The Need for Speed

March 2, 2010

The Jaguar Supercomputer at
Oak Ridge National Laboratory
(Courtesy ORNL)

It may be difficult to fathom that 74 million hours is actually a shortcut, but that's the case for some UTK physicists. By winning time on ultra-scale supercomputers, they'll be able to run the powerful calculations required to get a closer look at the intricate workings of the nucleus and the death of massive stars.

The opportunities were made possible through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program, sponsored by the Department of Energy. INCITE awards time on DOE supercomputers to researchers from universities, laboratories, other government agencies, and industry. This year they've assigned 1.6 billion supercomputer processing hours to 69 research projects, including two involving University of Tennessee physicists.

One of those projects is devoted to nuclear structure. While the atom may get most of the fame as the building block of matter, it's the atom's core—the nucleus—that makes up more than 99 percent of its mass. The inner workings of the nucleus have far-reaching societal implications for energy, medicine, and global security.

Comprising protons and neutrons, a nucleus can be simple or complicated, depending on its components. A hydrogen nucleus, for example, has but one proton, while a single stable nucleus of gold has 79, along with 118 neutrons. The heavier and more complex it is, the more difficult it becomes to get down to the basic characteristics of a nucleus—the details of its structure, the manner in which it decays, and the reactions it exhibits. Calculating these properties requires a phenomenal amount of computing power, which is precisely what physicists David Dean (ORNL Physics Division and Adjunct Associate Professor of Physics) and Physics Professor Witek Nazarewicz have acquired with their INCITE award of 40 million processor hours. The allotment is 25 million hours on the Cray XT (Jaguar) at Oak Ridge National Laboratory and 15 million on Intrepid, the IBM Blue Gene machine at Argonne National Laboratory. Their research team is rounded out by Hai Ah Nam of ORNL, Steven Pieper of Argonne National Laboratory, and James Vary of Iowa State University.

ORNL's Jaguar is the world's fastest supercomputer for unclassified research, churning out more than two thousand trillion calculations per second. The ultra-scale Intrepid has a peak performance of 557 teraflops. Computers with this level of power can whittle down research time by months, if not several years, by dramatically increasing the rate of calculations per hour.

Computing on this scale not only helps define small systems; it can illuminate the large ones as well. A UTK-ORNL research collaboration was awarded 34 million processor hours on Jaguar to study core-collapse supernovae—the violent end of stars more than 10 times the mass of our sun. These are complex, multi-physics events that have eluded creation of the realistic, three-dimensional models required to truly understand them. The INCITE award will help the team generate three-dimensional simulations that can help explain core-collapse supernovae, which are the dominant source of elements in the universe. This collaboration is lead by Joint Faculty Professor Anthony Mezzacappa and includes Adjunct Assistant Professor Bronson Messer, Assistant Professor Christian Cardall, Professor Michael Guidry, Research Associate Professor W. Raphael Hix, and Adjunct Professor Jirina Stone; all of whom work with the ORNL Physics Division. They're working with John Blondin of North Carolina State University and Stephen Bruenn and Pedro Marronetti, both of Florida Atlantic University.

INCITE projects were chosen based on peer review and evaluations of their potential to advance scientific discovery; particularly in the areas of climate change, alternative energy, life sciences, and materials science. The winners were announced during National Nuclear Science Week 2010 (January 25-29), a week-long celebration to focus local, regional, and national interest on all aspects of nuclear science.