OSCon

Optimizing SuperConductor Transport Properties through Large-Scale Simulation

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SciDAC Institute Integration
FASTMath (Munson)
SUPER (Wild)

Key Collaborations
Center for Emergent Superconductivity
Peter Johnson, Director (BNL)
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Wai Kwok, Lead (ANL)
Argonne Leadership Computing Facility
Mike Papka, Director (ANL)
MOOSE multiphysics group
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Argonne NATIONAL LABORATORY

This SciDAC Partnership will develop and apply novel methods for optimizing superconductors for energy applications using large-scale computational algorithms and tools.

OSCon is a joint effort of Argonne's Materials Science Division (MSD) and the Mathematics and Computer Science Division (MCS)

Background & Scope

Most energy applications of superconductivity, such as power transmission over superconducting cables, are based on achieving low energy dissipation in high-temperature superconductors.
Dissipation is minimized by restricting the mobility of the vortices carrying magnetic field in the superconducting material by pinning them with admixed inclusions. Understanding the interaction of vortices with general configurations of inclusions is a major, outstanding challenge both for fundamental science and energy applications. The task is complicated by the high density of the vortices, their mutual long-range interaction, and the dependence of their behavior on external parameters, such as temperature and the applied magnetic field. These features in general preclude an analytical description of vortex dynamics and, until recently, made numerical simulation prohibitively expensive.

Approach & Goal

The new emerging capabilities of DOE's leadership-class computing hardware and the development of scalable algorithms and software now put detailed numerical investigation of vortex pinning within reach. Capitalizing on these developments in combination with the broad expertise in superconductivity research at Argonne National Laboratory, this project aims to advance the fundamental understanding of vortex dynamics in superconductors and to predict the optimal size, shape and concentration of the admixed particles required to achieve optimal power transmission properties. Achieving these goals requires state-of-the-art research in the material properties of superconductors and numerical optimization and simulation.

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A History of Collaboration

The *OSCon* project builds on a rich history of collaboration between two of Argonne's divisions – Materials Science (MSD) and Mathematics and Computer Science (MCS) – as well as other institutions worldwide. Some of the earliest vortex simulations were among the first applications based on the Message Passing Interface (MPI), a parallel computing standard. The simulations were developed by hand in collaboration between MSD scientists and some of MPI's architects at MCS. Today, our research team boasts decades of collaboration across disciplines, and includes leaders in experiment, modeling, and simulation.

Building on Cutting-Edge Algorithms and Software

We are meeting the need for large-scale approaches to computational superconductivity with the help of the impressive algorithmic and software capabilities and broad expertise housed at the SciDAC Applied Math Institutes with strong connections to MCS and Argonne:

- adaptive meshing
- large-scale PDE simulation
- advanced time-stepping algorithms
- derivative-free optimization techniques
- scalable methods in the Toolkit for Advanced Optimization.

We are further collaborating with Idaho's Multiphysics Object-oriented Simulation Environment (MOOSE) group to leverage the SciDAC Institute capabilities for building complex scalable simulations.

Contact Information for OSCon Scientific Leads

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Argonne Division Web Sites

- Materials Science: http://www.msd.anl.gov
- Math and Computer Science: http://www.mcs.anl.gov

OSCon Web Site: http://www.oscon-scidac.org

For further information about OSCon, please contact Andreas Glatz or Dmitry Karpeev

Areas of Expertise

Ginzburg-Landau Theory and Vortex Matter
Igor Aronson
Andreas Glatz
Alexei Koshelev

Experimental Superconductivity
George Crabtree

Computational Materials Science
Andreas Glatz
Igor Aronson
Dmitry Karpeev

Large-scale PDE Simulation
Dmitry Karpeev
Jason Sarich

Optimization Algorithms
Todd Munson
Jason Sarich
Stefan Wild

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