time since Saturn's signals could be separated from the more powerful emissions of Jupiter), Michael L. Kaiser and Michael D. Desch of the NASA Goddard Space Flight Center and colleagues originally reported a period of 10 hours 39 minutes 54 ± 18 seconds. Correcting a computer error, says Desch, showed the actual uncertainty of the number to be larger — ±36 seconds. More than six months of data have now been analyzed, however, and not only has the precision of the calculation improved, but it has shifted slightly, to $10^h39^m24 \pm 9^s$. This does not mean that the planet has speeded up, Desch points out, but merely that it is difficult to pinpoint Saturn's rotation "signature" in the noisy radio data. A comparison of different timespans in the data shows the period to be stable to within 1 second per rotation (it is probably even "tighter"), even though the measurement itself is known only to within 9 seconds per rotation. By a year after Voyager 1's Nov. 12 flyby of Saturn, says Desch, the rotation speed too should be known to within a second. (The period of Jupiter, by comparison, established from a quarter-century of earth-based radio observations, is now known to within a second in about three weeks, and pulsars have been measured as accurately as a second in about two and a half years.)

Several years ago, radio signals detected by the earth-orbiting IMP-6 satellite were reported as possibly being from Saturn, and consistent with a roughly 9.5-hour period for the planet (SN: 12/14/74, p. 372). They were at a higher frequency than the ones detected by the Voyagers, and intense enough (if they were indeed from Saturn) for the Voyagers to have seen them too. But the Voyager group reports in the Sept. 12 SCIENCE that no such frequencies have been seen. One possibility is that Saturn's emissions are "tightly beamed," which could mean that frequencies detected by IMP-6, facing the planet's southern latitudes, do not show in the northern-hemisphere viewpoint of the Voyager data. Or the IMP-6 detections may not have come from Saturn at all. Since that report, it has been concluded that when IMP-6 was picking up simultaneous emissions from two sources, it might indicate a single source whose direction corresponded to the intensity-weighted mean angle between the two actual locations. It is possible, according to the Voyager group, that the IMP-6 data may have represented "a signal coincident with the Saturn direction which was formed by a combination of signals from Jupiter and earth (or perhaps the sun)."

But even if not readily detectable from earth, Saturn is still a powerful radio beacon. If the planet were as close to earth as the "standard earth-Jupiter opposition distance" of 606 million kilometers, the authors report, its emissions at 250 kilohertz would be as intense to a terrestrial observer as the 8-MHZ peak in Jupiter's broadcasts. □

Neutrinos to iron out cosmic problem

Neutrino oscillations are beginning to shake up physics. "Neutrino oscillations" is the term for the apparent ability of one and the same neutrino to change its identity back and forth among two or more of the identities available to neutrinos. For the moment those identities number three: electron neutrinos, muon neutrinos and tau neutrinos, each named for another particle that the given neutrino accompanies in the reactions and interactions where it plays a part.

It has generally been believed that a neutrino born with a certain identity kept that identity throughout its existence. Now it seems they may be able to oscillate from one to another. Theorists are beginning to examine the consequences of such uncertain identity. One cosmological consequence is discussed in the Sept. 15 PHYSICAL REVIEW LETTERS by A. De Rújula of Massachusetts Institute of Technology and Sheldon L. Glashow of Harvard University.

Since the existence of the neutrino was first hypothesized, about 1930, physicists have believed that the neutrino's mass (and so the neutrino itself) would vanish if it ever came to rest. It had zero rest mass. Not if it can oscillate. Now it must have some rest mass. (The requirement springs from the long-recognized dual nature of every bit of matter: It is at the same time a particle and a packet of waves. For the waves of oscillating neutrinos to behave properly the particles have to have rest mass.)

If neutrinos have rest mass, they may be useful cosmologically. As De Rújula and Glashow point out, the universe and the galaxies in it need more mass than they show in observable matter and electromagnetic radiation. Studies of the velocities and distances of far-off galaxies lead to the conclusion that the space of the universe is very nearly flat, but the universe exhibits only half the mass that is dynamically necessary to achieve such flatness. Studies of the rotations of galaxies and the motions within them also lead to the conclusion that the galaxies generally need more mass than they show to maintain their stability against disruption.

Neutrinos with rest mass could very well solve both aspects of this "missing mass problem," De Rújula and Glashow propose. The original big bang should have left us with as many neutrinos as it did photons, the particles of the universal black body radiation. If some of the neutrinos are slightly heavy they could solve both aspects of the missing mass dilemma by clustering as haloes around galaxies.

Calculations that combine gravitational theory with quantum statistics lead to the conclusion that the heavy variety of neutrino postulated here should have a rest mass of at least 24 electron-volts, huge for a neutrino, but minuscule compared to other particles (an electron's is 511,000 electron-volts). A massive neutrino, if that can be called massive, should also be subject to radioactive decay. Yet for these heavy neutrinos to have survived from the big bang in large numbers, their average lifetime must be greater than 10^{10} years, the age of the universe. Other considerations raise it to 10^{16} years.

In spite of that long life (which is a statistical average), some of these neutrinos are decaying all the time, and when one does, it sometimes yields a lighter neutrino and a photon of ultraviolet light. The final kicker in this story is that the ultraviolet from this source coming from our galaxy or the Andromeda galaxy might be on the verge of being detectable. □

Scanning bubbles from the deep

A small probe is attached to a scuba diver's chest shortly after the diver surfaces. On a screen connected to the probe, researchers view what appear to be tiny BBs moving through opening and closing valves.

Using the recently engineered "two-dimensional ultrasound phased array sector scanner," these researchers are watching in real-time as gas bubbles move through the heart of a potential victim of decompression sickness. According to the accepted theories of diving medicine, decompression sickness, or "the bends," can strike a diver who surfaces too rapidly from a deep dive of long duration (see p. 187). When a diver goes deep, the gas breathed under pressure is pushed into the bloodstream in liquid form. The longer the diver stays at a deep level, the more gas dissolves into solution. But when the diver begins to surface, ambient pressure is lowered, and the gases in the blood start to come back out. If the unloading process is hurried along, not allowing the gas enough time to slowly diffuse out of solution, the gas forms bubbles. The bubbling phenomenon is similar to the carbon dioxide fizzing that occurs when a bottle of champagne is uncorked. In the diver, the "fizzing" includes formation of nitrogen bubbles that can collect at the joints, causing pressure on the nerves and resulting in pain. In addition, researchers now say the interface between the surface of the bubble and the blood may activate clotting factors and cause capillary leakage. In extreme cases of the bends, paralysis, unconsciousness and eventual death can result.

To better understand the lead role gaseous bubbles play in decompression sickness, Richard D. Vann, Olaf von Ramm and colleagues of Duke University Medical