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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
August 24, 2018

Summary:

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$330,000 Donation to Focus Fusion Society Funds Research

Long-time LPPF investors Walter Rowntree and his wife Laura Reynolds have made a generous donation of a third of a million dollars in stocks to the Focus Fusion Society, the tax-exempt non-profit devoted to aneutronic fusion research. Eighty-five percent of the donation’s value will be used for a research grant from FFS to LPPFusion to accelerate our research. The remainder will fund FFS in carrying out other aneutronic fusion research as well as education about aneutronic fusion.

In a letter to fellow LPPF investors, Walter and Laura emphasize the benefits of contributing appreciated shares to FFS: “So we thought, ‘Why not give a bunch to charity *before* we die, and harvest the tax benefits for ourselves?’ Whoopee! Everybody wins. How much? Giving shares in this way avoids 15% capital gains tax and creates a charitable deduction worth about another 20%, a total of 35%. Put it another way, give appreciated shares and the IRS will chip in a dollar for every two dollars you actually give. The government should be investing in LPPF anyway!”

We at LPPF greatly thank Walter and Laura for their very generous donation. We will be giving them a surprise unique gift in recognition of this donation. This gift will be revealed in the next report, so stay tuned!

New Vacuum Chamber Arrives As Beryllium Assembly Nears

With assembly of the new beryllium electrodes into the Focus Fusion experimental device expected to start within weeks, new equipment is flowing to the LPPF lab in Middlesex, NJ. Our new vacuum chamber, (Fig.1) will provide far better views of the device operation through its three six-inch windows. The chamber has been annealed at high temperature to remove its magnetizability and has been sent out to get a titanium nitride coating. The annealing will prevent stray magnetic fields from interfering with the functioning of the axial field coil that controls the spin of the plasmoid, while the coating will prevent oxides and other impurities coming from the steel.

Figure 1 The new vacuum chamber will improve imaging both during and after the fusion shots.

LPPF Research Physicist Dr. Hassan and Chief Scientist Eric Lerner have completed disassembly of the old tungsten cathode and anode. The cathode, despite a perilous birth in 2015, has survived hundreds of fusion shots. The anode, installed in early 2017, was also in fine shape.

When the glove box arrives within the next two weeks, assembly of the beryllium electrodes will begin with experiments still planned for September. The glove box will isolate the electrodes during assembly onto steel plates, protecting the electrodes from humidity and the research team from beryllium dust.

Analysis of Tungsten Data Prepares New Experiments

Right before shutting down to dissemble, the research team took some final ICCD images of the early stages of the pulse, taking images both earlier and later than the series obtained in April. What the images showed is a somewhat more complex history of filament formation and destruction. In the first 75 ns or so, 16 filaments form opposite the 16 cathode vanes. This is where the small preionization currents have created regions of free electrons that channel the currents. But the initial filaments rapidly disperse, heated by the resistance of the heavy tungsten impurities. Then, as the current sheath moves faster, around 300 ns into the pulse, hydrodynamic forces form a new set of smaller, but still evenly-spaced filaments. This is basically the same process that forms vortices in the wake of any rapidly moving object like a car or plane. Unfortunately these filaments also heat up rapidly and collide with each other. As they collide, their magnetic fields cancel. This change in magnetic field creates electric fields that accelerate particles and rapidly heat the plasma, creating a flash of light that over-exposed the final images. The whole sequence of images has been arranged into a video here. Stills are included in this report (see Figure 2). These images tell us that the preionization works in creating symmetric filaments.

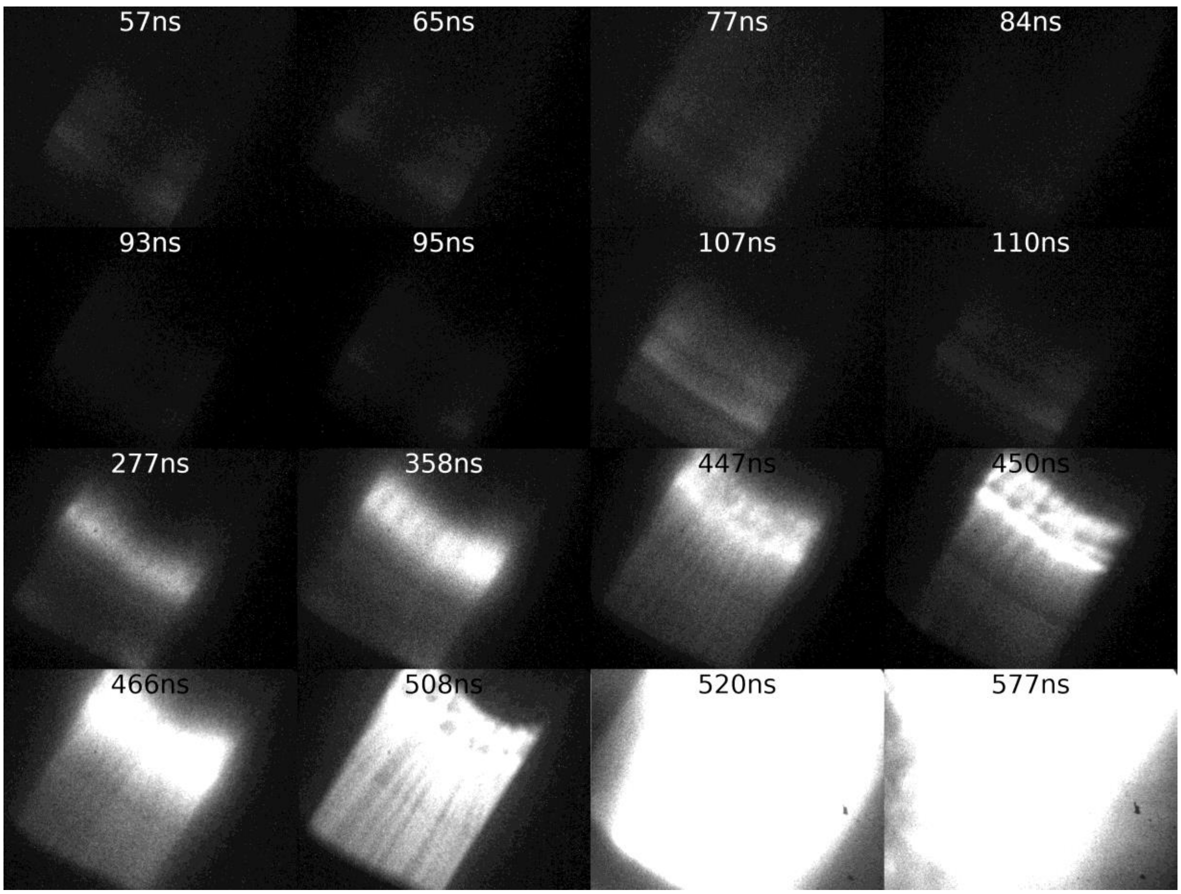

Figure 2 In this sequence of ICCD images from FF-1 shots, larger filaments form very early in the pulse, dissipate (making the image dimmer) and then smaller filaments form. Finally the smaller filaments collide, heating the plasma, emitting large amounts of light and saturating the images.

In addition, we can calculate from the over-exposed images the minimum amount of light emitted by the colliding filaments, about 160 kW/cm^2. The dimensions of the filaments also give us an estimate of their temperature, around 10eV or 100,000 K. Putting these numbers together, we find that the filaments are emitting 30 times as much light as a pure D plasma at this temperature could emit. This shows that it is the tungsten impurities that are emitting the light. Even though the tungsten is mostly at a low ionization state, it has so many electrons that it can radiate far more energy than either deuterium or the nitrogen we sometimes mix in.

Since both the emissivity and electrical resistivity of the plasma increase in the same way with impurities, the fact that the emission is so dominated by the impurities is more evidence that the resistance is impurity- dominated as well. This confirms the LPPF teams' theories of why the filaments blow up: they are heated by the impurities' high resistance. It also increases confidence that this will not occur with the beryllium electrodes. Beryllium, with only four electric charges per nucleus, has a very small effect on resistance.

Disassembly of the electrodes and vacuum chamber also provided other encouraging data. To distinguish between metallic tungsten and tungsten-oxide erosion, LPPF Chief Scientist Eric Lerner measured the resistivity of the material deposited on the vacuum-chamber windows and on the anode itself. Since tungsten is an excellent electrical conductor and tungsten-oxide is a good insulator, the high resistances found showed clearly that the vast majority of the deposits, more than 98%, were tungsten oxide. This again confirmed LPPF's hypothesis that erosion from the electrodes was fragile tungsten oxide, which breaks up at 500 C, not tough tungsten, which melts at 3,422 C.

This is again good news, since beryllium is much more heat resistant than tungsten oxide, so is unlikely to erode when exposed to energy levels that only break up the oxide. Beryllium oxide forms only in extremely thin layers, so is not expected to be a problem.

Beryllium and Boron: Uncovering Cosmic Origins

As we described in our last report, our new planned experiments will be critically based on two particular elements—beryllium for our electrodes and boron, which, together with hydrogen, will be our aneutronic fuel. We pointed out that these two elements are produced by cosmic rays. But what is even more interesting is that they can be used to figure out the history of the universe and in particular if there ever was a Big Bang.

In 1988, Eric Lerner, now LPPF Chief Scientist, published results showing that cosmic rays from stars formed when the galaxy was young could have produced the observed amounts of not only boron and beryllium, but lithium as well. Lithium was hypothesized to have been created in small amounts in the Big Bang. But by 1988, there was already evidence that the Big Bang predictions were higher than the amount observed. Astronomers can observe the amount of elements produced billions of years ago by observing the spectra of old stars. These old stars are identified by the small amount of heavy elements like iron evident in their spectra. Iron and other heavy elements are produced only by supernova explosions, which occur at the end of the lifetime of massive stars. Stars that have small abundances of heavy elements must have been formed early in galactic history, before many stars had time to explode as supernova.

The Big Bang theory had predicted that even the oldest stars should have at least 0.4 lithium atoms for every billion hydrogen atoms, but observations found only 0.16. Lerner's calculations demonstrated that all this lithium could have been produced not by the Big Bang, but by cosmic rays from intermediate mass stars (4-12 times more massive than the sun) in the early stages of formation of any galaxy. A few other researchers made similar analyses at the time, but as non-Big Bang research became less and less acceptable to funding committees (dominated by Big Bang theorists) such analyses almost stopped being published in the 21st century.

However, observers equipped with more and more powerful telescopes kept accumulating data on old stars. What the data showed was that stars that had less carbon had less boron and beryllium, but the same amount of lithium. Boron and beryllium are formed by the collisions of protons in cosmic rays with carbon atoms, while lithium can be formed from the collisions of far more abundant helium atoms in cosmic rays with other helium nuclei. Since all researchers agree that carbon has to be formed later in galactic history than helium (it forms by helium-helium fusion in the cores of massive stars) this picture is exactly what would be expected if lithium, boron and beryllium are all formed by cosmic rays. Lerner has recently performed detailed calculations showing this to be the case.

But if all lithium was formed by cosmic rays, none could have been formed by the Big Bang. Since any Big Bang explosion would definitely have created a minimum amount of lithium, this is more evidence that the Big Bang never happened. Thus boron and beryllium abundances give clues to the history of the galaxy and indeed of the universe. Lerner will be presenting these new results at an astrophysics conference in Prague in late September, together with an overview of evidence on the Big Bang.

Survey Results from New Wefunder Investors

We've now analyzed a survey of LPPF's new Wefunder investors, thanks to 313 responses, a 71% rate. Thanks to all for their time!

The survey showed that the money came in "by halves"—54% was from "old contacts", who knew us before the campaign, 46% from new contacts. Half of the investment came from 94 accredited investors, half from 346 non-accredited investors. We achieved a somewhat better level of diversity with our new contacts: 9% were women, compared with only 3% in our previous investors and nearly 65% had no technical background, also triple the previous level of 20%.

The new people learned of us overwhelmingly from Wefunder. Unfortunately in this campaign we did not succeed in getting significant media coverage, unlike in the 2014 Indiegogo campaign.

In terms of what convinced people to invest, the three videos LPPF made for the Wefunder campaign were key. They were cited by 43% of the investors, with 37% of the total investment, as the primary or sole way they were convinced to invest. This was especially true of the new contacts, with 56% citing the videos: 34% the main video, 19% the How It Works video and 4% the Direct Conversion video. For the old contacts, most of whom were already convinced, 28% cited the videos: 22% cited How It Works and 3% each the other two. So it looks like some of the old contacts did not entirely understand how Focus Fusion works and now they do. For the old contacts, the website was the biggest source of information, cited by 34%, as compared with only 10% of the new.

So, from the survey we conclude that we now have explained our project well, including to non-technical people, but we need more outreach, especially more news stories to reach more folk. The campaign overall was a spectacular success, with money raised at least 90% of the total we could have legally raised. Thanks again to all!