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Lawrenceville Plasma Physics, Inc

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

# *LPPFusion Report*
# *October 24, 2018*

**Summary:**

- **Assembly Begins for Beryllium Electrode Experiments**
- **Plasma Focus Researchers Discuss Progress in Warsaw**
- **SMoC is Smacked at Prague Cosmology Conference**
- **Anode Heating Studies Advance**
- **"Let There be Light" Video Available for Free**

## Assembly Begins for Beryllium Electrode Experiments

The LPPF research team has begun the re-assembly of the Focus Fusion experimental device for the long-awaited experiments with beryllium electrodes. With the new glove box for handling the electrodes now installed, the first step was to attach new windows to the vacuum chamber (Figure 1). Two of the new larger windows are now protected by shutters that will be closed during firing. This will allow them to be used later in the experiment if the main window becomes too coated for use by the ICCD camera. While this did not occur in earlier experiments, the research team plans for a much longer experimental run this time, with 1,500 or more shots. In addition, the use of hydrogen-boron fuel later in the experimental run might lead to heavy coating with boron. The shields will allow for many more shots if coating becomes a problem.

The next steps in assembly will be to mate the beryllium electrodes with their steel connecting plates, using soft indium metal between the parts to ensure good electrical contact. As with the earlier tungsten electrodes, all electrical contacts will be outside the vacuum chamber, eliminating any possibility of arcing into the plasma. The silicone vacuum seals will be baked out at high temperature in our new vacuum oven. Then, the team will carefully center and mount the electrode-plate assemblies onto the rest of the Focus Fusion device. The new vacuum chamber and auxiliary vacuum system will then be installed, sealed and pumped down. After that we will re-install the ICCD camera and other upgraded instruments, including a new electron-beam spectrometer. The final step will be to re-assemble the capacitor switches with new Lexan and ceramic insulators. So we still have a bit of work to do!

*Figure 1. Dr. Syed Hassan bolts a window to the new vacuum chamber, which is coated with golden-colored titanium nitride. The protective shutter has already been installed on a second window, facing the viewer. Note the small silver lever extending below the window, which can open and close the shutter without breaking the vacuum. This window is protected by a plastic cover during assembly.*

At the same time as Research Physicist Syed Hassan and Chief Scientist Eric Lerner assemble the hardware, Chief Information Officer Ivy Karamitsos and System Administrator Jose Varela, helped by Electrical Engineer Fred van Roessel are upgrading the data processing system. The new system will automatically download all data, process it to produce an estimate of plasma parameters (density, temperature and others) after each shot, and store the data into a new database, with a user-friendly interface. We expect this will greatly accelerate analysis of the data during the breaks between firing the machine, allowing the fine-tuning of the experiment on the fly.

# Plasma Focus Researchers Discuss Progress in Warsaw

In addition to LPPFusion, two other experimental groups in Poland expect to be testing hydrogen-boron fuel in a plasma focus device in 2019. This was a key highlight of the annual International Centre for Dense Magnetized Plasma workshop in Warsaw, October 4 and 5. The workshop is a summit meeting for researchers using the plasma focus around the world. LPPFusion's Lerner attended the workshop, representing the USA on the International Scientific Committee, which seeks to coordinate work on the plasma focus.

The two groups will take somewhat different approaches to mixing the hydrogen and boron. While LPPF will be using a compound of hydrogen and boron, decaborane, as a fill gas, the PF-1000U group in Warsaw, will puff a plume of different gas, boron fluoride, through a hole in the anode just before a pure hydrogen pinch converges on the center. The gas-puff idea, which has been used before in other experiments with deuterium, is intended to allow greater densities in the final stages of compression. However, the turbulence in the puff may lead to asymmetries in the compression, and so to lower final density.

The Krakow group, using PF-24, a device very similar to LPPF's, will use a laser to vaporize a puff from a block of solid boron in the anode tip, only 1 microsecond before a pure hydrogen pinch converges on the spot. Since the boron block has to sit slightly off-axis to avoid being destroyed by the electron beam from the plasmoid, the problem of potential asymmetry is present in this approach as well. Initial tests indicate that the laser can be tightly correlated with the plasma focus pinch process.

Both Polish groups had hoped to run boron experiments in 2018 (as had LPPF's team!) but ran into a variety of delays. All three groups will be sharing results and learning from each other's work.

Possibilities for a number of other collaborations arose at the workshop. Dr. Leopoldo Soto of Chile showed evidence from a tiny plasma focus device that there is a sharp front between the filamented and unfilamented portions of the current sheath. LPPF expects to be able to use Dr. Soto's clear images to test our theory of a critical velocity needed for filament formation. In addition, Dr. V. Krauz from Russia has initiated a collaboration with astrophysicists using the plasma focus as a model for Herbig-Haro objects in space (Figure 2). These objects form as a cloud of plasma contracts to form a star like our Sun. Like a plasma focus plasmoid, Herbig-Haro objects eject highly focused beams. LPPF will be seeking to enlarge this collaboration to US researchers.

Finally, in the broadest collaboration agreed to at the workshop, the Scientific Committee agreed to start a year-long process leading to a "consensus" review paper, summarizing what we, as PF researchers, all agree to about the device's functioning, what aspects are still being debated, and what questions are still entirely open. The discussion will start with the circulation of brief statements and will be capped by a special workshop in a year.

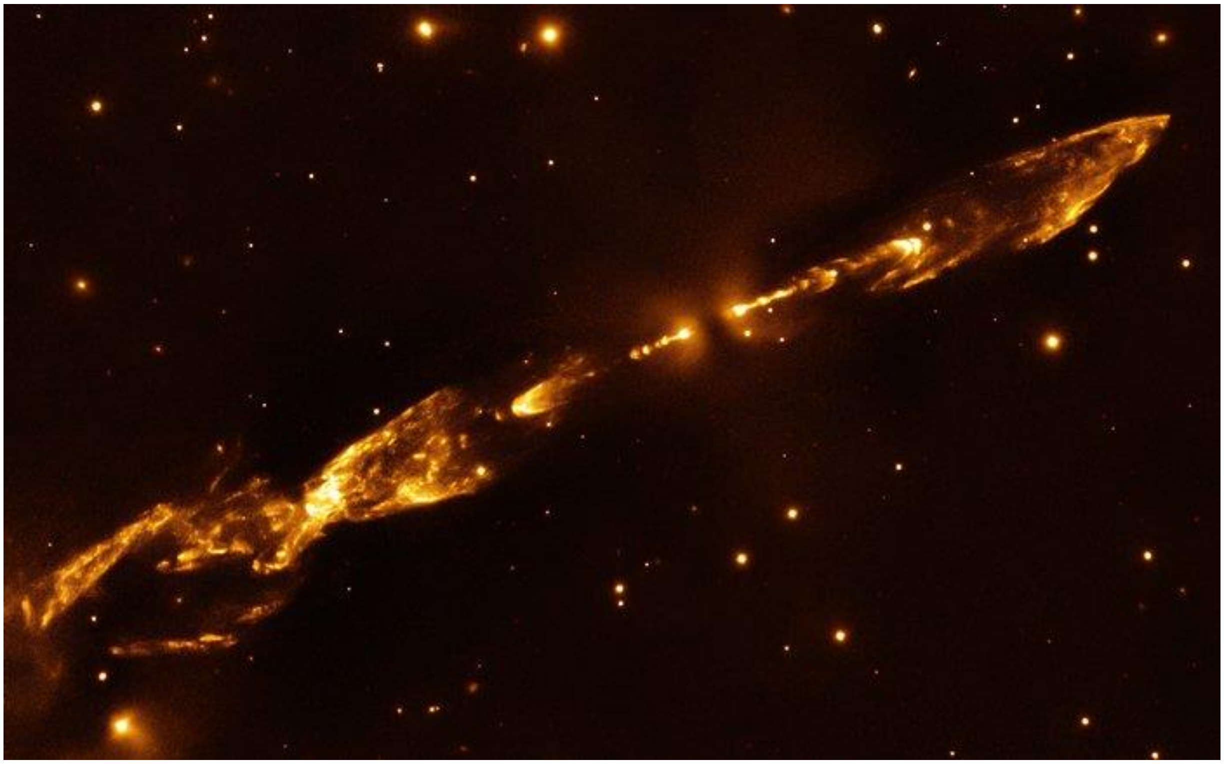

*Figure 2. Herbig-Haro object 212 (not in the New York area code!) as imaged by the European Southern Observatory in Chile. A star is forming in the dark area between the two symmetrical jets, each a few light years long. The jets are accelerated outwards by electromagnetic forces extremely similar in all but scale to those within a PF plasmoid.*

# SMoC is Smacked at Prague Cosmology Conference

The Big Bang theory, also known as "Concordance Cosmology" or the Standard Model of Cosmology (SMoC) came under sharp criticism from a group of researchers at the International Conference on Cosmology at Small Scales, held in Prague Sept. 26-28. With some 60 scientists participating, the conference was one of the largest gatherings of those skeptical of parts, or all, of the dominant theory of cosmology. LPPF's Lerner was among those smacking the SMoC, presenting an overall survey of the failings of the theory, and the successes of alternative explanations of the major observed features of the Universe. A video of Lerner's presentation is available.


*Figure 3. Lerner points out the contradictions between the Big Bang theory (SMoC) and observations during his talk at the Prague Conference.*

Many of the presentations detailed observational evidence against the existence of dark matter—a key hypothesis of the SMoC. The most impressive new evidence, presented by Pavel Kroupa of the University of Bonn, among others, was based on the concept of dynamic gravitational viscosity. This viscosity would occur as a body such as a star moves through an evenly distributed gas of dark matter (DM) particles, which are supposed to interact with ordinary matter only through gravitation. The DM particles will be attracted by the star and their trajectories will be bent towards it. That will result in a concentration of DM particles forming *behind* the star. Since the concentration of DM particles will attract the star more from behind than the evenly-spread-out DM will attract from ahead, the net result will be a backward pull on the star, slowing it down as if it was moving through a viscous fluid.

The crushing evidence against this dynamic viscosity (which MUST occur if there is DM) is the existence of many small concentrated groups of galaxies. Presentations showed that dynamic viscosity would have caused these groups of galaxies to slow down and merge with each other long ago. But the groups are far too common for them to exist for only a short time. And such short lives would require that five or more galaxies accidently arrived at the same point simultaneously, which is extremely unlikely. So no dynamic viscosity exists and with no dynamic viscosity, no DM. Dr. Kroupa drew the further conclusion, that no DM meant no SMoC.

Instead of DM, magnetic fields can contain the rapidly-moving plasma in galaxies, Lukasz Bratek explained in another presentation. A key piece of evidence that magnetic fields, not mythical DM, was controlling the plasma was the observation that stars in galaxies move considerably slower than plasma. Stars are far too dense to be affected by the magnetic fields in a galaxy, but are of course affected by gravity. Plasma is accelerated by both the magnetic fields and gravitation, so the combined fields can contain faster motion. This line of research, which

Lerner has been involved with for over 20 years, may also lead to possibilities for collaboration and modeling with the plasma focus.

# Anode Heating Studies Advance

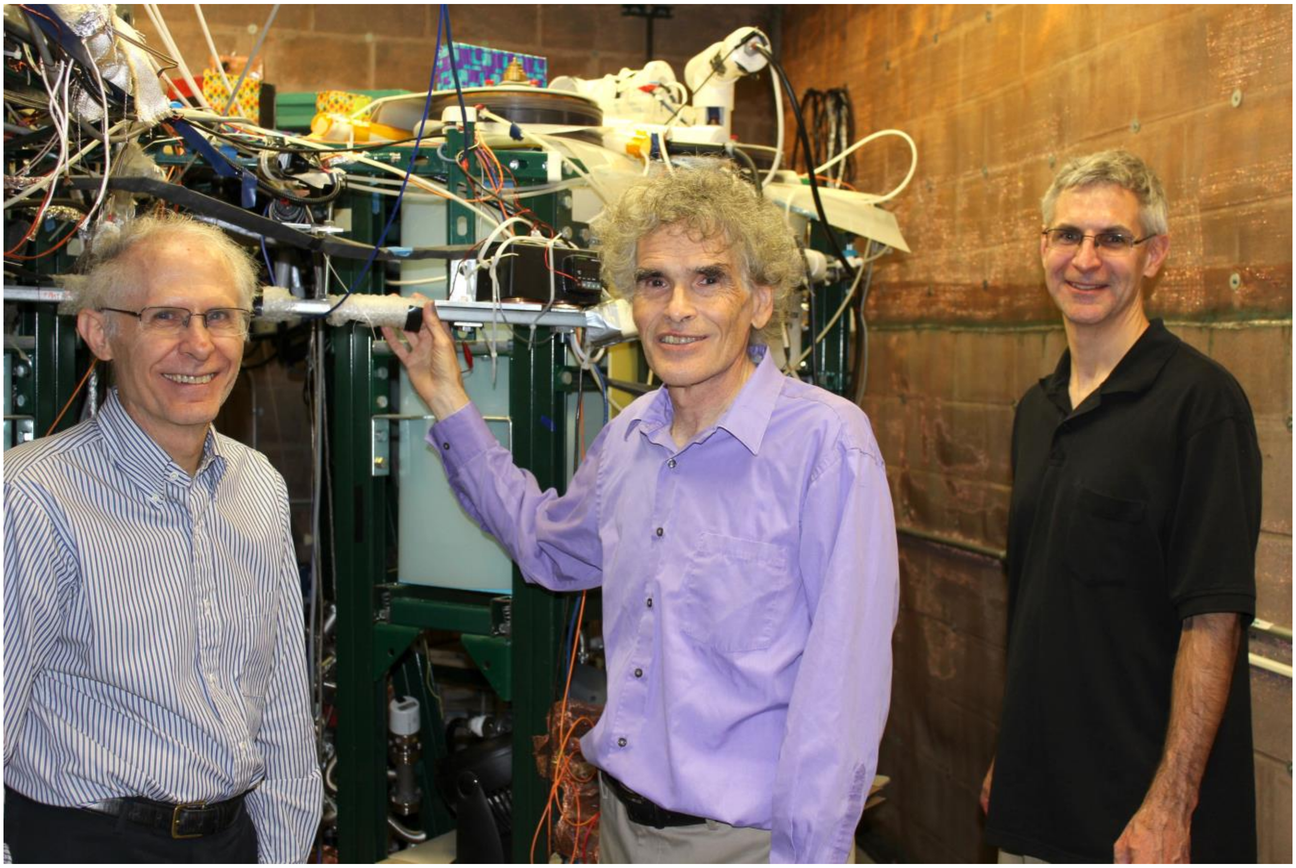

*Figure 4. Lerner, center, and engineers Gerry Black, left and Mike Ruthemeyer, right, pause for a photo-op in the midst of discussions of ways to reduce heating of the DPF anode. Black and Ruthemeyer have advanced further in simulations of the anode tip heating, which they confirm is far less for beryllium than tungsten electrodes.*

# "Let There be Light" Video Available for Free

The exciting CBC documentary on fusion, "Let There be Light" is now available for free on Vimeo, courtesy of the producers, EyeSteelFilm. This is the best overall introduction to the state of fusion research today, and focuses not only on the giant ITER project, but also on LPPF, General Fusion and W-7X as examples of alternative approaches.