the inner edge of the C-ring at least halfway in to Saturn's cloudtops.

Another recent surprise came when scientists were searching through the photos for a skinny, unknown ring believed to have cast a stripy shadow on the surface of one of two nearly co-orbital moons (S-11) circling just beyond the main ring system. They found one, and labeled it the G-ring (SN: 11/22/80, p. 327), but analysis now indicates that ring to be outside the little moon's orbit, while the shadow-maker would have to be just inside — still waiting to be discovered.

Then there's the Pioneer 11 finding, by the University of Chicago's David L. Chenette et al., that the rings, which chop off Saturn's inner radiation belts like a guillotine, seem to give off their own charged particles from cosmic-ray bombardment. There'll be more — and Voyager 2. □