Lawrenceville Plasma Physics, Inc

High technology research, development and consulting in plasma physics, X-ray sources, and Focus Fusion

Focus Fusion Report

November 13th, 2012

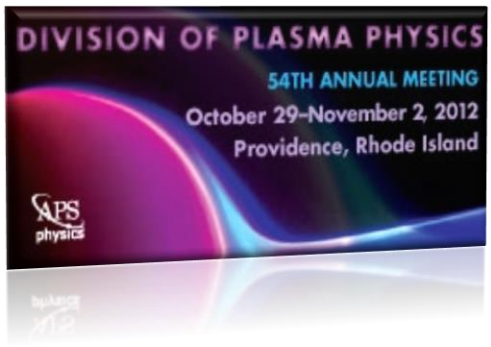
- **Hurricane Sandy shows need for decentralized energy**
  - **But delays its arrival (slightly)**
- **American Physical Society Plasma Physics Conference:**
  - **Focus Fusion still in the lead**
  - **Opportunities for cooperation**
- **Former DOE fusion chief says aneutronic is the way**
- **New LPP video, Manhattan presentation lift visibility**
- **Visit by Prof. Hamid Yousefi furthers PPRC collaboration**

Summary: Hurricane Sandy left the lab without power for a week, which fortunately overlapped with much of the team being away at the APS annual conference. That conference showed LPP remains at the forefront of efforts to reach net fusion energy. Dr. Robert L. Hirsch, an architect 40 years ago of DOE's concentration on the tokamak, now says aneutronic fuels are the path to fusion. LPP's new video ranks highly. Dr. Hamid Yousefi visit furthers our scientific publication agreement.

Sandy briefly stalls progress, but shows the need to go forward

"Surely the series of disasters we have witnessed in the past two years—the Deep Horizon oil spill, the Fukushima meltdowns and now the widespread and lasting power disruption following Sandy—should convince us that we urgently need a new source of energy that is safe, reliable, clean, and distributed—spread out in many locations so that a few disruptions do not knock out an entire region." LPP's statement on Hurricane Sandy emphasized how the storm's disruption is yet another dramatic illustration of the necessity of new energy development. Downtime at a few crucial refineries, for example, paralyzed the entire region with gasoline shortages. But the development of aneutronic plasma focus generators could put power generation into every community, which, combined with electric cars, would make widespread disruptions history. Fortunately, while LPP's Middlesex laboratory lay squarely in Sandy's path, no flooding or other damage occurred at the lab. Power was out for one week at the lab, and for two weeks at LPP's office in Warren, NJ, where LPP President Eric Lerner lives. So this has delayed our work, but did not stop it entirely or seriously set it back.

Credit: SBC News Oct 27 2012



LPP at APS Conference: Strengthening our lead towards fusion power

LPP Chief Scientist Lerner, accompanied by visiting scientist Dr. Hamid Yousefi of the Plasma Physics Research Center in Tehran, and Ahmad Talaie of Utah State University (our most recent summer graduate research fellow) participated in the annual American Physical Society Plasma Physics conference in Providence, RI, October 29-November 1 (conveniently riding out the storm away from NJ while LPP's Laboratory Coordinator Derek Shannon held down the fort.) The conference provided new information and opportunities, but the most important conclusion for us was the lead that LPP's Focus Fusion effort maintains over other approaches. This, of course, is no guarantee that our approach will actually get to a practical fusion generator first, but it is a snapshot of the fusion race right now.

Tri Alpha Energy, which is pursuing aneutronic fusion with a different device from the plasma focus, presented their past year's progress with a half-dozen poster presentations. The clear and thorough presentation of their results was due to a shift in management's approach to a new openness, according to several of the researchers participating. Tri Alpha's device, called a Field Reversed Configuration or FRC, generates two large rings of plasma and heats them with an externally accelerated ion beam. Their most recent results show that they have confined plasma at about 100 eV energy for about 2 milliseconds at a density of $2x10^{13}$ ions/cm^3. A rough measure of overall progress is the product of these three numbers, called "nτT", which for Tri Alpha is **$4x10^{12}$**. By comparison, LPP's FF-1 with an ion energy of 160 keV, confinement time of about 30 ns and density of $3x10^{19}$ ions/cm^3 has a nτT product of **$1.4x10^{17}$**, a factor of about 30,000 larger than that of Tri Alpha. **This puts LPP far closer to the goal of net energy for now.** Tri Alpha has raised about $140 million in private investments and works with a staff of 30 physicists.

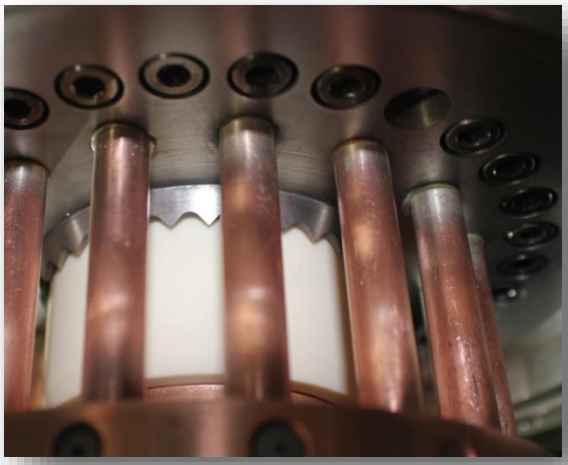
LPP feels strongly that all possible routes to aneutronic fusion should be researched, as long as we don't know for sure which one will work. We expect to continue discussions with the Tri Alpha team about possible avenues of cooperation.

Lerner's presentation on LPP's experimental progress was attended by about 60 researchers, a good turn-out. We explained our latest progress (see attached slides) on understanding how arcing affects the formation of filaments and our efforts to overcome this. Our latest work shows that arcing lays down irregular deposits on the insulator and anode which in turn leads to an uneven spacing of the filaments. When closer-spaced filaments collide during compression, they generate the "early beam" phenomenon and prevent full compression and high density of the plasma.

Our new micro-ohm meter allowed us to test for the contact resistance that causes arcing without assembling and testing the whole machine. But continuing small resistances forced us to switch from the copper cathode plate with tungsten ring to an all-tungsten plate. We did not have time to test that new plate before the conference (and the simultaneous storm). Despite this anti-climactic conclusion, our presentation was well-received with good questions and several researchers complimenting the work afterwards. Several researchers appreciated our addressing the detailed

technical problems that are often overlooked in reporting scientific results and were impressed by the progress we are making.

Talaie and Lerner's theoretical description of heating due to plasma viscosity and the currents induced by the electron beam unfortunately reached a smaller audience, in part because our poster happened to be located in the far corner of the hall, but the insight this work provides for further progress is no less valuable.



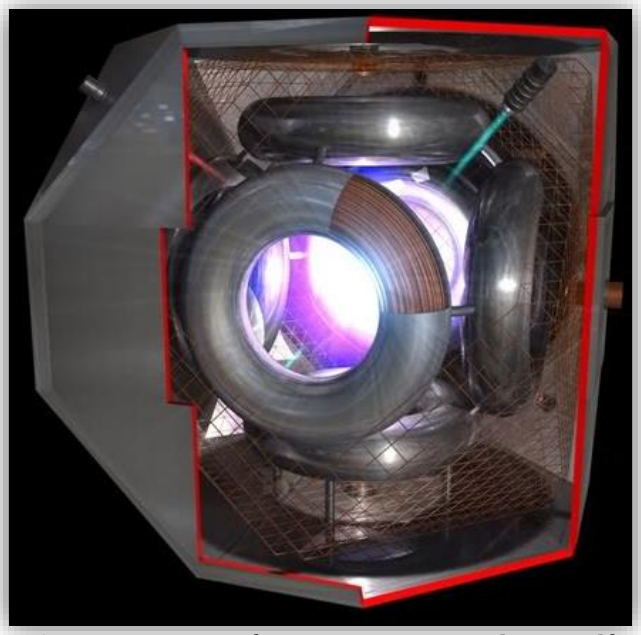
The saw teeth above are one solid piece with the tungsten base, eliminating a current contact that had caused arcing. The teeth concentrate electric fields to enhance filamentation in the plasma sheath that extends outward to the copper rods.

At least two possibilities for collaboration arose at the conference. University of Alabama has received some funding for fusion space propulsion from NASA, and researchers there are interested in a possible collaboration with LPP in designing plasma focus devices for a new, powerful mega-ampere facility there. Researchers at Lawrence Livermore National Laboratory have developed a computer simulation of the compression phase of plasma focus functioning and may be willing to collaborate with LPP to benchmark their simulations against our detailed experimental results. We will be following up both possibilities in the coming month.

Former DOE Fusion Chief, Robert Hirsch, says aneutronic fuel is path to fusion, and the tokamak will not provide practical energy

"So where are we likely to find practical fusion power? First, we must look for a concept or concepts that are inherently small in size, which means high plasma density. Second, we must look for something that can be based on a low or zero neutron fusion reaction. One example is the proton-boron reaction." So said Dr. Robert L. Hirsch, in a presentation given at the 14th U.S.-Japan IECF Workshop, October 16, 2012, and then widely reported in the New York Times blog, Dot Earth. In the same presentation, Dr. Hirsch concluded that the tokamak cannot lead to practical energy sources because it is too large, too expensive, and does not avoid radioactive waste due to neutron production.

Dr. Hirsch's views are notable because, 40 years ago, he was director the Department of Energy's fusion research program and was a key figure in pushing the program into its narrow emphasis on tokamaks, a major error that Dr. Hirsch now acknowledges. It is not news that Dr. Hirsch thinks tokamaks are a dead-end, as he has been saying something like this for about 15 years. But this is the most forceful statement he has made of these views, and the first to gain widespread media attention.



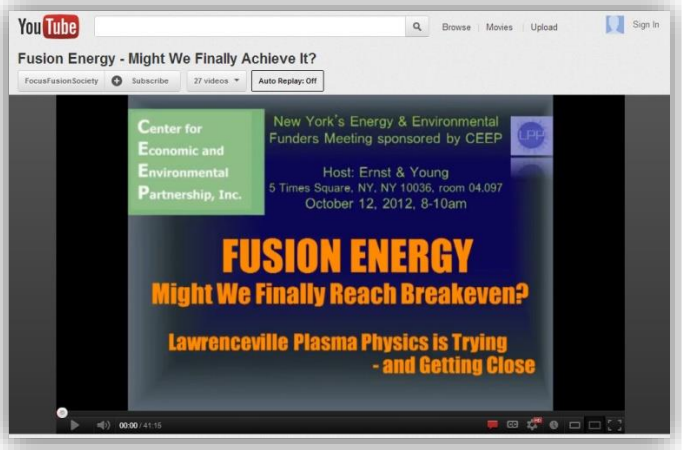
Artist's concept of an IEC generator by Torulf Greek, who is also responsible for LPP's Focus Fusion depictions.

The only specific approach for aneutronic fusion that Dr. Hirsch cited in his speech was Inertial Electrostatic Confinement (IEC), which is understandable, since he was a pioneer of this approach before becoming an advocate of the tokamak, and the presentation was directed to an IEC workshop. (In response to various requests, LPP will soon release a comparison of the plasma focus with IEC and other approaches to aneutronic fusion.)

The attention given to Dr. Hirsch's negative analysis of the tokamak came only a few weeks after a government report on the National Ignition Facility (NIF) revealed that it had essentially no chance of reaching fusion ignition (the self-heating of a plasma by fusion reactions) in the foreseeable future. NIF, based on a giant laser array, and the tokamak program have consumed (and still consume) the vast majority of US funding for fusion research. These two analyses show that it is long past due for the government to redirect its fusion funding in more inclusive directions.

Video of LPP presentation in Manhattan lifts our visibility

LPP's latest presentation "Fusion Energy: Might we finally achieve it?" is ranking near the top in video searches for fusion energy. Over 7,000 people have already viewed this presentation by the LPP team, hosted October 12th by the Center for Economic & Environmental Partnership, Inc at the Times Square offices of Ernst and Young in Manhattan. The presentation was organized by center director Gelvin Stevenson, who was contacted by LPP Senior Consultant Sam Salamay. LPP's Chief Information Officer, Ivana Karamitsos, designed the presentation's graphics and edited it into a finished version that has now had a reach far beyond the original thirty audience members. The new video adds considerably to LPP's web presence, which already includes several widely-viewed videos either by us or about us on mass media such as RT (Russian Television).



PPRC's Dr. Hamid Yousefi visits LPP for 3 weeks, furthers scientific publication collaboration, proposal to IAEA on the horizon

From October 14 to November 3, Dr. Hamid Yousefi, an internationally-known researcher in aneutronic fusion and long-time collaborator of LPP's Chief Scientist Lerner, visited LPP's NJ lab and participated in its research activities. Dr. Yousefi is a professor at the Plasma Physics Research Center in Tehran, which recently agreed to collaborate with LPP on scientific publications in the field of aneutronic fusion. While here, he had long discussions with Lerner and Shannon on the details of the Focus Fusion effort. The scientists also finalized a first step in the collaboration agreement. This is to propose to two PhD plasma physics students at PPRC that they initiate theses based on analyses of neutron and X-ray data from LPP's FF-1 experiment. Through this effort, LPP will be able to obtain skilled analysis of data that we have simply not had time to study in detail, and PPRC students will get access to an unparalleled data set from a large plasma focus fusion experiment. (While Iran has several plasma focus groups, none can use deuterium or other fusion fuels, due to the sanctions against Iran.)

In addition, Dr. Yousefi and another PPRC colleague, Dr. Pejman Khorshid, who also paid a brief visit to LPP, have had discussions of the Fusion for Peace initiative with representatives of the International Atomic Energy Agency. Based on these discussions, we are proposing to the IAEA the establishment of a Collaborative Research Project for Aneutronic Fusion. Such an international collaboration under IAEA auspices, if approved, will make it easier for many groups in the US, Japan, Australia, and elsewhere to collaborate with us and Iranian researchers without concerns about potential violations of the sanctions on Iran.

Below (l-r): LPP's Derek Shannon and Eric Lerner smile for peace alongside Professor Hamid Yousefi of the Plasma Physics Research Center in Tehran—Hamid's young son was very eager for pictures from his dad's trip!