First to the Summit

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When the next generation of high performance computing comes to Oak Ridge National Laboratory, UT's physicists will be working on the first projects that put its power to work.

Summit, the third in the evolution of ORNL's supercomputers, is set to come online in 2017. Descended from Jaguar and most recently Titan, it will ramp up the current performance level by at least a factor of five. Late in 2014 the Center for Acceleration Application Readiness (CAAR) program at the national lab invited research teams to submit proposals to make the most effective use of this new system. Plans had to include a three-year readiness phase for coding and porting and culminate in a scientific grand-challenge project when Summit becomes available to users in 2018. This spring CAAR selected 13 initial partnership projects to showcase Summit's prowess, and among them are ventures into long-standing questions in nuclear physics and astrophysics, both of which involve UT-affiliated faculty.

Above image courtesy of ORNL.

Physics Professor Thomas Papenbrock is working with ORNL's Gaute Hagen (the project's principal investigator and also an adjunct member of UT's physics faculty) and postdoc Gustav Jansen on NUCCOR, or Nuclear Coupled Cluster Oak Ridge. Because nuclear physics requires scientists to work with the interactions and properties of multiple particles (many-body systems), they've implemented an efficient approach—the coupled-cluster method—to sort out what's going on below the atomic level. By optimizing code for a supercomputer as powerful as Summit, they may be able to compute the nuclear matrix for an elusive benchmark: neutrinoless double-beta decay.

In this process, two neutrons convert to two protons and emit two electrons. The phenomenon has not yet been observed, and its demonstration would show that a neutrino is its own antiparticle. This is the scientific grand challenge for NUCCOR: as Papenbrock explained, "this decay, if observed, would identify the neutrino as a Majorana Particle (i.e., its own antiparticle), and the nuclear matrix element is needed to relate the lifetime of the decay to the neutrino mass scale."

The observation of neutrinoless double beta decay could help explain neutrino masses and their hierarchy, changing the way we understand elementary particles and expanding research avenues in nuclear energy.

Expanding known parameters is also key to a project using the FLASH code that will extend simulations of the violent end of massive stars and in the process reveal more about the stardust from which we're made. ORNL's Bronson Messer (a bachelor's and Ph.D. graduate of UT Physics, as well as a joint member of the faculty) is the principal investigator on the project.

"We want to do fully self-consistent calculations of supernova nucleosynthesis with the FLASH code," he explained. "This will require extending our simulations to much later times and using much larger nuclear networks (tracking ~150 nuclei rather than just ~13). Since everything on the periodic table heavier than beryllium is made in stars (or synthesized directly in supernovae) and dispersed by supernovae, this project seeks to do nothing less than to figure out how and where the elements that make up 'us' were formed."

Although Summit won't be available to users until 2018, the partnership projects are already underway on a carefully-defined timeline.

Papenbrock said that codes must demonstrate that they run efficiently on Titan, ORNL's current heavyweight supercomputer, by summer 2016.

"As Summit is about a factor (of) 5 larger in computing power than Titan, being able to fully use Titan, one can estimate that teams will use at least 20 percent of Summit," he explained. "This defines 'leadership computing.'"

Messer is in a unique position as both a PI on a partnership project and a member of the Oak Ridge Leadership Computing Facility Scientific Computing Group. He has already ported the FLASH code to an internal Power8 machine. Physics graduate student Tom Papatheodore has used FLASH as part of the dissertation he will defend this summer and will join the project as a postdoc.

Messer added that "there will be a call for early science projects before Summit arrives. It is expected that the CAAR codes will be the most competitive group of codes for this call. In addition, all the CAAR teams will get time on the early hardware platform (sort of a 'pre-Summit'), which should arrive at the end of next year."

Summit is poised to open new territory on a myriad of scientific questions, and UT's physicists will be at the forefront of that exploration.

Learn More

- CAAR Partnership Projects: **https://www.olcf.ornl.gov/caar/ (https://www.olcf.ornl.gov/caar/)**
- Summit: **https://www.olcf.ornl.gov/summit/ (https://www.olcf.ornl.gov/summit/)**
- Nuclear Physics at UT: **http://www.phys.utk.edu/research/nuclear/index.html (http://www.phys.utk.edu/research/nuclear/index.html)**