Radio Pulses Hint at Unseen Planets

Amid radio signals emitted by a pulsar lying a mere 1,600 light-years from Earth, two U.S. astronomers have found evidence that two, or possibly three, unseen planets may orbit this dense, rotating star. Their report comes less than six months after astronomers at the University of Manchester in England announced that they had inferred the existence of a planet-like mass orbiting another Milky Way pulsar (SN: 7/27/91, p.53).

If further studies indicate that planet-like objects routinely form around pulsars, "we may be beginning [to uncover] a whole new branch of astrophysics," says Aleksander Wolszczan of the Arecibo Observatory in Puerto Rico, who made the new pulsar finding.

He and Dale A. Frail of the National Radio Astronomy Observatory in Socorro, N.M., who conducted follow-up observations of the pulsar, detail their work in the Jan. 9 NATURE.

Wolszczan made his initial discovery in February 1990, during a seemingly inopportune observing session at Arecibo. With support equipment shut down for routine maintenance, the observatory's radiotelescope lacked the ability to do long-term tracking of astronomical targets. Nonetheless, the astronomer managed to find two previously undiscovered millisecond pulsars — compact objects, known as neutron stars, that rotate thousands of times per second.

Radio emissions from one of the pulsars, called PSR1534+12, have helped to verify key predictions of Einstein's general theory of relativity, Wolszczan and several coauthors note in a separate article in the Jan. 9 NATURE. The other pulsar, PSR1257+12, is proving at least as intriguing, thanks to quasiperiodic fluctuations in the arrival times of radio waves emitted by this resident of the Virgo constellation.

Normally, millisecond pulsars flash like lighthouse beacons, beaming radiation toward Earth at regular intervals. But some of the radio waves emitted by PSR1257+12 reach Earth about three thousandths of a second sooner than predicted, while others arrive about three thousandths of a second later than expected. This suggests that the pulsar wobbles in space — sometimes moving slightly closer to Earth and sometimes receding slightly — in a nearly periodic fashion.

What might cause this peculiar wobble? Wolszczan and Frail assert that the gravitational tug supplied by unseen planets orbiting the pulsar best explains the motion.

After analyzing some 4,000 radio signals from the pulsar, recorded during the past 18 months at Arecibo, the two researchers conclude that one of the proposed planets would orbit the pulsar at a distance of about 53,800,000 kilometers, with an apparent orbital period of 66.6 Earth-days. The other would orbit at around 70,300,000 kilometers, with a period of 98.2 Earth-days. Each body would have a mass roughly three times that of Earth, Wolszczan and Frail assert.

A slight extra wobble in the pulsar — which the researchers detected by comparing the Arecibo data against observations made with the Very Large Array radiotelescope near Socorro — suggests that a third planet may orbit the pulsar. This object would resemble Earth in terms of period, mass and orbiting distance, Wolszczan says.

He and Frail say they have ruled out "star quakes" — motions originating within the pulsar — as an explanation for the wavering radio signals. Some researchers have suggested that star quakes might explain the far simpler, perfectly periodic wobble in the pulsar described by the Manchester team last summer. But star quakes can't easily produce the complex, quasiperiodic variation in the radio pulses emitted by the newly discovered pulsar, Wolszczan says. And while a youthful quake or two might occur in the previously described pulsar, only a few million years old, the more recent discovery — about 100 times older — would likely undergo little internal motion, he adds.

The new work "adds credence to the whole notion that some pulsars have planets," says Stanford E. Woosley of the University of California, Santa Cruz. "Probably almost everyone will now believe that there are objects orbiting some pulsars having masses comparable to terrestrial planets."

Furthermore, he says, if pulsar-orbiting planets can form — possibly representing the remnants of a massive companion star that might have once whirled around the pulsar — then it's likely that asteroid-sized objects also form, and even slam into the star. And if such jolts were to occur routinely in pulsars throughout the cosmos, they might generate bursts of gamma rays that could account for the energy and distribution of bursts recently detected by the orbiting Gamma Ray Observatory (SN: 9/28/91, p.196), Woosley maintains.

Although these musings remain speculative, Wolszczan says radio studies conducted over the next two or three years should provide a test of the planet theory. If the planets exist, their gravitational interactions with the pulsar will alter its radio signals during that time in a predictable and highly testable fashion, he says. *— R. Cowen*

Witnessing the birth of a radio supernova

Supernova 1987A is on the air again with a new, intriguing radio message. After a lengthy interval of quiet following a brief, initial outburst of radio waves associated with the violent explosion of a blue supergiant star, the region surrounding the star's remains has resumed emitting at radio frequencies.

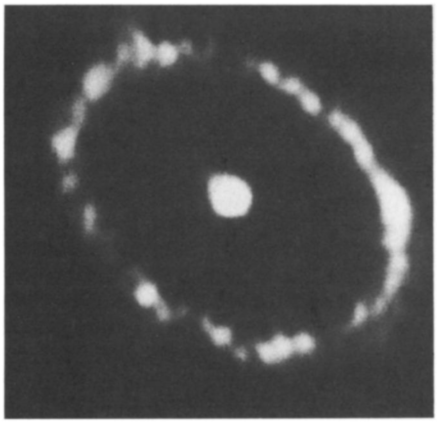
Radio astronomers in Australia first detected these renewed — but then faint — signals in the summer of 1990, more than three years after the initial explosion. Since then, the signals have grown stronger, but this increase in intensity has occurred unevenly across the monitored frequencies.

"This is the first time the birth of a nearby radio supernova remnant has been witnessed, and future observations will allow the structure of the remnant to be compared with the many other known radio remnants," researchers at the Australia Telescope National Facility and the University of Sydney write in the Jan. 9 NATURE.

The stellar explosion that created supernova 1987A generated prodigious amounts of electromagnetic radiation over a wide range of wavelengths. It also hurled vast quantities of matter — electrons and ions — into space.

Astronomers expected the impact of the ejected material, traveling at roughly one-tenth the speed of light, to cause tremendous shock waves in any gas clouds surrounding the exploded star. This interaction would accelerate electrons to nearly the speed of light. As these relativistic electrons spiraled down magnetic field lines in a cloud of gas, they would emit radio waves at particular frequencies.

The fact that radio waves from supernova 1987A remained undetectable at the monitored frequency of 843 megahertz until July 6, 1990, and at higher frequencies until Aug. 16, 1990, suggested the absence of gas clouds in the region immediately surrounding the central object. This scenario fits with the notion that a fierce stellar wind from the blue supergiant had scoured out the region just before the star finally exploded. Radio emissions resumed when ejected material eventually encountered sufficiently dense clumps of gas.



NASA/ESA

Hubble Space Telescope image of the gaseous ring surrounding supernova 1987A. Representing emissions of visible light from doubly ionized oxygen, this image shows a clumpy, glowing ring 1.37 light-years in diameter. Because the ring is inclined to the line of sight, it appears elliptical. Radio signals from supernova 1987A apparently emanate from a region between this ring and the central object.

Having carefully examining the supernova's belated radio emissions, the Australian team concludes that the signals come from an extended source surrounding the explosion site, rather than from a compact object such as a central pulsar. The bulk of the radio waves appears to emanate from clumps of material that lie between the extinct star and an outlying, well-defined ring of dense gas about 1.37 light-years across, the researchers report.

"This hypothesis is consistent with the absence so far of soft X-ray emission from the region," they note. "Strong X-ray emission is expected when the blast wave encounters the relatively dense ring material."

The apparent width of the radio-emitting region indicates that the supernova blast wave is moving at roughly 30,000 kilometers per second. At this rate, the shock wave's first impact with the outlying ring may occur within a few years, the researchers suggest.

Fluctuations in the intensity of the radio wave emissions at various frequencies provide indirect clues to the geometry and distribution of the gas clumps surrounding the exploded star. Last summer, a rapid increase in the intensity of radiation at 843 megahertz without a corresponding increase at higher frequencies indicated that the blast wave may have reached a new clump of circumstellar gas, the researchers say. As electrons in the new region are accelerated to higher energies, the higher-frequency emissions will probably catch up.

"Further observations will help to establish parameters of the electron acceleration process and the relationship between the radio and [visible-light] emitting regions," the team concludes.

— I. Peterson

School memories endure as time goes by

In contrast to the widespread conviction that the passing years wipe away most recollections of concepts and facts learned in school, a new study has uncovered robust memories among former students for material learned in a college course after as long as 11 years.

Since most study participants believed that within seven years they had lost all memory for what they had learned in the class, the investigators conclude that "acquired knowledge may influence behavior even when an individual is unaware of having retained that knowledge." Martin A. Conway of Lancaster (England) University and his colleagues present their data in the December JOURNAL OF EXPERIMENTAL PSYCHOLOGY: GENERAL.

For the most part, the study supports a theory developed by psychologist Harry P. Bahrick of Ohio Wesleyan University in Delaware, Ohio, who holds that much well-learned information remains accessible for up to 50 years, even if an individual never thinks about or uses it after leaving the classroom (SN: 3/10/84, p.149). Bahrick found that people who took Spanish in high school forgot some of what they learned during the six years following completion of classes, but a considerable amount of vocabulary and grammar survived for decades. People who took several Spanish classes and achieved high grades remembered the most.

Conway's group administered memory tests to 373 former students of a yearlong cognitive psychology course taught at a British university between 1978 and 1989. Approximately equal numbers of volunteers had attended each year of the course. The researchers tested participants for recognition of names and concepts covered in the class, ability to verify factual statements about psychological theories, proficiency at sorting psychological concepts into related groups, recall of names and concepts deleted from short statements, and ability to recognize definitions of statistical and research techniques. Participants rated their confidence in each answer and were instructed to guess whenever they could not remember an item.

The average percentage of correctly recalled names and concepts declined in the first three years following the course, dropping from 80 percent to about 70 percent, where it remained for the next eight years. Blind guessing by people who never took a cognitive psychology course would yield an average of 50 percent correct on the recognition tests used in this study, Conway and his co-workers say. Recognition of facts about theories hovered at an average of 65 percent correct for all of the former students, and recognition of research techniques held at an average of 75 percent up to 11 years after students had taken the course.

The average percentage of correctly grouped concepts declined from 57 percent to 35 percent during the three years following course completion and then held relatively steady for eight years. Blind guessing would group only 17 percent of the concepts correctly, the researchers maintain.

Correct recall of names and concepts fell from an average of 60 percent to 25 percent in the three years following the class — still much better than blind guessing. Only name recall improved thereafter, reaching an average of 35 percent correct 11 years after completion of the course.

The findings indicate that students primarily retained specific, detailed facts presented in the course, say the researchers. Little support emerged for the theory that a student develops an abstract mental framework, or "schema," for a particular subject, from which he or she generates educated guesses that produce correct responses to memory tests, they argue.

Moreover, after six or seven years, former students reported no recollection of most names and concepts from the class. Conway and his coauthors say this suggests that performance on the memory tests tapped into "implicit" memory — the unintentional retrieval of previously studied, unconsciously stored information (SN: 11/17/90, p.312).

In the new study, unlike Bahrick's investigation of former Spanish students, higher grades in the course did not strongly predict better recall later on. Conway's team asserts that students with good grades in Bahrick's sample took more than one Spanish course, boosting their long-term memory, whereas the British sample consisted of people who took only one psychology course and for whom grade differences proved less critical.

Bahrick, who says he views the new study as generally supportive of his prior research, offers a different interpretation for the lack of an association between grades and memory. Good grades predict better memory for academic subjects in which previously learned material proves critical for understanding new information, such as mathematics and languages, he contends. Subjects with less emphasis on cumulative learning, such as psychology and history, make possible successful "cramming" before tests, thereby weakening the link between grades and memory, Bahrick asserts. *— B. Bower*