Listening for the cosmic symphony: New SU supercomputer will help scientists listen for black holes

February 8 2008

Scientists hope that a new supercomputer being built by Syracuse University's Department of Physics may help them identify the sound of a celestial black hole. The supercomputer, dubbed SUGAR (SU Gravitational and Relativity Cluster), will soon receive massive amounts of data from the California Institute of Technology (Caltech) that was collected over a two-year period at the Laser Interferometer Gravitational-Wave Observatory (LIGO).

Duncan Brown, assistant professor of physics and member of SU's Gravitational Wave Group, is assembling SUGAR. The department's Gravitational Wave Group is also part of the LIGO Scientific Collaboration (LSC), a worldwide initiative to detect gravitational waves. Brown worked on the LIGO project at Caltech before coming to SU last August.

Gravitational waves are produced by violent events in the distant universe, such as the collision of black holes or explosions of supernovas. The waves radiate across the universe at the speed of light. While Albert Einstein predicted the existence of these waves in 1916 in his general theory of relativity, it has taken decades to develop the technology to detect them. Construction of the LIGO detectors in Hanford, Wash., and Livingston, La., was completed in 2005. Scientists recently concluded a two-year "science run" of the detectors and are now searching the data for these waves. LSC scientists will be analyzing this

data while the sensitivity of the detectors is being improved. Detectors have also been built in France, Germany, Italy and Japan.

Before they can isolate the sound of a black hole from the LIGO data, the scientists must figure out what a black hole sounds like. That's where Einstein's theories come in. Working with colleagues from the Simulating eXtreme Spacetimes (SXS) project, Brown will use SUGAR and Einstein's equations to create models of gravitational wave patterns from the collision of two black holes. SXS is a collaborative project with Caltech and Cornell University.

Black holes are massive gravitational fields in the universe that result from the collapse of giant stars. Because black holes absorb light, they cannot be studied using telescopes or other instruments that rely on light waves. However, scientists believe they can learn more about black holes by listening for their gravitational waves.

"Looking for gravitational waves is like listening to the universe," Brown says. "Different kinds of events produce different wave patterns. We want to try to extract a wave pattern -- a special sound -- that matches our model from all of the noise in the LIGO data."

It takes massive amounts of computer power and data storage capacity to analyze the data against the gravitational wave models Duncan and his colleagues built. SUGAR is a collection of 80 computers, packing 320 CPUs of power and 640 Gigabytes of random access memory. SUGAR also has 96 terabytes of disk space on which to store the LIGO data.

It also takes a dedicated, high-speed fiber-optic network to transfer the data between Caltech and SU. To accomplish that, SU's Information Technology and Services (ITS) collaborated with NYSERNet to build a special pathway for the LIGO data on the high-speed fiber optic network that crisscrosses the United States. The one-gigabit pathway begins in the

Physics Building and traverses SU's fiber-optic network to Machinery Hall and then to a network facility in downtown Syracuse, which the University shares with NYSERNet. From there, the pathway connects to NYSERNet's fiber-optic network and goes to New York City. In New York City, the pathway switches to the Internet2 high-speed network and traverses the country, ending in a computer room in Caltech.

Both the supercomputer and the high-speed network are expected to be up and running by the end of February. Once the data is transferred to SU from Caltech, Brown and his LSC colleagues will begin to listen to the "cosmic symphony." "Gravitational waves can teach us much about what is out there in the universe," Brown says. "We've never looked at Einstein's theory in this way."

LIGO is funded by the National Science Foundation and operated by Caltech and the Massachusetts Institute of Technology.

Source: Syracuse University