

## SCIENCE NEWS OF THE WEEK

# Sorting Out the Saturn System

Some of the researchers trying to analyze the Voyager 1 spacecraft's voluminous and exciting data about Saturn, its rings and moons have had relatively little time for the task, what with presenting the early results at scientific meetings and rushing to prepare a preliminary report on them for a journal. New findings are emerging, however, and they range from the core of the planet out to its distant satellites.

**The planet:** Like Jupiter, Saturn gives off more heat than it receives from the sun. In Jupiter's case, the excess can be explained by compression due to the massive world's gravity. Saturn, however, is far less massive. One pre-Voyager idea was that the excess could be caused by the helium in Saturn's gassy structure settling to the bottom of the lighter-weight hydrogen, leaving a helium depletion that might show to Voyager's instruments. In the frantic activity surrounding last November's Saturn flyby, scientists first thought Saturn to have about the same helium percentage in its outer layers as does Jupiter, about 19 percent, leaving the smaller world's warmth a mystery. Refined analysis, however, has now lowered the Saturn measurement to 11 percent — just about what the helium-hydrogen separation idea would predict, providing tentative confirmation of a totally different way of heating a planet's insides.

Another of Saturn's inner mysteries has been that the axis of its magnetic field, instead of being tilted about  $10^\circ$  like those of other planets known to have intrinsic fields, is virtually straight up. This one is still a puzzle (though the reason for the tilts in the other cases is equally elusive), but researchers have at least succeeded in measuring the tiny angle of the Saturnian field's tilt: a mere  $0.7^\circ \pm 0.3^\circ$ .

Newer discoveries, meanwhile, continue to be made, as scientists get time to reexamine photos and other data that could only receive a glance in the initial rush. Mere days ago, Allan F. Cook of the Harvard-Smithsonian Center for Astrophysics discovered a previously unsuspected layer of extremely high-altitude haze visible along portions of Saturn's limb or edge. Some 60 kilometers thick, the layer looms about 150 km above the much denser layer that is believed to contribute to Saturn's bland appearance by masking its colored bands. "It takes a gross increase in temperature to raise something that high," says Cook, yet the smooth layer shows no signs of the turbulence that would indicate it to be uplifted by convection from within the planet, and the sun's heat, he believes, is too weak for the job at Saturn's great distance. Perhaps, Cook suggests, the magnetosphere plays



High haze layer tops parts of Saturn's atmosphere.

some role, possibly heating the top of the atmosphere by bombarding it with charged particles, but "there's no similar phenomenon at Jupiter, where the magnetosphere is much more active." The high layer seems to be localized, existing in isolated regions rather than surrounding the planet, and some Voyager photos show it to be absent from regions where it was formerly seen. Another Saturnian quandary.

**The rings:** Two of Voyager 1's greatest Saturn mysteries—the spoke-like features in the wide B-ring and the seemingly braided, multi-stranded-F-ring — have drawn scores of tentative hypotheses from scientists around the country and abroad, but there is yet no widely accepted explanation for either phenomenon. Detailed study of the spokes, in fact, has made them more perplexing still: Early looks at the photos led researchers to think that the spokes remained radial to Saturn as they traveled around the ring when they should have been progressively "slanted" by the differing orbital speeds of ring particles near and far from the planet. The idea then evolved that the spokes remained radial because they were in some way related to the planet's magnetic field, and this in turn

suggested various possible ways in which the strange features might be formed. Now, however, Voyager scientists have found that the spokes do, in fact, slant — which sends the researchers back to square one in trying to understand what causes them. The F-ring's "braids," meanwhile, are even more baffling. The F-ring is extremely narrow, apparently kept that way by two tiny satellites that orbit just inside and outside it, and the University of Arizona's Bradford Smith suggests that the braiding may be related in part to some gravitational perturbation caused when the little moons exactly straddle the ring. Voyager 2, due to pass Saturn in late August, will photograph the F-ring exhaustively, but the answer may still be a long time coming.

**The moons:** Photos showing a lack of large impact craters on part of Saturn's moon Rhea prompted the suggestion last November that solar-system objects may have been subjected to more than one major episode of meteorite bombardment (separated by periods of resurfacing), rather than the one "great bombardment" often cited. Inferred from only one moon, the idea met with some skepticism, but scientists have since identified similar evidence on Mimas and Dione. □

## White dwarf stars that make pulsars

Pulsars are supposed to be neutron stars. Those that pulse in X-rays have so far been neatly explained as neutron stars residing in binary systems in which the two stars are very close together. A neutron star is unbelievably condensed: As massive as the sun, it may be only 20 kilometers in diameter. Such density means a fantastically strong gravitational field and a formidable magnetic field. The gravitational field pulls material from the neutron star's companion. The magnetic field channels it to the magnetic poles of the neutron star. As the infalling matter crashes into the atmosphere or the surface of the neutron star, X-rays are generated. We see them in pulses as the poles of the rotating neutron star cross our line of sight.

It's a neat theory, except that now there are two X-ray pulsars that seem to have white dwarfs as the active members of the binary. Both were studied with the Einstein observatory satellite. A report on AE

Aquarii was published a short time ago by Joseph Patterson, D. Branch, G. Chincarini and E. L. Robinson of the Harvard-Smithsonian Center for Astrophysics. Now comes H2252—035, discussed in the most recent *ASTROPHYSICAL JOURNAL LETTERS* (vol. 243, p. L83) by Patterson and Christopher M. Price of the University of Michigan.

White dwarf stars are hardly rare as members of binary systems, but they should not have the gravitational and magnetic fields necessary to channel infalling material with the precision of a pulsar. In fact, there is evidence that material from their companions comes to them erratically: Their optical or X-ray brightness fluctuates in a disorderly way, as though matter were now falling on them and now not. From this characteristic they are known as cataclysmic variables. Cataclysmic variables are not expected to act as pulsars, but here are two that seem to. H2252 — 035, as Patterson and Price

point out, presents an interesting tale of three periods. There is a 3.6-hour variation in the overall output of visible light and in the wavelengths of prominent lines of the object's spectrum. There are also an optical pulsation superimposed on the other optical output every 14.3117 minutes and the X-ray pulsation every 13.415 minutes. The 3.6-hour period is identified with the orbital period of the binary system.

What is more interesting is that 3.6 hours happens to be also the *beat* period between the periods of the optical and X-ray pulses. That finding leads Patterson and Price to suggest that the optical pulses arise in the atmosphere of the companion star as an X-ray beam from the white dwarf hits it. They are so-called reprocessed radiation. The overall photometric variation with the 3.6-hour period also represents radiation from the companion star. In addition to producing a sharp pulse of reprocessed radiation, the X-rays heat up a hemisphere of the companion star, and light is produced by that heating. The brightness varies because we on earth see more or less of the heated hemisphere depending on where in its orbit the white dwarf is located at any moment. Finally, there is the 805-second or 13.415-minute X-ray pulse period. This indicates that a highly magnetized body is efficiently channeling the infall of accreting material. One would expect a neutron star in that role. Yet the underlying photometric and spectroscopic character of the object under study is that of a cataclysmic variable. Furthermore, the general ratio of X-ray to optical output is characteristic of a cataclysmic variable. "These considerations definitely favor a white dwarf identification," the observers write. □

## Snuff and cancer

Sniffing or dipping snuff rather than smoking tobacco may reduce the risk of getting lung cancer, but it may increase the risk of cancer of the mouth and throat, according to a report by Deborah M. Winn of the National Cancer Institute in Bethesda, Md., and her colleagues in the March 26 NEW ENGLAND JOURNAL OF MEDICINE.

Women in the rural Southeast United States have far more mouth and throat cancers than do women in other areas of the United States. These women also use far more snuff than do the latter, suggesting that snuff might be the cause of their cancers. Winn and her team studied the snuff habits of 255 North Carolina women with mouth and throat cancer and compared them with 502 control subjects. They found that 46 percent of the cancer victims had been snuff users, compared to only 30 percent of the control subjects. Or, looking at the data another way, snuff users increase their risk of mouth and throat cancer from 4 to 50 percent, depending on how long they use snuff. □

## Cricket teratogen in synfuels wastes

A contaminated waste byproduct of synfuel production, or coal gasification and liquefaction, causes the development of cricket "monsters"—insects with extra heads and compound eyes and antennae. The teratogenic, or birth-defect-causing, property of the impurity is reported in the April 3 SCIENCE by Barbara T. Walton of Oak Ridge National Laboratory (ORNL) in Tennessee.

Walton found the one or more contaminants that cause abnormal cricket development in the chemical acridine ( $C_{13}H_9N$ )—a three-ringed structure found in coal, in the coal-tar waste byproducts of the synfuel production process and probably in synfuels themselves. The ORNL researcher moistened sand with solutions of commercial samples of acridine and then allowed the female crickets (*Acheta domestica*) to deposit eggs on that substrate. The resulting embryos had extra compound eyes. Walton then discovered that while purified acridine caused no deformities, eggs treated with a mixture of the acridine contaminants resulted in the two-headed, branched antennae, three- or four-eyed crickets.

The abnormalities caused by the teratogen resemble deformities observed by another researcher who had seared the tips of damselfly eggs. This suggests that the mechanism of teratogen activity involves killing cells prior to the formation of the embryonic germ band and that there is a specific time of chemical entry—perhaps during the first period of water uptake in the cricket eggs.

But little else is known about the mysterious teratogen, and research continues in an attempt to isolate and characterize the impurity or impurities in acridine. Meanwhile, Walton also has discovered that treating cricket eggs with synfuels also causes abnormal insect development.

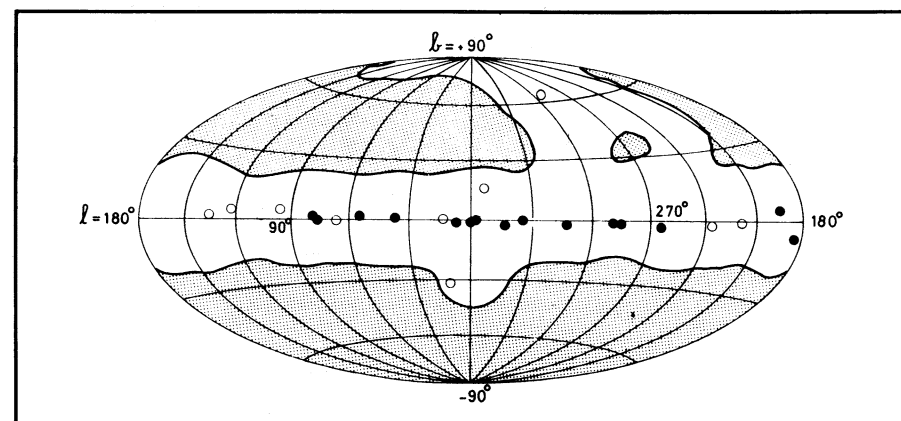


Extra compound eye in cricket treated during egg stage with acridine contaminant.

"We still don't know if the impurity from acridine is the same chemical from synfuels that produces the effect," Walton says, so her research involves not only analyzing acridine impurities, but also synfuel components. Future research will attempt to determine whether both teratogens produce the same effect in higher animals and whether they should be removed from the synthetic fuel process.

The significance of Walton's research extends beyond its obvious potential implications for the future of synfuels. "This finding underscores the necessity for complete chemical characterization of mixtures subjected to toxicological assays because a minor component can assume major significance in producing a response," Walton explains. "In a more positive light, however, this teratogen offers possibilities as a new tool for exploring cellular events in embryonic development, such as determination of cell fate, pattern formation and possibly the role of cell death in morphogenesis." □

## 2nd Cos B gamma-ray source catalog



The 25 newly found sources are black and white circles on this sky map. Twenty-one cluster along the plane of our galaxy and may represent a new class of object.

Swanenburg et al./Ap. J. Letts