Fundamental Magnetofluid Physics Studies on the Swarthmore Spheromak Experiment: Reconnection and Sustainment

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FINAL REPORT

Summary

The general goal of the Magnetofluids Laboratory at Swarthmore College is to understand how magnetofluid kinetic energy can be converted to magnetic energy as it is in the core of the earth and sun (the dynamo problem) and to understand how magnetic energy can be rapidly converted back to kinetic energy and heat as it is in solar flares (the magnetic reconnection problem). Magnetic reconnection has been studied using the Swarthmore Spheromak Experiment (SSX) which was designed and built under this Junior Faculty Grant. In SSX we generate and merge two rings of magnetized plasma called spheromaks and study their interaction. The spheromaks have many properties similar to solar flares so this work is directly relevant to basic solar physics. In addition, since the spheromak is a magnetic confinement fusion configuration, issues of formation and stability have direct impact on the fusion program.

Collaborators

Chris Cothran, Swarthmore, post-doctoral fellow; William H. Matthaeus, Bartol Research Institute, University of Delaware (theory and modelling); Gang Qin, University of Delaware (grad student, modelling); Steve Paul, PPPL (spectroscopy); Dalton Schnack, SAIC (modelling); Michael Schaffer, GA (equilibrium calculations); Masaaki Yamada, PPPL (scientific discussions); Hantao Ji, PPPL (scientific discussions, diagnostic support);

Impact

SSX is easily the highest profile science lab on the Swarthmore campus. Photos of the machine are featured in admissions and fund raising literature

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for the college. I think it's safe to say that my positive tenure decision was based in part on the success of my research program (which has been primarily funded by DOE). Swarthmore students both in the physics department and throughout the entire science division know about plasmas and fusion. Dozens of Swarthmore graduates now in graduate programs in physics, astronomy, and engineering have had some exposure to plasma physics and fusion energy science through the Swarthmore Spheromak Experiment.

SSX undergraduate honors theses

We have had continuous undergraduate involvement since we began setting up the lab in 1995. We average about 3 students working in the lab at any time and have had at least one honors senior graduate each year since 1997. During the grant period for ER54422, seven students have written a full senior honors thesis (on the order of 100 pages in length and each one defended before a committee of external examiners).

Cameron Geddes '97, "Spheromak equilibrium studies on SSX", graduated with high honors, studying plasma physics at Berkeley, recently obtained his PhD in plasma physics.

Tom Kornack '98, "Magnetic reconnection studies on SSX", graduated with high honors, studying plasma physics at Princeton

Slava Lukin '00, "Modeling SSX spheromak plasmas: Internal physics from external measurements", graduated with high honors, studying plasma physics at Princeton

Tim Gray '01, "Density studies on SSX", graduated with high honors, studying plasma physics at Princeton

Dave Schlossberg '01, "Energetic particle studies on SSX", graduated with high honors, studying plasma physics at Wisconsin

Dave Auerbach '01, "Ion temperature measurements in SSPX", graduated with high honors, studying plasma physics at UCLA

Matt Landreman '02, graduated with highest honors, awarded the Lang Prize as the top Swarthmore graduate in 2002, recipient of a Rhodes Scholarship, currently studying in Oxford

Related honors theses

Walter Luh '99, "Measurements of magnetic field convection in spherical liquid sodium flows", graduated with high honors, studying physics at Stanford

Amy Reighard '01, "The beta effect: Turbulent conductivity measurements in spherical liquid sodium flows", studying plasma physics at Michigan

Additional SSX workers

Eric Engstrom '96, Peter Sollins '98, Keith Gilmore '01, Aaron Carlisle '01, Andrew Fefferman '02

Publications associated with the grant

Not all of these are entirely associated with the Junior Investigator Award but the program was acknowledged.

References

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[3] A. B. Reighard and M. R. Brown, Turbulent Conductivity Measurements in a Spherical Liquid Sodium Flow, Phys. Rev. Letters **86**, 2794 (2001).

[4] M. R. Brown, Experimental Studies of Magnetic Reconnection, Phys. Plasmas **6**, 1717 (1999).

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[6] C. G. R. Geddes, T. W. Kornack and M. R. Brown, Scaling Studies of Spheromak Formation and Equilibrium, Phys. Plasmas **5**, 1027 (1998).