

CHAIR'S REPORT: EPR 2014

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1. Summary

The Exploratory Plasma Research (EPR) community met in Madison, WI on August 5-8, 2014 for EPR 2014. The EPR community was joined by the US/Japan Compact Torus (CT) Workshop making for a decidedly international presence. There were 114 registered attendees, up from the 69 attendees for our 2013 meeting in Fort Worth. The workshop featured 34 invited talks and a total of over 86 presentations including posters. There were 35 registered graduate students accounting for 35% student participation.

The Department of Energy Office of Fusion Energy Science (DOE-OFES) has restructured into four categories, three in Burning Plasma Science (High Power, Foundations, and Long Pulse), and one called Discovery Science. High Power covers ITER operations. Foundations covers the operations of existing US tokamaks. Long Pulse covers the US and International Stellarator programs (including W7-X). EPR programs are represented in Foundations (LTX, Pegasus, HBT-EP) and Long Pulse (HSX, CTH, theory support), as well as in Discovery Science (including MST). The EPR community is unique in its representation in three of the new OFES categories.

At the Wednesday evening banquet, we heard from Sam Barish of OFES, that within the new OFES program funding categories Burning Plasma Science: Foundations and Burning Plasma Science: Long Pulse there will be a solicitation for FY 2015-2017 funding. There will be a Funding Opportunity Announcement for non-national laboratories and a companion notice for national laboratories. Proposals for three-year projects will be solicited. Pre-applications will be required. The new budget category, entitled Discovery Plasma Science, consists of the following: General Plasma Science, High Energy Density Laboratory Plasmas, Madison Symmetric Torus (MST), part of Experimental Plasma Research (mainly compact toroids), and Measurement Innovation. All of the above, except for Measurement Innovation, form the subcategory of "Plasma Science Frontiers." EPR projects in the Discovery Plasma Science budget category will be given the opportunity to submit one-year renewal proposals for FY 2015 funding. These proposals will be evaluated in the same

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way as the one-year renewal proposals submitted in FY 2013 for FY 2014 funding. MST will also be given the opportunity to submit a one-year renewal proposal.

On August 18, 2014 Sam Barish and Francis Thio posted the OFES invitation to submit one-year renewal proposals to the EPR Discovery Science PIs. The one-year renewal proposals will be due Sept. 26. They state that “although FES plans to implement the new budget structure in FY 2015, it has not yet been finally approved. Also, FES has not yet decided how the Discovery Plasma Science category will be managed.”

Here we provide a summary of EPR 2014. It was an exciting meeting with a wide variety of topics presented. The workshop sessions featured several themes distributed throughout the week and are summarized below. There were 34 invited talks of which about half (approximately 15) were presented by young scientists (postdocs or graduate students). Copies of many of the presentations already appear under the Proceedings tab of the EPR 2014 website.

2. Stellarators: US and International

The opening keynote talk on Tuesday morning was by Ralf Koenig of the Max Planck Institute for Plasma Physics. He gave us a detailed progress report on the W7-X stellarator. He also laid out specific projects suited for US university collaboration. These were mostly secondary diagnostics but important for W7-X analysis: divertor Thomson system, bolometry, pop-up Langmuir probes, visible spectroscopy, HIBP, Li-beam, neutron diagnostics, fast-ion loss detectors, in-situ PFC analysis (LIBS), polarimetry system, imaging software analysis, real-time feedback control. W7-X will have the first phase of operation in summer 2015 (OP1.1). We hope to hear initial results at the next EPR workshop in early 2016. Francesco Volpe gave an interesting talk on the Columbia University stellarator (CNT) featuring two interlocked coils, as well as ideas and prototypes with larger numbers of interlocked coils. Matthew ArchMiller reviewed results from the Auburn stellarator CTH, including the use of inductive current drive for exploring disruption control. Gavin Weir reviewed the status of the Wisconsin stellarator HSX, including electron heat transport studies using ECH ($T_e \sim 1 \text{ keV}$). It appears that the world stellarator program will have an exciting next couple of years.

3. Alternate Approaches and Improvements

On Tuesday afternoon, we heard about some very innovative alternate approaches to fusion, as well as some improvements to established schemes. Universities and private companies were represented. John Santarius provided an overview of inertial-electrostatic confinement (IEC) research at the University of Wisconsin. Their lab is currently upgrading to 300 kV operation. Neutrons from IEC devices could be

used to detect clandestine explosives. Michel Laberge of General Fusion reported on explosively driven compression experiments on hot spheromaks. General Fusion has attained magnetic lifetimes of $600 \mu s$ and $T_e = 290 eV$. Confinement is ultimately lost during implosion but there is an initial increase in magnetic energy. Derek Sutherland of the University of Washington presented a reactor study called Dynamak, based on the HIT-SI concept. In the improvements area, Dick Majeski of PPPL discussed liquid lithium PFCs on LTX, Kathreen Thome of Wisconsin discussed the use of high-field fueling on the near-unity aspect ratio ST Pegasus, and Kyle Casperly of Wisconsin reported record RFP total beta observed at MST ($\beta = 28\%$). These devices were featured in a tour of Wisconsin plasma experiments on Thursday afternoon (Pegasus, MST, HSX, IEC, and MPDX).

4. Tom Intrator Memorial Session: Twisting and Merging

On Wednesday morning, we had a special session dedicated to the memory of our friend and colleague Tom Intrator who passed away June 4, 2014. Tom was a long-time participant of the EPR/ICC workshops presenting results from his FRX-L field reversed configuration and his RSX flux rope experiments at Los Alamos. Tom's friend, science writer David Tenenbaum opened the session with a testimonial in Tom's memory. Brian Nelson of U. Washington knew Tom for 32 years since their days together in Madison. Brian's talk was on the flow stabilized z-pinch ZAP, a stabilized version of Tom's twisting flux ropes. Scott Hsu of LANL had worked with Tom most recently. Scott presented work on colliding supersonic plasma jets. Paul Bellan of Caltech presented experimental work closely related to Tom's on MHD-driven plasma jets, as well as discussion of a 4th order differential equation governing collisionless reconnection in the jets.

5. Discovery Science

Also on Wednesday morning, we had a session featuring fundamental plasma physics experiments of the type in the new Discovery Science funding category in OFES. David Weisberg presented some initial results from the Madison Plasma Dynamo Experiment (Cary Forest PI). MPDX can generate a hot (20 eV) unmagnetized plasma core in a 3 m spherical chamber that can be spun to 12 km/s. Mike Mauel of Columbia reported on the Levitated Dipole Experiment (LDX) at MIT, the world's largest laboratory magnetosphere. David Schaffner of Swarthmore reported on experiments with the MHD plasma wind tunnel configuration of SSX, including turbulent spectra, intermittency, and a new analysis technique involving permutation entropy of fluctuating time series.

6. Validation and Verification

A real strength of the EPR community is the close coupling of numerical simulation and experiment. Last year, for EPR 2013, we invited William Oberkampf (Oberkampf Consulting) to give an overview of his verification and validation techniques as outlined in his book, “Verification and Validation in Scientific Computing”. This year we heard several talks from our community from practitioners employing those techniques to EPR experiments. Slava Lukin presented HiFi simulation comparisons to SSX plasma wind tunnel experiments. Joshua Reusch presented a comparison of an MHD simulation of MST. Chris Hansen presented an application of the PSI-TET framework to the HIT-SI injector. Matthew Galante showed us how integrated data analysis could be used to determine Z_{eff} in MST from limited data sets.

7. US/Japan CT workshop

Finally, the US/Japan CT workshop was incorporated into the EPR workshop this year with great success. We heard the latest from the world CT community (field reversed configurations and spheromaks). Yasushi Ono presented ion and electron heating measurements TS-3 and 4 at the University of Tokyo. Bihe Deng of the private company TriAlpha Energy showed results of a 4 *ms* lifetime and toroidal field measurements from the C-2 FRC merging experiment. Masayoshi Nagata of the University of Hyogo presented results of multi-pulse CHI experiments on HIST. Brian Victor of the University of Washington (and CT workshop chair) discussed the latest exciting sustainment experiments on HIT-SI at high frequency operation. A highlight was Tomohiko Asai’s fast framing movies of an accelerated FRC at Nihon University.

8. Next meeting: EPR 2016 Auburn

At the executive committee meeting, Brett Chapman of the University of Wisconsin was elected as the next EPR chair (replacing M. Brown). We discussed Auburn University as the next venue for EPR 2016, and approached David Maurer of Auburn University to act as host. The time frame of February 2016 and sites at Auburn are being actively explored. It appears that with a solicitation for FY 2015-2017 funding for Foundations and Long Pulse, and with a one-year renewal for 2015 funding for EPR Discovery Science PIs, there will be a viable community ready to report results in 2016. A new program committee will be formed for EPR 2016 in the coming year, chaired by Brett Chapman.