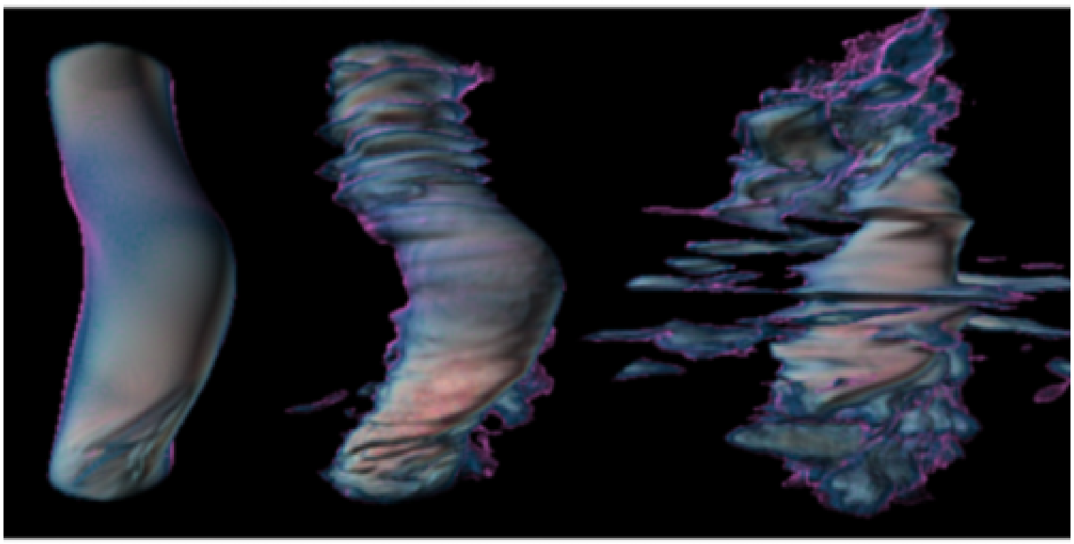
Physicists use supercomputer to gain insight into plasma dynamics

September 29 2014, by Makeda Easter



Pictured are visualizations representing plasma turbulence in a tokamak and in the ionosphere. Scientific visualizations, such as these, allow researcher Wendell Horton to see the full 3-D structure and dynamics of plasma. Credit: Greg Foss, TACC

Studying the intricacies and mysteries of the sun is physicist Wendell Horton life's work. A widely known authority on plasma physics, his study of the high temperature gases on the sun, or plasma, consistently leads him around the world to work on a diverse range of projects that have great impact.

Fusion energy is one such key scientific issue that Horton is investigating and one that has intrigued researchers for decades.

"Fusion energy involves the same thermonuclear reactions that take place on the sun," Horton said. "Fusing two isotopes of hydrogen to create helium releases a tremendous amount of energy—10 times greater than that of nuclear fission."

It's no secret that the demand for energy around the world is outpacing the supply. Fusion energy has tremendous potential, however, harnessing the power of the sun for this burgeoning energy source requires extensive work.

Through the Institute for Fusion Studies at The University of Texas at Austin, Horton collaborates with researchers at ITER, a fusion lab in France and the National Institute for Fusion Science in Japan to address these challenges. At ITER, Horton is working with researchers to build the world's largest tokamak—the device that is leading the way to produce fusion energy in the laboratory.

"Inside the tokamak, we inject 10 to 100 megawatts of power to recreate the conditions of burning hydrogen as it occurs in the sun," Horton said. "Our challenge is confining the plasma since temperatures are up to 10 times hotter than the center of the sun inside the machine."

Perfecting the design of the tokamak is essential to producing fusion energy and since it is not fully developed, Horton performs supercomputer simulations on the Stampede supercomputer at the Texas Advanced Computing Center (TACC) to model plasma flow and turbulence inside the device.

"Simulations give us information about plasma in three dimensions and in time, so that we are able to see details beyond what we would get with analytic theory and probes and high-tech diagnostic measurements," Horton said.

The simulations also give researchers a more holistic picture of what is needed to improve the tokamak design. Comparing simulations with fusion experiments in nuclear labs around the world helps Horton and other researchers move even closer to this breakthrough energy source.

Plasma in the Ionosphere

Because the mathematical theories used to understand fusion reactions have numerous applications, Horton is also investigating space plasma physics, which has important implications in GPS communications.

GPS signaling, a complex form of communication, relies on signal transmission from satellites in space, through the ionosphere, to GPS devices located on Earth.

"The ionosphere is a layer of the atmosphere that is subject to solar radiation," Horton explained. "Due to the sun's high-energy solar radiation plasma wind, nitrogen and oxygen atoms are ionized, or stripped of their electrons, creating plasma gas."

These plasma structures can scatter signals sent between global navigation satellites and ground-based receivers resulting in a "loss-of-lock" and large errors in the data used for our navigational systems.

Most people who use GPS navigation have experienced "loss-of-lock," or instance of system inaccuracy. Although this usually results in a minor inconvenience for the casual GPS user, it can be devastating for emergency response teams in disaster situations or issues of national security.

To better understand how plasma in the ionosphere scatters signals and affects GPS communications, Horton is modeling plasma turbulence as it occurs in the ionosphere on Stampede. He is also sharing this knowledge with research institutions in the U.S. and abroad including the UT Space and Geophysics Laboratory.

Seeing is Believing

Although Horton is a long-time TACC partner and Stampede user, he only recently began using TACC's visualization resources to gain deeper insight into plasma dynamics.

"After partnering with TACC for nearly 10 years, Horton inquired about creating visualizations of his research," said Greg Foss, TACC Research Scientist Associate. "I teamed up with TACC research scientist, Anne Bowen, to develop visualizations from the myriad of data Horton accumulated on plasmas."

Since plasma behaves similarly inside of a fusion generating tokamak and in the ionosphere, Foss and Bowen developed visualizations representing generalized plasma turbulence. The team used Maverick, TACC's interactive visualization and data analysis system to create the visualizations, allowing Horton to see the full 3-D structure and dynamics of plasma for the first time in his 40-year career.

"It was very exciting and revealing to see how complex these plasma structures really are," said Horton. "I also began to appreciate how the measurements we get from laboratory diagnostics are not adequate enough to give us an understanding of the full three-dimensional plasma structure."

Word of the plasma visualizations soon spread and Horton received requests from physics researchers in Brazil and researchers at AMU in

France to share the visualizations and work to create more. The visualizations were also presented at the XSEDE'14 Visualization Showcase and will be featured at the upcoming SC'14 conference.

Horton plans to continue working with Bowen and Foss to learn even more about these complex plasma structures, allowing him to further disseminate knowledge nationally and internationally, also proving that no matter your experience level, it's never too late to learn something new.

Provided by University of Texas at Austin

Citation: Physicists use supercomputer to gain insight into plasma dynamics (2014, September 29) retrieved 2 May 2024 from https://phys.org/news/2014-09-physicists-supercomputer-gain-insight-plasma.html