PPPL
U.S. DEPARTMENT OF ENERGY
PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY
MONDAY, MARCH 19, 2012

Exascale Computing Allows Scientists to Approach New Class of Problems

By Gale Scott

Scientists at Princeton University are starting to compose the complex codes designed to instruct a new class of powerful computers that will allow researchers to tackle problems that were previously too difficult to solve. These supercomputers, operating at a speed called the "exascale," will produce realistic simulations of dazzlingly complex phenomena in nature such as fusion reactions, earthquakes, and climate change.

The capacity to deploy computations at such an extreme scale could put scientists closer to solving a wide range of research problems, including the quest to make fusion energy a safe, affordable power source, according to William Tang, head of the Fusion Simulation Program at PPPL. The new computing power would also greatly enhance the realism of simulations used in that research.

In recognition of the prospects for making much faster progress in understanding higher levels of complexity in science, and as part of a new international collaboration, the Group of Eight Research Councils Initiative on Multilateral Research Funding has awarded grants to Tang and two other Princeton University-based scientists: Jeroen Tromp, a geophysicist; and Venkatramani Balaji, a climate modeler. All are focused on helping to develop the advanced software that will put the coming new generation of computers to work on solving complex scientific problems of global interest.

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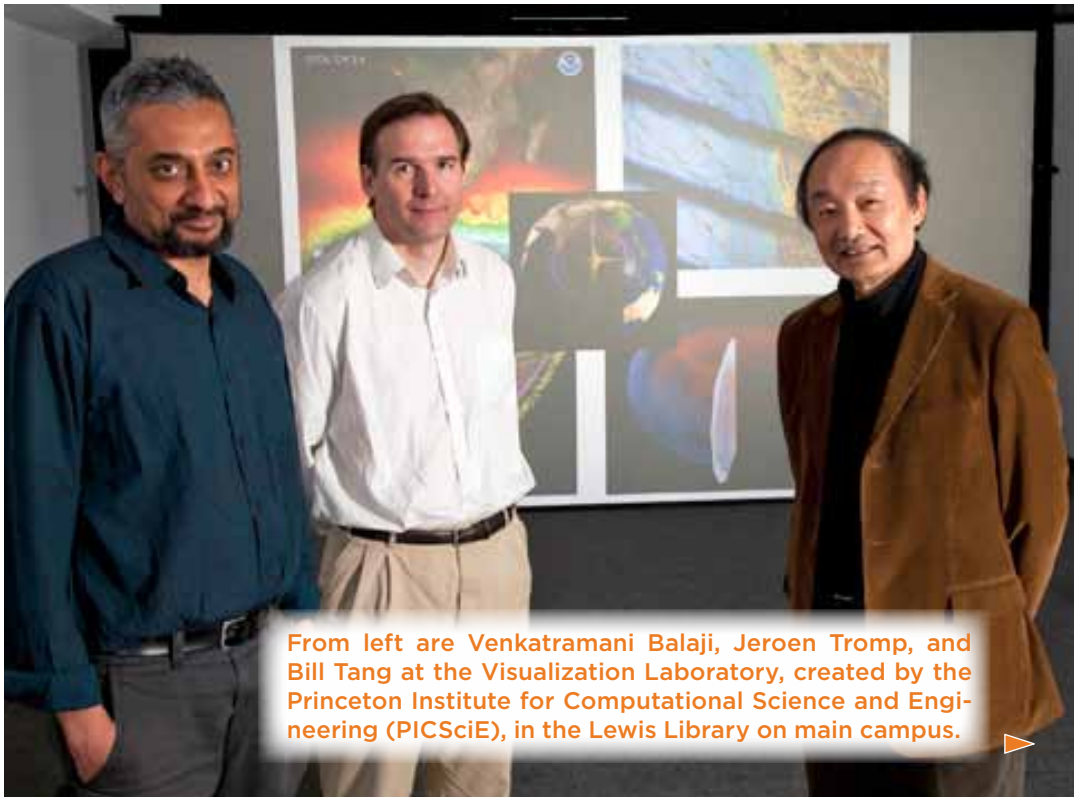

From left are Venkatramani Balaji, Jeroen Tromp, and Bill Tang at the Visualization Laboratory, created by the Princeton Institute for Computational Science and Engineering (PICSciE), in the Lewis Library on main campus.

At PPPL THIS WEEK

TUESDAY, MARCH 20

Spring Begins

WEDNESDAY, MARCH 21

Red Cross Blood Drive at PPPL
8 a.m. - 2 p.m. ◆ Lower Parking Lot

GFDL Events and Seminars
Noon - 1 p.m. ◆ GFDL
Smagorinsky Seminar Room

Dependence of convectively coupled tropical waves on the basic state

Stefan Tulich (CIRES)
www.gfdl.noaa.gov/events

(Gov't, Univ. or 2 other forms of I.D. needed)

PPPL Colloquium
4:15 p.m. ◆ M.B. Gottlieb Auditorium

Socialized Medicine in Honey Bee Colonies

Marla Spivak (University of Minnesota)

CLICK HERE FOR ABSTRACT

THURSDAY, MARCH 22

PPPL Theory Seminar
10:30 a.m. - noon ◆ T-169

Edward Startsev

FRIDAY, MARCH 23

Young Women's Conference in Science, Mathematics, Technology and Engineering
9 a.m. - 2 p.m. ◆ Main Campus

hosted by PPPL

DIII-D Science Meeting
1 p.m. ◆ B-233

Computing

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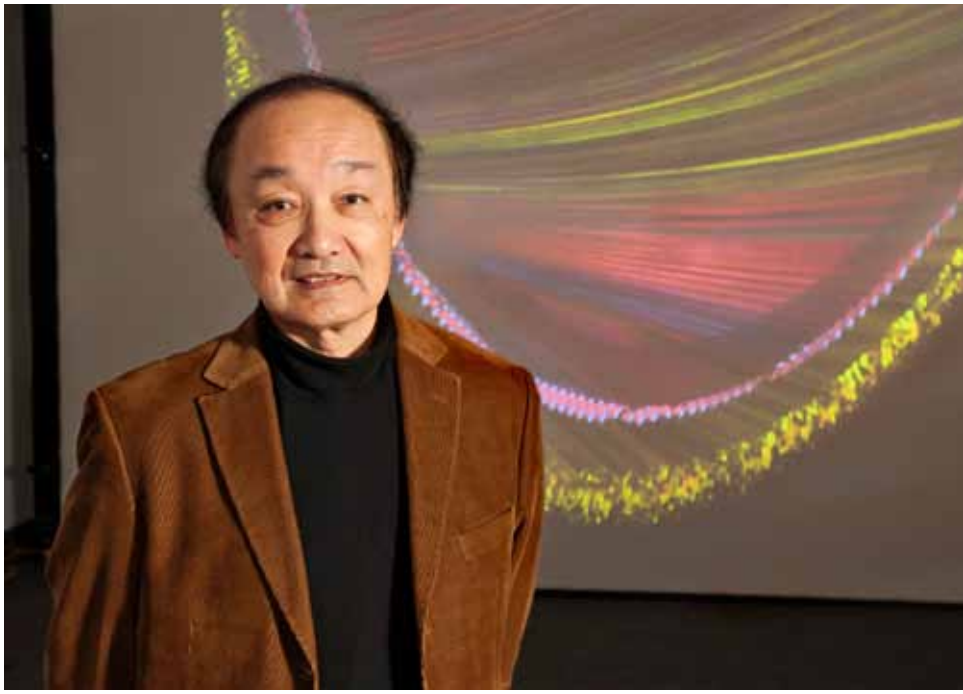
"What we hope to demonstrate is that this focused level of international scientific collaboration can help deliver breakthrough payoffs in high-performance computing," Tang said. He is also a member of the executive committee of the Princeton Institute for Computational Science and Engineering (PICSciE).

The G-8 is an organization involving leaders of various industrialized nations. Its leaders, who represent Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, the United States, plus the European Union, gather for an annual summit.

Tang intends to use his $470,000 grant to develop advanced simulation codes that will be compatible with this emerging class of supercomputers. The goal is to produce higher fidelity simulations of the physics behind fusion reactions. That will mean solving problems it would not be possible to address in a timely way using present-day supercomputers.



PPPL's Bill Tang with a computer simulation of plasma turbulence.

Computers approaching the exascale possess the capability of doing a quintillion — the number means a billion billion — calculations at once. By one estimate, a quintillion pennies laid out edge to edge would cover the surface of the earth twice. The three-year awards are part of a 2010 pilot program, a G-8 effort to foster multinational collaboration among scientists.

"There is recognition that science is international in scope and that there is an advantage to scientists from different countries partnering together," said Marc Rigas, staff associate for planning and coordination of the Office of Cyberinfrastructure at the National Science Foundation, which selected and funded the U.S.-based grantees for the G-8 council.

The Princeton grants are among six winning proposals selected from 100 international applicants' submissions. All the projects require partnering with scientists from other G-8 nations. According to Tang, the grant selections were made after an intense peer review process in which the Princeton researchers led U.S. participation.

Tang's project, known as NuFuSe (www.nu-fuse.com), focuses on learning how to better control fusion reactions. Working with researchers in the U.K., France, Germany, Japan, and Russia, Tang hopes to learn how to better control the behavior of magnetically confined fusion plasmas. Though fusion reactions are responsible for energy release in the universe, harnessing fusion as a clean and sustainable supply of energy on earth is a major scientific and technological challenge. It has commanded the attention of researchers at laboratories worldwide, including PPPL.

Fusion reactions are produced in experimental devices where isotopes of hydrogen are heated and contained in a magnetic field. When these charged hydrogen particles are confined long enough at temperatures that exceed 10 million degrees, a large amount of energy is produced. However, the hot plasmas can behave erratically, a phenomenon known as microturbulence. Such an event can accelerate heat loss and compromise the efficiency of the reaction. Tang noted that "it is the balance between these heat losses and the self-heating rates of the fusion reactions which largely determine the size and cost of a fusion reactor."

As part of the quest to build efficient fusion power plants, Tang envisions using the new exascale computers to create sophisticated simulations of fusion reactions to gain new insights into how to reduce the heat losses brought on by microturbulence.

The international cooperation required by the G-8 council will have another benefit, Tang said. The research partners will be collaborating instead of working in separate silos. For example, new software developed within the international project could be tested on the collaborating partners' supercomputers. The grant will cover the salary of a post-doctoral student along with some travel expenses so research staff can attend conferences.

At Princeton University, Venkatramani Balaji, head of the modeling system group in the University's Department of Atmospheric and Oceanic Sciences and NOAA's Geophysical Fluid Dynamics Laboratory on the Forrestal Campus, is planning to use his $313,000 G-8 grant to design software that will organize the huge but unmanageable archives of climate data from all around the world.

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Computing

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Producing accurate forecasts of a changing climate, especially on the regional scale, is of vital interest to those managing impacts on the environment and public health. For instance, "a scientist at work on malaria might want to know how many mosquitoes are likely to be in a region in the future, which means predicting temperature or humidity," Balaji said.

Complicating matters, different research groups have constructed different mathematical models to use in making such predictions, he added. There is a "giant data archive" that exists. But, with 20 different models in use, he said, scientists could come up with 20 different predictions. "We have to run them all and make an average, but then the problem is the data is now in 20 different places," he said.

There is currently enough data out there to "project the temperature in Burkina Faso 25 years from now," Balaji said, "but you would need to analyze probable outcomes from many models and multiple scenarios of how society might change." It will take exascale computing to make that happen, he noted. His group is developing computer language that would instruct powerful computers to coordinate and streamline such an analysis.

"The G-8 gives us a unique opportunity to have science agencies around the world work together," Balaji said. He will be working with peers in five other nations.

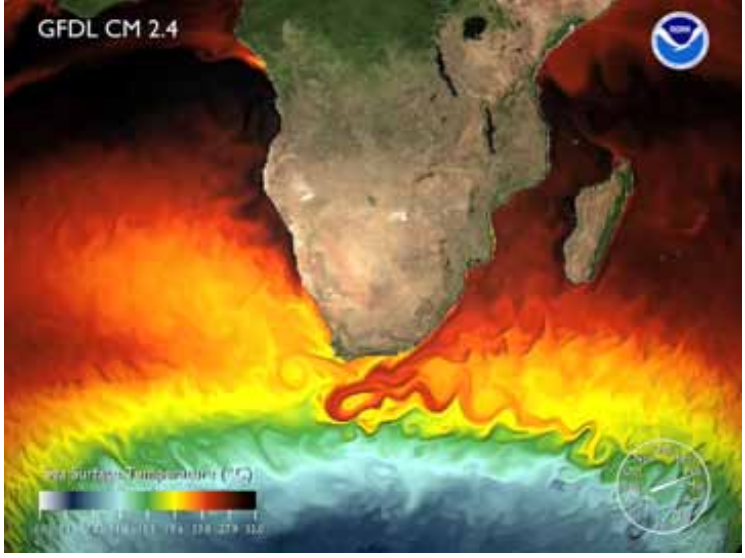
In a similar approach, Tromp, the Blair Professor of Geology and director of PICSciE, will use his $500,000 grant to further his work mapping the interior of the earth. Using data from seismograph readings from all over the globe, Tromp and colleagues in Canada and France construct computer images showing the structures underneath the earth's crust to a depth of 700 kilometers. That makes pre-human history come alive.

"We are just finishing an image for Europe," said Tromp, a professor of geosciences and applied computational mathematics. "We can see the subduction of Africa, see that slab being pushed into the mantle; we can see old and recent volcanism in the Czech Republic, and how Italy has rotated counterclockwise over the last six million years to where it is today."

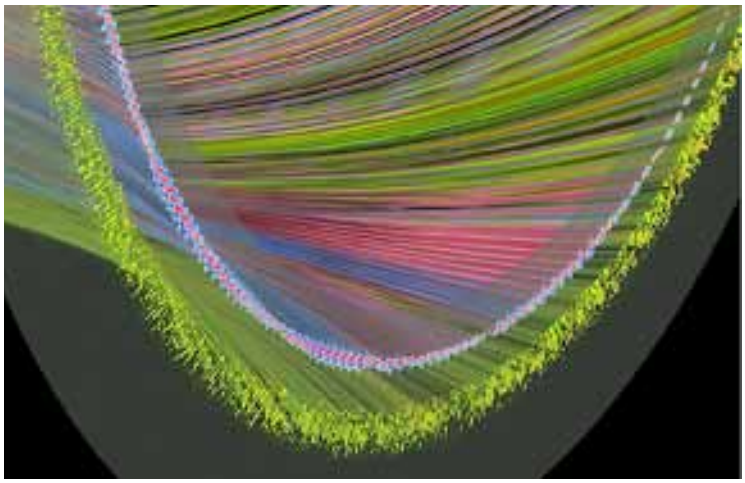
Tromp and his colleagues are also known for taking seismographic findings and turning them into earthquake simulations, known as "shake movies." Though earthquakes cannot be predicted, he said, the virtual earthquakes help assess potential hazards so that engineers can build structures to withstand the quakes.

"This is how modern science should be conducted," he said.

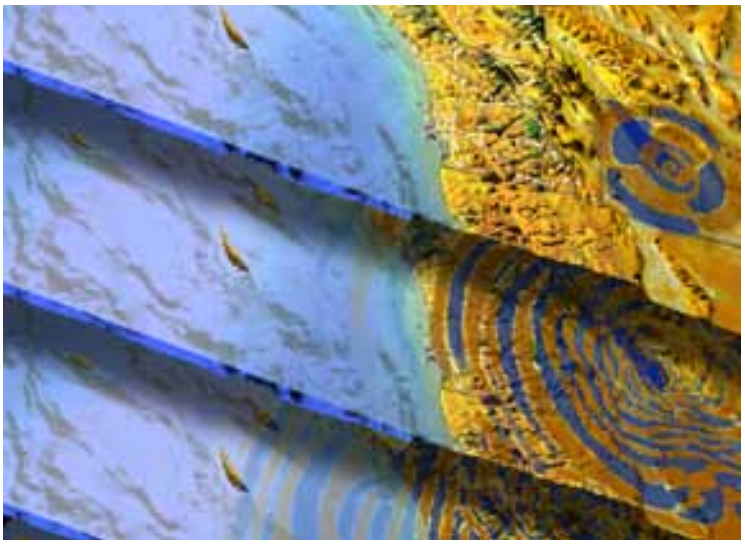
He sees the G-8 approach to funding multinational collaborations as "a wonderful model for computational science."



A plot of a region of sea surface temperatures from a high-resolution global coupled climate model. Pictured are the beautiful Agulhas rings, a well-known feature of the currents around Southern Africa.



High-resolution simulation of electron-scale plasma turbulence in the National Spherical Torus Experiment (NSTX) at PPPL using the GTS global particle-in-cell code. The colored "strings" represent regions of higher (warm colors) and lower (cool colors) electron density.



Spectral-element simulation of earthquake dynamics. The sequence of three snapshots depicted here illustrates wave propagation in southern California.

COLLOQUIUM

Socialized Medicine in Honey Bee Colonies

MARLA SPIVAK
University of Minnesota

Wednesday, March 21
4:15 p.m. (Coffee/Tea at 4 p.m.)
M.B. Gottlieb Auditorium, Lyman Spitzer Building

BLOOD DRIVE

On Wednesday, March 21 from 8 a.m. to 2 p.m. the American Red Cross Mobile van will be in the Lower End parking lot to collect as many units of blood as we can supply.
Please give blood. All blood types are needed.

To schedule a donation appointment, please contact the OMO at ext. 3200.

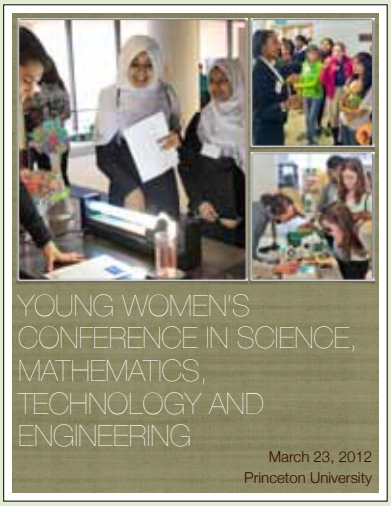
American Red Cross

Volunteers Needed

Young Women's Conference in Science, Mathematics, Technology and Engineering

hosted by PPPL
on the MAIN CAMPUS of Princeton University
Friday, March 23
9 a.m. to 2 p.m.

Contact Stephanie Wissel at swissel@pppl.gov



Brock PPPL Café Menu

BREAKFAST ..... 7 a.m. – 10 a.m.
CONTINENTAL BREAKFAST..... 10 a.m. – 11:30 a.m.
LUNCH ..... 11:30 p.m. – 1:30 p.m.
SNACK SERVICE ..... until 2:30 p.m.

	MONDAY, MAR. 19	TUESDAY, MAR. 20	WEDNESDAY, MAR. 21	THURSDAY, MAR. 22	FRIDAY, MAR. 23
COMMAND PERFORMANCE CHEF'S FEATURE	 **Pasta Bake with Garlic Bread**	 **Meatloaf with Mashed Potatoes**	 ***Create Your Own...*** **Grilled Chicken Caesar**	 **Jermaine's Curry Chicken with Rice**	 **Baked Tilapia over Rice w/Garlic Sauce**
EARLY RISER	Blueberry Pancakes with Sausage	The Hungry Man (Pancake, Eggs, Meat, Potatoes)	The Breakfast Roll	Bacon, Egg and Cheese on a Fresh Baked Croissant	Crustless Quiche Lorraine
COUNTRY KETTLE	Chicken Noodle	Black Bean with Ham	Texas Chili	Manhattan Clam Chowder	Cream of Crab
GRILLE SPECIAL	Vegetarian Quesadilla with Salsa and Sour Cream	California Bacon Cheeseburger Hoagie	Black Bean and Corn Veggie Burger with Cheese	Two Chili Cheese Dogs with Fries	Sloppy Joe with Onion Rings
DELI SPECIAL	Turkey BLT Wrap	Grilled Vegetables With Provolone and Hummus	Fish Filet Sandwich	Roast Beef Ranchero Wrap	Louisiana Seafood Salad
PANINI	Turkey, Provolone, and Bacon Flatbread Grille	Ham, Swiss, Bacon, Tomato and Chipotle	BBQ Pulled Chicken, Provolone, Sautéed Onion	Flatbread Tuna Melt	Chicken Parmesan Panini

MENU SUBJECT TO CHANGE WITHOUT NOTICE

CLICK HERE FOR A PRINTABLE WEEKLY MENU

WEEKLY

Editor: **Patti Wieser** ◆ Copy Editor /Graphic Design: **Gregory Czechowicz**
Photography: **Elle Starkman** ◆ Web: **Chris Cane**

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Send to: pwieser@pppl.gov ◆ Comments: commteam@pppl.gov ◆ **PPPL WEEKLY** is archived on the web at: http://www.pppl.gov/ppplweekly.cfm