A spectral line of atomic deuterium

Atomic hydrogen emits a characteristic radio signal at about 21 centimeters wavelength. The discovery of this 21-centimeter line in radio waves coming from interstellar space enabled astronomers to map the interstellar hydrogen clouds and gave them an entirely new picture of our galaxy.

The discovery of the analogous line from deuterium, one of the heavy isotopes of hydrogen, has now been announced by Diego A. Cesarsky and Alan T. Moffet of the Owens Valley Radio Observatory of California Institute of Technology and Jay M. Pasachoff of Williams College-Hopkins Observatory. The deuterium line is at 91.6 centimeters wavelength. (In December the discovery of deuterium in an interstellar compound, deuterated hydrocyanic acid, was announced, SN: 12/16/72, p. 390.) Comparison of the abundances of hydrogen and deuterium can give information about the origin of the universe.

Deuterium is very much less abundant than hydrogen, and this rarity led to disappointingly negative results in previous attempts to find the deuterium line. It probably also discouraged others who would have made the search. Cesarsky, Moffet and Pasachoff looked in the direction of the center of the galaxy, where the hydrogen is expected to lie most thickly in the line of sight. The observations were done between March and August 1972 at Owens Valley.

The relative abundance of deuterium to hydrogen is an important datum for cosmologists who believe in big-bang theories. According to such theories, there was a time when deuterium was manufactured out of protons and neutrons in the primeval material. As galaxies formed, much of this deuterium condensed into stars. Since deuterium is a prime fuel for the thermonuclear processes that produce heavier nuclei, astrophysicists believe that all of it that condensed into stars and any that may have been produced within them was used up. Any deuterium remaining in interstellar space would come from the primeval production.

To obtain a deuterium/hydrogen ratio from the newly reported observations requires making certain assumptions about the temperature and density of the clouds in which the deuterium lies. These produce a range from 1/2,000 to 1/40,000. The largest amount of remanent deuterium permitted by big-bang theory gives a ratio of about 1/50,000, roughly compatible with one end of the range. The results are thus not inconsistent with a big-bang theory. □

Titan: Volcanoes and an organic rain

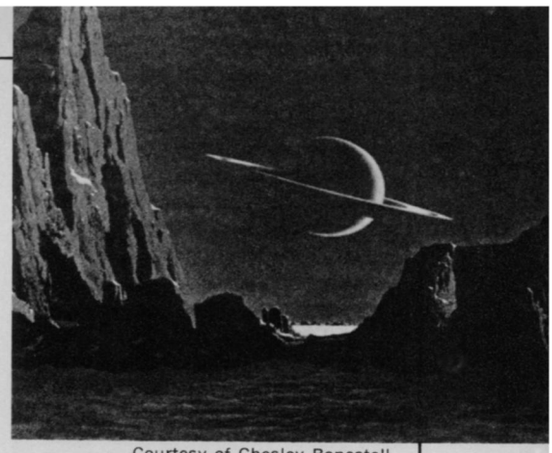
According to new observational and theoretical work by Carl Sagan and Joseph Veverka of Cornell University, Saturn's largest satellite, Titan, has an atmosphere very like that possessed by earth at an early point in earth's evolution.

Titan, about the size of Mercury, has been known since 1944 to have an atmosphere containing methane. Astronomers believed the amount of gas in the atmosphere was very small. But lately intrared observations have shown that the satellite is warmer than it ought to be considering the amount of radiation it can absorb at its distance from the sun.

Sagan proposes that the extra heating is due to a greenhouse effect, the same effect that keeps earth's temperature above freezing and makes Venus very hot. It demands an atmosphere with constituents that are transparent to solar radiation in the visible part of the spectrum but are opaque to the intrared in which the energy is reradiated by the planet. The solar energy can get in to the planet's surface, but reradiated energy is strongly trapped by the atmosphere. In the cases of Venus and earth, water and carbon dioxide are prominent greenhouse constitutents. For Titan. Sagan suggests molecular hydrogen.

A Titan greenhouse would require large amounts of molecular hydrogen, but astronomers have noted little hydrogen on Titan. Sagan gets around this by suggesting that most of it is masked by a layer of dense clouds. Veverka has found evidence for such clouds. Observing sunlight reflected from Titan, he notes that the polarization characteristic of light reflected from a solid surface is absent, suggesting that the radiation is reflected from clouds.

Sagan suggests that the hydrogen comes from the interior of the satellite. Beneath the solid surface, he supposes, are hot regions containing liquid methane, ammonia and water. These come through the surface by volcanic action. Spewed forth into the atmosphere, the water, methane and ammonia are broken down into two major products: molecular hydrogen and organic compounds, particularly a reddish-brown polymer that is produced in such reactions in the laboratory. In fact, the clouds of Titan are found to be very red. Hydrogen, methane and ammonia in gaseous form are all colorless.



Courtesy of Chesley Bonestell

Painted view from Titan: Sagan's new evidence would 'cloud' the landscape.

Thus the emerging picture of Titan is one in which volcanoes are constantly spewing water, ammonia and methane into the atmosphere while organic compounds rain down to the surface. Sagan believes Titan may be warm enough to support some primitive forms of life in spite of its average distance from the sun of 890 million miles. If not, its surface should at least be littered with organic compounds such as covered earth in the days before life began.

Sagan and Veverka believe that Titan should be a prime target for space probes. They propose it should be closely scrutinized by both flybys and landers.

Titan isn't the only satellite evoking new interest. In the Dec. 8 SCIENCE Carl B. Pilcher of Massachusetts Institute of Technology, Stephen T. Ridgway of the State University of New York at Stony Brook and Thomas B. McCord of MIT reported that they have conclusively identified absorptions due to water frost in the infrared reflectivities of two of Jupiter's satellites, Europa and Ganymede. There is also a possibility of water frost on Io and Callisto. The observers calculate that Europa is 50 to 100 percent frost-covered, Ganymede between 20 and 65 percent and Callisto possibly 5 to 25 percent. Io is anomalous. Its spectrum resembles that of Callisto, but its visible reflectivity is three times as high. This leads the researchers to conclude that if frost is present on Io the ice particles must be smaller than on the others. This would allow them to reflect more visible and infrared but without the typical absorption bands. The work further supports the idea that water is a constituent of the bodies of the outer solar system, which was borne out by the discovery in 1970 of water ice in the rings of Saturn.