Report June 10, 2024

Summary:

- **LPPFusion at ITER: Smallest, Fastest Path to Fusion**
- **Electrons are Hot!**
- **Quantum Simulation Collaboration Starts**
- **Magnetism Shapes the Cosmos—New York Times Catches Up**
- **Evolution of Physics Class: The Second Law of Thermodynamics**
- **Wefunder Drive Passes $150,000—We Need to Go Faster to $200,000!**

LPPFusion at ITER: Smallest, Fastest Path to Fusion

Less than a mile from the world’s largest fusion energy construction site, LPPFusion Chief Scientist Eric Lerner described our Fast Path to Fusion Energy to the Inaugural Private Public Fusion Workshop May 27th. More than 350 scientists, engineers and others from more than two dozen private fusion companies, twenty universities and ITER’s organization gathered at the first global conference devoted to bringing together private fusion companies with government-funded fusion projects. In contrast to the planned 300,000-ton ITER device, Lerner emphasized that we aim to produce net energy with a 3-ton device, FF-2B. He explained that with our approach of imitating, rather than fighting, natural plasma behavior we've achieved the highest temperatures of any fusion experiment and the highest ratios of fusion energy out to device energy in (wall-plug efficiency) of any fusion company for an expenditure of only $10 million. In the past year, we've increased peak current by 60% with no increase in energy input and drastically decreased electrode erosion.

The presentation was part of the panel on "innovative approaches "that included the two other oldest fusion energy companies—TAE and General Fusion. In it, Lerner also announced exciting, if preliminary, new results showing record high temperatures for the electrons in the fusion-producing plasmoid (see next story). The panel presentations will soon be available on the ITER website. We'll let everyone know when they are. LPPFusion's slides are available here.

The workshop was set up on the joint initiative of ITER and the Fusion Industry Association, the organization of private fusion companies that LPPFusion is a member of. ITER is the international government-funded project to build the world's largest (and most expensive) tokamak fusion experimental device. The goal of the workshop is to "help to establish priorities and formulate plans for how ITER will engage with private sector fusion companies going forward. The insights gained will also be provided freely to other efforts geared toward public-private collaboration, including for example the IAEA's program for its recently formed World Fusion Energy Group."

In addition to LPPFusion and TAE, ENN, China's natural gas company also presented work aimed at using hydrogen-boron fuel (pB11). There was a large contrast between the three pB11 projects and the much more numerous ones aimed a deuterium-tritium fuel. The DT projects all had a very complex path to producing energy because of their need to protect the structures against neutrons, to breed tritium fuel (which does not exist in nature) from lithium and to build large machines. The pB11 approaches were mainly concerned with getting to the conditions needed for net energy—after that the path to working generators would be far easier with no neutron damage and direct conversion of energy to electricity.

However, one company aiming for DT operation, MIFTI, was able to announce major progress in fusion yield, with a z-pinch experiment. The z-pinch is a close cousin of the dense plasma focus and MIFTI had already claimed the second spot among private fusion companies for wall-plug efficiency, behind LPPFusion. With the new results they closed the gap with us from a factor of 100 to a factor of 15. LPPFusion expects to re-open the gap soon.

Lerner was able to have a number of helpful technical discussions with other participants, including researchers from MFIT General Fusion and ITER. Among the insights gained were better ways to shield our ICCD camera and possible ways to mitigate the anticipated coating of our windows when we operate with boron fuel.

Perhaps most significant, at this conference the different approach LPPFusion was taking was welcomed, with many participants coming up to Lerner to express keen interest in the presentation. Not so long ago, both dense plasma focus and pB11 approaches tended to be ignored by tokamak and DT researchers. Times have changed!

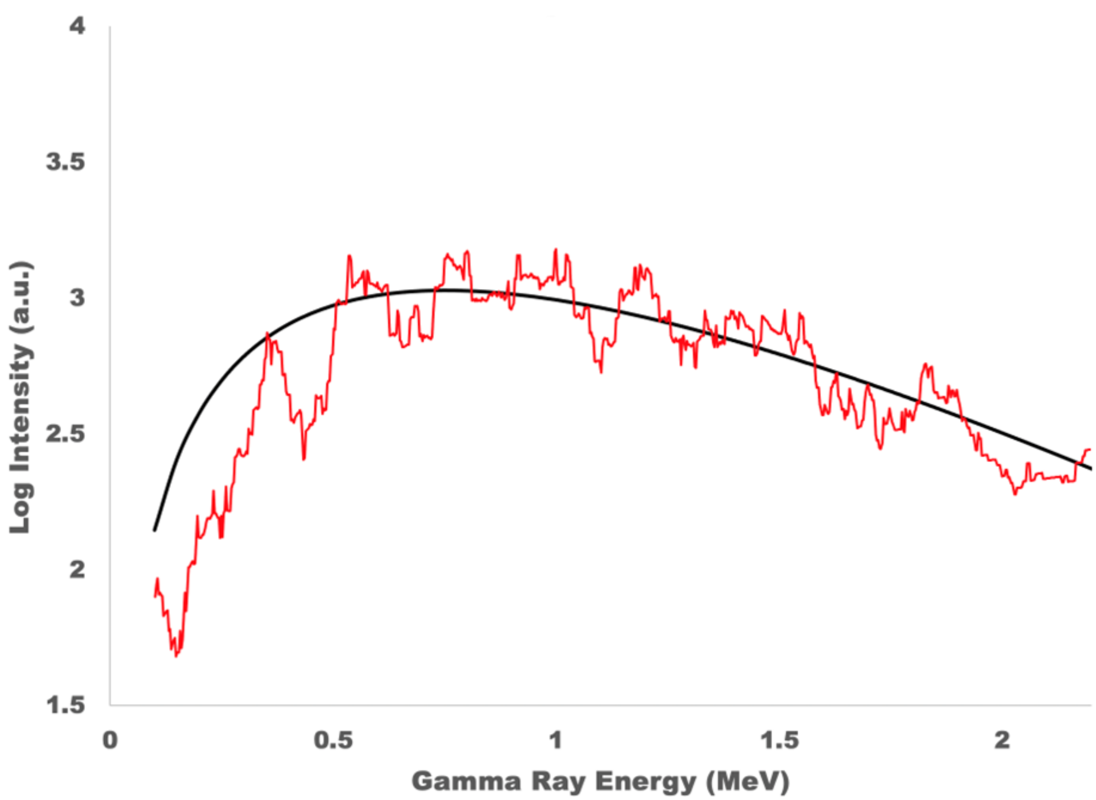
Electrons are Hot!

While the LPPFusion team is still completing the control tests with tungsten electrodes, our new gamma ray spectrometer has produced important new results. In the last report, we described how the new, economical, spectrometer gave measurements of the ion beam. We then moved the spectrometer from the outside of the drift tube to in front of the main window, where it was exposed to the x-rays and gamma-rays from the plasmoid. The electrons in the plasmoid produce this radiation when they collide with the ions. The shape of the spectrum is a direct consequence of the distribution of electron energies in the plasmoid.

Only two shots have been taken so far with the spectrometer observing the plasmoid, but they produced very similar spectra. The spectra were an excellent fit to that predicted from a plasma with a 420 keV electron temperature plasma. This is even hotter than the record ion temperature we obtained back in 2016 and is the equivalent of 4.6 billion degrees K. The spectrum fits closely to a Maxwellian or thermal distribution of electrons, where the electrons are moving in a completely random way

(Fig.1) . This is important, as it is a strong indication that the x-rays are produced by electrons that are confined to the plasmoid and thus have enough time to randomize, rather than produced by the electron beam, which exits the plasmoid rapidly.

Our next step is to buy one or two more spectrometers so we can simultaneously observe the gamma rays from the plasma and from the beam. That will allow us to more accurately subtract any beam contribution to the plasmoid spectra. Once we do the calculation to calibrate the beam spectra, we will be able to simultaneously measure the total beam current, plasmoid density, electron temperature and plasmoid volume. Since we already measure the ion temperature from our neutron-detecting PMTs (photomultipliers) we'll have all plasma parameters for each shot.



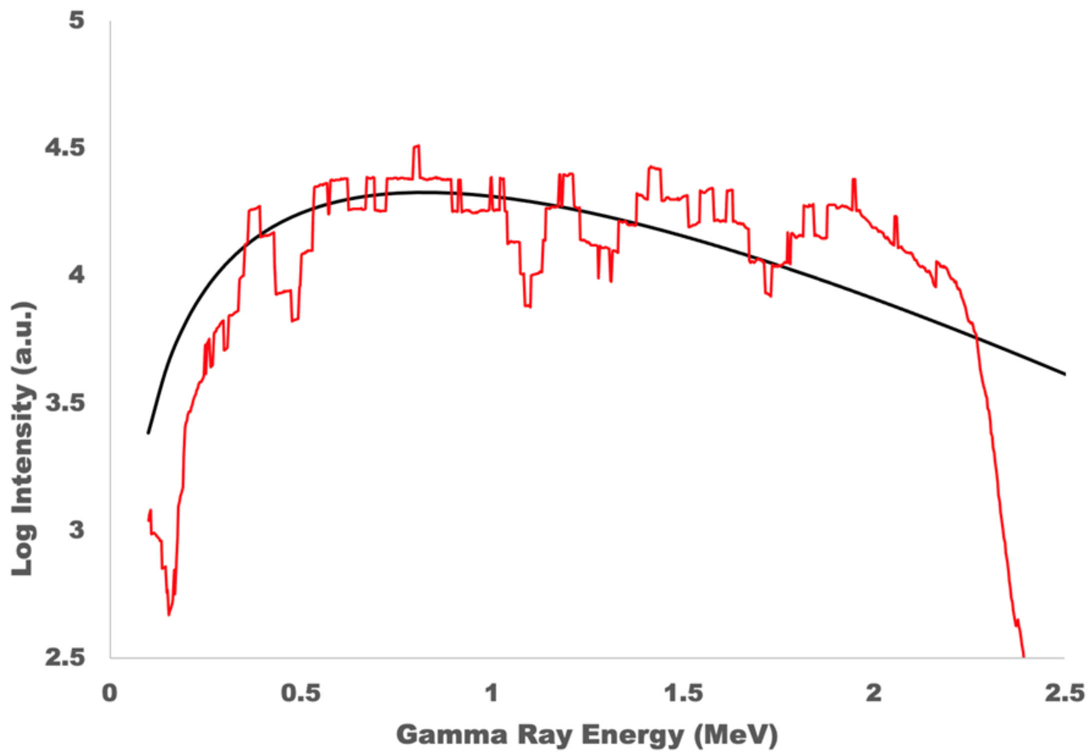


Figure 1. A) Gamma rays from the plasmoid (the sum of two shots in May) are plotted as the logarithm of the gamma ray intensity vs gamma ray energy. The redline is the data averaged over 100 keV and the black line is the spectrum predicted from a 420 keV(4.6 billion K) Maxwellian (random) plasma. The black line is a good fit to the data. B) The gamma rays from the ebam of April 12th shot 2. Again the black lineis the best fit from a Maxwellian plasma. But unlike for the plasmoid spectrum, the Maxwellain line is not a good fit to the data, which has too much power aroundn 2 MeV and a sharp cutoff above 2.3 MeV, well below the spectrometer's limit of 3 MeV. Together these spectra show that the plasmoid spectra is from a confined hot plasma, not a beam passing through a background.

Quantum Simulation Collaboration Starts

Last October, LPPFusion Chief Scientist Eric Lerner attended a conference on Hydrogen-Boron Fusion in Prague and proposed a collaboration with other groups in simulating key phenomena in fusion plasma. Now the first such collaboration has begun with Arun Kumar, research scholar from Indian Institute of Technology Hyderabad, India. Kumar will be working with Lerner to study the quantum magnetic field effect, (QMFE), an effect that is key to getting net energy production with hydrogen-boron fuel.

The QMFE is a well-understood effect that will help to keep the fusion plasma at the billions-of degrees temperatures needed to burn hydrogen-boron fuel. X-rays emitted by electrons cool the plasma. Because of the five electric charges on the boron nuclei, the electrons interact more strongly with these ions and cool the plasma faster than with pure hydrogen. But the strong magnetic fields in the tiny plasmoid in FF-2B generate a quantum-mechanical effect that greatly slows down the heating of the electrons by the ions. Since the electrons don't get very hot, they radiate far fewer x-rays and cool the plasma far less than without QMFE.

LPPFusion's published calculations show that QMFE allows production of more fusion energy out than is put into the entire FF-2B fusion device. But these published calculations involve a number of approximations. A simulation is a much more detailed calculation that can, potentially, provide much more exact and reliable results.

Kumar has been working with a well-tested plasma simulation program, using it to simulate a laser-based fusion approach. In this approach, an ultra-fast laser hits a “pitcher” target, generating an intense beam of protons. This beam then enters the “catcher” target containing boron, where hydrogen -boron fusion reactions take place. While LPPFusion’s approach involves no lasers, our plasmoid do contain high-energy protons, so have conditions that are “similar” to the catcher target that Kumar has been simulating.

In the new collaboration, the QMFE will be included, altering the formulae that calculate energy transfer between the electrons and ions. We’ll first see what difference this makes to the existing “catcher” simulations. In the following steps, the conditions in the situation will be altered to more closely imitate conditions that we expect in upcoming hydrogen boron tests in FF-2B. If we get the simulations working by the time of these tests in the coming months, we can gain insights into what’s happening inside the plasmoid and how to get more fusion reactions. We’ll also be able to see how good the simulations are in predicting the results of the experiments—a key test of any simulation.

Magnetism Shapes the Cosmos—New York Times Catches Up

Readers of these updates and our Youtube fans know that vast electronic currents and magnetic fields have played a large role, together with gravitation, in shaping the stars and galaxies of the universe, a process continuing today. Imitating nature, we use many of these processes in our FF-2b experimental Fusion device. The role of magnetic fields has been known to plasma scientists for a half century. But most cosmologists tend to entirely neglect electrical and magnetic processes, in favor of gravitation alone, inventing imaginary entities like dark matter to substitute for the well-known effects of magnetism in plasmas.

Now the New York Times has, somewhat belatedly, "broken" the news that magnetism indeed does help shape the cosmos with an article accompanying striking new images of magnetic fields in the center of our Milky Way galaxy. In an article titled "The Magnetic Heart of the Milky Way", Times science reporter Dennis Overbye reports on how "magnetism controls the universe", as he only half-jocularly writes.

The images, which somewhat resemble Van Gogh's famous Starry Night, trace the directions of the magnetic fields throughout the central 500 -light-year-wide region of our galaxy. The images were produced by David Chuss, a physicist at Villanova University and an international team of astronomers in a project called FIREPLACE, for Far-InfraRed Polarimetric Large Area CMZ Exploration.

What the patterns show is that the magnetic fields are ordered over huge regions of space. The pattern looks like a swirling flow, not random. This can only happen if the fields are generated by vast electric currents, as first explained by Hannes Alfven in the 1970's. The magnetic fields guide the direction of the currents that in turn produce the fields. As all current must, these currents circulate along the field lines in loops, some of which are clearly visible in the image.

Hopefully this will be just the start of the Times coverage of the real (as opposed to the Dark) universe!

Fig 2. Image of the center of the galaxy, showing magnetic fields. The colors represent different temperatures of interstellar dust. Cool, dense dust is green; warmer dust is pink. The white lines show the direction of the magnetic field. Electric currents flow along the field lines.

Evolution of Physics Class: The Second Law of Thermodynamics

In the next class, June 22 at 2:30 PM EDT, we will be talking about the origins of the second law of thermodynamics and the controversies this set off, which continue to today. Zoom link below.

Here are the initial readings. There are two more that we must send as attachments, so register early to get them. We realize the history of entropy is too mathematical and far from clear, but that is part of the problem with the 2nd law we will be discussing. With the Kelvin reference, equations can be skipped without missing the meaning. We suggest you start with entropy-Darwin to get the context of the evolution of physics in this period.

https://zapatopi.net/kelvin/papers/on_the_age_of_the_suns_heat.html

https://www.chemeurope.com/en/encyclopedia/History_of_entropy.html

Register in advance for this meeting:
https://us02web.zoom.us/meeting/register/tZctde-srTIvHdwJQqNqyRF0b0mdW79EiMQl

Wefunder Drive Passes $150,000—We Need to Go Faster to $200,000!

Three months into our 2024 Wefunder capital campaign we've raised $150,000 from 169 investors. Thanks to all, including Dewayne Higgs who just put us over $150 G! However, we are way behind schedule in raising this money, as we had planned on raising about $100,000 a month. Since we spend about $60,000 a month, to get ahead, we need $100,000 a month. To hire two more full-time people, who we really need, takes even more money. Let's get to the next goal of $200,000 in just 15 days, by June 25! If you want to see faster results in the lab, help us hire more people. If you have not invested, please do. If you have, let others know about us. You can see our Wefunder page and invest here.