Astronomers Glimpse Birth of a Pulsar

Like expectant parents, astronomers have been nervously waiting for almost two years to see what supernova 1987A had spawned. The first indication came last week when an international team of scientists reported evidence for a pulsar — an extremely dense, spinning sphere of neutrons — inside the debris left over from the stellar explosion. Apparently spinning nearly 2,000 times per second, this pulsar is the fastest ever found.

"We were expecting a pulsar, but we never expected anything rotating this fast," says Stanford E. Woosley of the University of California, Santa Cruz. "Just seeing any baby pulsar born would have been exciting enough, but to see something so unusual, spinning so rapidly that it's hanging in this universe by a thread, that's phenomenal."

Astronomers observed the pulsar for roughly seven hours on Jan. 18 at the Cerro Tololo Inter-American Observatory in Chile. To detect the pulsar's minute fluctuations in brightness, they used an extremely sensitive silicon detector to collect visible and infrared light from the supernova. The brightness data, recorded on magnetic tape, were then analyzed using a supercomputer at the Los Alamos (N.M.) National Laboratory.

The analysis revealed tiny pulsations in the supernova light, demonstrating the presence of a neutron star completing each rotation about its axis in about 0.5 millisecond. At the same time, the star's overall brightness varied by a factor of three during the observation period. The analysis also showed a systematic variation in the pulsar's spin frequency, which seemed to indicate the presence of an orbiting companion.

Unfortunately, when astronomers tried to confirm the discovery a week later, they found no trace of the pulsar. One possibility is that dust clouds surrounding the supernova's core may have parted briefly to reveal the pulsar and then closed again. Astronomers will make several more attempts over the next few weeks to find the pulsar signals.

"It's a little worrying that we didn't see it again, but the data we have are so strong that we had to report it," says Jerome A. Kristian of the Observatories of the Carnegie Institution of Washington, based in Pasadena, Calif. "We've looked at a lot of data over the last two years, and these data are totally unlike anything we've seen before."

If astronomers confirm the pulsar observations, the results pose a number of astronomical puzzles. The neutron star's behavior — spinning so fast and still holding together — rules out a number of postulated equations of state for neutron matter. Such equations express the relationship between the pressure, density and temperature of a material.

"Just the fact that this thing could exist and rotate that fast puts some stringent constraints on the structure of matter at supernuclear densities," Woosley says. "It's rotating as fast as a neutron star can possibly rotate with the softest equations of state and biggest mass that it can have."

Astronomers are also surprised by the fact that a pulsar can be born already spinning at a rapid rate. In recent years, astronomers had come to believe that neutron stars initially spin relatively slowly and pick up speed when they start gathering material from a nearby companion. However, Kenneth Brecher of Boston University has long contended that neutron stars with weak magnetic fields can be born with a high rate of spin. This discovery bolsters his argument.

One key parameter astronomers will track is the rate at which the pulsar slows down. Most researchers expect the pulsar to slow, but they disagree over whether the spin rate will decline rapidly or more gradually. Moreover, astronomers are unsure what mechanism is responsible for the pulsar's searchlight-like beam of light.

The apparent presence of an orbiting companion about the size of Jupiter is especially hard to understand. The object is so close to the pulsar that it would have been inside the original star before the star exploded. That means it was probably created during or after the explosion. For instance, it may represent a blob of matter flung off by the neutron star because the star was spinning so fast it couldn't hold on to the material.

"I sure hope we see the pulsar again," says John Middleditch, who did the computer analysis at Los Alamos. "The only way we can discount these observations is to see another frequency, in which case we'll have to discard [the present results] as arising from a very bizarre set of circumstances."

"If it's confirmed," says Woosley, "the discovery of the pulsar will be the event of the year in astronomy." *— I. Peterson*

First 3-D image of AIDS virus protein

Researchers this week reported determining the three-dimensional structure of a key protein in the AIDS-causing virus, HIV. The protein — a virally produced enzyme called aspartyl protease that is critical to HIV replication — is the first HIV protein to have its 3-D structure revealed. An understanding of the enzyme's structure, and by extension, its function, opens a new approach for the design of drugs that would specifically block HIV replication.

Manuel A. Navia of Merck Sharp and Dohme Research Laboratories in Rahway, N.J., and his co-workers used X-ray crystallography techniques to create the image of aspartyl protease — one of only three enzymes produced by the simple but deadly HIV. (AZT, the only anti-HIV drug to gain U.S. approval, targets another HIV enzyme, reverse transcriptase.) The protease cleaves large, freshly produced viral proteins into smaller, functional subunits. Inside an infected mammalian cell, those subunits assemble into new AIDS viruses.

Scientists have found similar proteases in other organisms, but to design a drug specifically against HIV they needed a detailed picture of the HIV version. They especially wanted an image of the enzyme's active site — the three-dimensional cleft into which proteins in need of cleaving nestle. With a clear picture of that site's molecular topography, researchers will seek to design molecules that mimic the enzyme's protein target, or substrate, but that block the enzyme's activity.

The newly reported image, in the Feb. 16 NATURE, is of only "medium" resolution, notes Alexander Wlodawer of the National Cancer Institute-Frederick (Md.) Cancer Research Facility. But "there is very little doubt that the substrate-binding pocket is described reasonably well."

Higher-resolution images should provide important details about hydrogen bonding between enzyme and substrate, he says. And future images of the enzyme bound to experimental inhibitors may suggest new approaches to blocking the enzyme's activity. Even then, he cautions, there remains the problem of drug delivery. "It's not only the protein that you have to look at, but you have to get it into the cell."

Wlodawer and his colleagues provided the first three-dimensional picture of a closely related protease earlier this month. Working from that image, he and others provide a predicted structure of HIV aspartyl protease in the Feb. 17 SCIENCE very similar to the Merck team's image. *— R. Weiss*