Researchers make important advancement in unraveling mysteries of fusion energy

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Unraveling one of most grandiose and heady problems in physics -- the creation of controlled fusion energy -- is still decades away. But thanks to research done recently on a smaller, less grandiose scale at the Nevada Terawatt Facility at the University of Nevada, Reno and in the University's College of Science, an important step has been made in the understanding of some fundamental processes required to achieve fusion energy.

And it all came thanks to work done on the shoulders of Z-pinches that are more "midget" in stature than the "giant" lasers at national laboratories that can generate up to 40 trillion watts of x-ray power.

The Z-pinch is a type of plasma confinement system that uses a fast electrical current in the plasma to generate a magnetic field. "Shots" of fast, 100-nanosecond pulses exceeding 20 million amps are fired through tungsten wires on the order of tens of microns, at the Sandia National Laboratory Z-pinch.

"With our 1 million amp NTF Z-pinch, we can explore some very interesting physics that can be applied to the bigger pinches at the national laboratories," says Vladimir Ivanov, whose research with wire array Z-pinches at NTF has led to a journal article in the prestigious journal, *Physical Review Letters*.

In Ivanov's article, "Dynamics of mass transport and magnetic field fields in low wire array z-pinches," Ivanov and a team of students and researchers found the microscopic effects that cause inefficiencies limiting the conversion of electrical energy required for implosion energy.

The implications of Ivanov's work are important, says Tom Cowan, director of the NTF. "This is the fundamental stuff, the physics if you will, that is limiting the transfer of the electrical energy into the implosion energy which is responsible for the heating and x-ray production that will eventually lead to a fusion energy reaction in a laboratory," Cowan says.

Ivanov's experiment used the 1 million amp "Zebra" Z-pinch generator along with plasma diagnostics that included five-frame laser probing of the z-pinch in three directions. This measured mass transport during implosion.

Previously, laser probing work in this area proved difficult to read. Images from the "shots" often suffered from poor resolution, blurring, or lack of contrast.

The images created by Ivanov's technique were vivid. They showed not only plasma "bubbles" rising on breaks in the wires used, but what Cowan calls the "fingers" of matter left behind from the implosion.

"With these trailing fingers of mass, some of the current is left behind," Cowan says. "The current drives the implosion process, so these inefficiencies are very important. The sequence of these little failure modes, these little fuse effects happening on the wires, is what is limiting the big experiments. By understanding this better, we can come up with new ways at looking at how the current flows into the plasma, and how the mass interacts."

In a deft stroke of research creativity, Ivanov was able to use his previous research in laser plasma physics to his advantage in dealing with his experiment in Z-pinch plasma physics. Thus, Ivanov attacked the experiment suspecting that previous Z-pinches, working in deliveries of 100-nanosecond pulses, could be improved if one could understand the dynamics on a shorter time scale. For typical laser plasmas, a delivery of a nanosecond or even faster, such as a thousandth of a nanosecond, would be more common.

"So he decided that he would like to look at this with shorter laser pulses, and that was the enabling piece of the technology to get the useful information out," Cowan says.

"This is one of these absolutely beautiful examples where Vladimir, his students and his team have developed brand new ways to measure the fundamental processes such as the current flow and the mass flow when plasma bubbles accelerate to implode and heat a plasma," Cowan says.

Source: University of Nevada, Reno

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