Louisiana EPSCoR

EXPERIMENTAL PROGRAM TO STIMULATE COMPETITIVE RESEARCH VOL.6 NO.5 MAY 2009

Black Hole Simulation a Winner

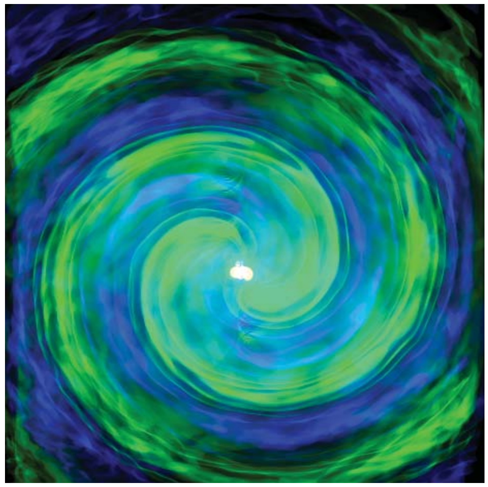
Black holes. You hear about them, read about them, but never see them. There is a good reason for that.

While supermassive in size, with hundreds or even billion times the mass of the Sun, black holes are invisible; so compact that even the speed of light can't escape them. They can only be found indirectly, via their effects on the matter that surrounds them.

John Wheeler, an eminent American theoretical physicist, compared observing them to watching women in white dresses dancing with men in black tuxedos in a dimly lit ballroom. You can only see the women, but you can predict the existence of their invisible partners because of the spinning and whirling motions of the women around a central axis.

A team of 13 researchers and students from Louisiana State University Center for Computation & Technology (CCT) has, however, produced a black hole simulation project involving equations written by Albert Einstein that are so complex they can't be written down on paper.

It was the top winner in an international competition, the SCALE 2009 challenge at CCGrid09, a conference for scalable computing, in which scientists use computer systems that can easily adapt, or scale up, to provide greater performance and computing power and give them greater capability to solve complex problems. The competition took place in Shanghai, China, where the team beat four other groups of finalists.



A visualization of the gravitational waves resulting from the simulation of two black holes.

> "The Einstein equations were the culmination of a mix of astrophysics, computer science and mathematical work." (Dr. Gabrielle Allen, Team Leader of both the black hole simulation and the cybertools component of LA EPSCoR's CyberTools project.)

The LA team leader and many of the student and research faculty team members also participate in various aspects of the LA EPSCoR CyberTools project funded by a National Science Foundation Research (RII) Infrastructure Improvement grant.

The award-winning entry showcased a scalable, interactive system to simulate and visualize black holes to study the physics of gravitational waves, a complex process involving many challenges that scientists are only now able to address with modern cyberinfrastructure.

Distributed across the LA Optical Network Initiative (LONI), the simulation was also run on 2,048 cores of the Ranger machine at the Texas Advanced Computing Center in Austin.

It also addressed the scalable computing challenges of the competition, including automatically generating simulation code, developing programs and software components to provide fast data transfer across LONI, transforming scientific data into images, and building interactive, tangible devices that allow observers to engage directly with the scientific data as it is visualized live.

In addition, it tested the team's ability to

Black Hole Simulation, Continued page 2

GSU/LA Tech Physics Professor Wins Major NSF Award

The recipient of a LA EPSCoR award that resulted in joint faculty appointments at Louisiana Tech and Grambling State universities in 2005 has received the National Science Foundation's 'most prestigious" award for junior faculty.

Dr. Tabbetha Dobbins, an Assistant Professor of Physics, received an NSF Faculty Early Career Development (CAREER) award given in support of junior faculty "who exemplify the role of teacher-scholar through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations."

A $400,000 grant accompanied the award to Dr. Dobbins, who holds joint appointments at Louisiana Tech's Institute for Micromanufacturing and Grambling's physics department. A 2003 Board of Regents' LA EPSCoR Joint Faculty Appointments Program grant funded by NSF EPSCoR led to her current positions.

Physics Professor, Continued page 2

Dr. Tabbetha Dobbins

Black Hole Simulation Continued

effectively use high-performance computing machines concurrently, running applications on thousands of computing cores at once while using multiple, distributed resources of different types (computation, storage, networks, graphics) for a single application.

"The Einstein equations were the culmination of a mix of astrophysics, computer science and mathematical work," says Dr. Gabrielle Allen, Team Leader of the black hole simulation and the cybertools component of LA EPSCoR's CyberTools project.

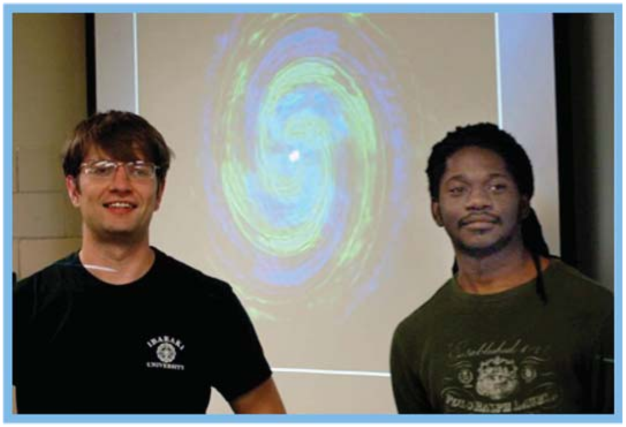
"Numerical simulations, the only practical way to study black hole systems, require a complex system of mathematical equations describing effects that span a wide range of length-and time-scales."

To address this challenge, the team used Cactus Software Framework, an open-source environment that enabled teams of researchers from different fields in different locations to work together on modeling black hole collisions and solving Einstein's equations.

It also allowed them to automate a process that would be too time-consuming and error-prone to perform by hand.

"We were honored to receive first prize, particularly since we had many challenges leading up to our demonstration," says Dr. Allen, who is an LSU Associate Professor of Computer Science and CCT faculty member. She explains that travel restrictions prevented all but one team member, who is from China, from attending the competition to give the presentation.

The team addressed that problem by using a scientific visualization system distributed across LONI to show live, interactive images of the black hole data at the Shanghai conference. Tangible interaction devices were also provided on the show floor, allowing observers to interact in real-time with the visualization process. The rest of the team members described the process and answered questions from LSU via Skype®, an Internet-based system that can be used to make voice calls and live chat.



Two graduate student members of the LSU Black Hole simulation team are, left to right, Oleg Korobkin, physics, and Cornelius Toole Jr., computer science.

Noting that the LSU team is one of six or seven in the world working on the problem of how a black hole collision affects distortions in space and time, Dr. Allen adds:

"This is a perfect example of how people can use modern cyberinfrastructure to solve real-world, complex problems that would have otherwise been impossible even just a few years ago."

To watch a video recording of the team's demonstration, visit http://preview.cactuscode.org/media/videos/.

Physics Professor Continued

An active nanotechnology researcher, she has previously served as principal investigator for NSF, Department of Energy, and Board of Regents Support Fund grants totaling over $600,000. She teaches and performs research at both institutions where she also excels in mentoring students in both graduate and undergraduate research projects.

After receiving her Ph.D. from Penn State in 2002 she was awarded a prestigious National Research Council Post Doctoral Fellowship to conduct research at the National Institute for Standards and Technology.

Her CAREER grant project will study important unanswered questions which limit the implementation of hydrogen as a practical and viable fuel source, and support both undergraduate and graduate students. Additionally, Dr. Dobbins, who has a history of mentoring student researchers in synchrotron x-ray studies, will institute an annual high school design challenge project with a team of students.

NSF CYBERTOOLS

The LA EPSCoR RII program, CyberTools, is funded by NSF EPSCoR, Louisiana Board of Regents and participating universities. Those institutions are: LSU*, LSU Health Sciences Center-New Orleans, Louisiana Tech University*, Southern University-Baton Rouge*, Tulane University*, Tulane Health Sciences Center, University of Louisiana-Lafayette*, University of New Orleans* and Xavier University. (* LONI Institute members)

Louisiana EPSCoR
P.O. Box 3677
Baton Rouge, LA 70821-3677
#4475