National Center for Computational Sciences Snapshot
The week of January 8, 2007

ORNL Team Discovers New Way to Spin Up Pulsars

In 1967, a Cambridge University graduate student poring over data from a newly constructed radio telescope noticed something new and odd—a radio signal blinking regularly from a far corner of the sky.

The signal came from a pulsar, the spinning remnant of a core-collapse supernova. A pulsar appears to blink because radiation shoots out of its magnetic poles, which, as with the earth, can be tilted a little from its axis of spin. As a result, the pulsar behaves like a stellar lighthouse, pointing at an observer once with each rotation.

Nearly 4 decades later, a team of scientists using Oak Ridge National Laboratory (ORNL) supercomputers has discovered the first plausible explanation for a pulsar's spin that fits the observations made by astronomers. Their surprising results show that the spin of a pulsar is not just a continuation from the massive star that preceded it; in fact, the pulsar spin can be in the opposite direction.

Anthony Mezzacappa of ORNL and John Blondin of North Carolina State University explain their results in the January 4, 2007, issue of the journal *Nature*. According to three-dimensional simulations they performed at the National Center for Computational Sciences (NCCS), the spin of a pulsar is determined not by the spin of the original star, but by the shock wave created when the star's massive iron core collapses.

That shock wave is inherently unstable, a discovery the team made in 2002. The instability creates two rotating flows—one in one direction directly below the shock wave and another, inner flow, that travels in the opposite direction and spins up the core.

The discovery comes at an opportune time, because astronomers did not have a workable explanation for how the pulsar gets its spin. The assumption to this point has been that the spin of the leftover collapsed core comes from the spin of the original star. The problem with that approach is that it would explain only the fastest observed pulsars. The ORNL team, on the other hand, predicts spin periods that are in the observed range between 15 and 300 milliseconds.

The discovery is an outgrowth of the team's use of three-dimensional simulations and the advances in high-performance computing that made the simulations possible. The simulations performed for the *Nature* paper used the Cray X1E system at ORNL, known as Phoenix. Later simulations done by the team made use of the center's Cray XT3 system, known as Jaguar.

Mezzacappa stressed that the team is looking forward to further advances in high-performance computing that will be coming to ORNL. For example, the team's

simulations have not incorporated the influence of nearly massless, radiation-like particles known as neutrinos and the star's magnetic field.

The real prize, though, for his and other teams is a complete explanation of how the collapse of a star's core leads to the explosion that ejects most of its layers. So far, that explanation has proved elusive.

"That is one of the most important unsolved problems in astrophysics," Mezzacappa said. "Core-collapse supernovae are the dominant source of elements in the universe, and the mechanism has everything to do with that."

Training Covers Next-Generation File System

Systems experts will gather later this month at the NCCS to learn the nuts and bolts of the state-of-the-art Lustre file system.

The Lustre Internals Training, scheduled for January 17–19, will be given by Peter Braam, chief technology officer of Cluster File Systems, Inc., and primary architect of the Lustre file system. This training is being provided as a part of the Lustre Center of Excellence (LCE), which was established at the NCCS recently as a joint venture between the Department of Energy Office of Science and Cluster File Systems.

Lustre, a highly scalable file system, is used on a number of the world's most powerful supercomputers, including the NCCS Cray XT3 system known as Jaguar. Lustre will also be used on ORNL's upcoming petascale system.

One of the key goals of the LCE is to promote expertise in the Lustre file system through training and workshops. According to Shane Canon, leader of the NCCS Technology Integration Group, this month's training will allow systems professionals to explore Lustre's internal workings, making them better at developing code, diagnosing problems, and troubleshooting.

Canon said the training will be attended primarily by systems experts at ORNL but that it may see participants from Los Alamos, Sandia, and Lawrence Livermore national laboratories. He noted that future trainings will focus on helping application developers make the best possible use of the Lustre system.