New study will contribute to better understanding of nuclear ignition

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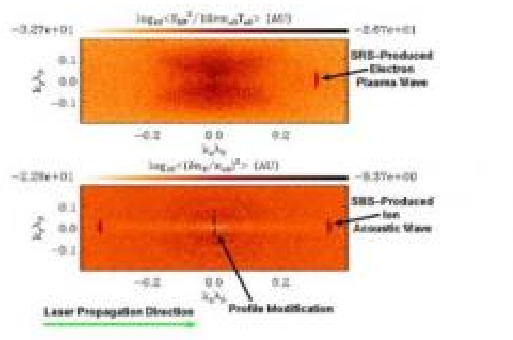

UCSD scientists create computer simulations like the ones above to determine how to successfully achieve controlled, miniaturized nuclear ignition of spherical fuel pellets in laboratory environments using lasers as energy drivers. Credit: UC San Diego

As the nation's nuclear weapons are aging (think the beginning of the Cold War), the U.S. government is turning to researchers and scientists at universities such as UC San Diego to figure out safe and reliable ways to estimate their longevity and to understand the physics of thermonuclear reactions in the absence of underground testing currently prohibited under law. One of them is Hoanh Vu, a research scientist in the Electrical and Computer Engineering Department at the UCSD Jacobs School of Engineering.

Under a recent three-year, $510,000 grant from the National Nuclear

Security Administration (NNSA), Vu and his colleagues at Los Alamos National Laboratory (NM), Lodestar Research Corporation and the Laboratory for Laser Energetics at the University of Rochester in New York, are using computer simulation tools to figure out how to successfully achieve controlled, miniaturized nuclear ignition of spherical fuel pellets in laboratory environments using lasers as energy drivers.

"The way nuclear weapons work is that there is a spherical core of deuterium-tritium that is driven by a radiation source to nuclear ignition; we know that these bombs work because they have worked underground," Vu said. "But the nuclear materials inside these fuel cores, primarily deuterium-tritium, and the radiation sources that drive these cores to nuclear ignition, have a relatively short shelf life. We don't know with any certainty if these weapons still work. Since we can't test them on a full scale, what do we do? We actually look at the physics and scale down the problem so we can test the viability of these weapons in a safer and more controlled environment.

"These weapons are massive so we try to scale it down to pellets that are millimeter-size," Vu continued. "The method of choice for compressing these fuel pellets is using a laser, which provides a radiation source."

Vu said the primary lasers for these studies are the Omega laser at the University of Rochester (NY) and the newly built National Ignition Facility at Lawrence Livermore National Laboratory (CA).

"What we would like to do is take the laser and shine the laser onto what we call a hohlraum, a cylindrically shaped black-body radiator made of high-Z materials (typically gold), in the middle of which the miniaturized fuel pellet is placed," he explained. "The material on the wall of the hohlraum absorbs the laser energy, heats up, and becomes a plasma. The plasma in turn irradiates off its newly acquired energy, and the resulting black-body radiation is what drives the miniaturized fuel pellets to nuclear ignition. It's like sunlight hitting the dashboard of a car - the energy of the sunlight is absorbed by the dashboard and is irradiated as heat, essentially electromagnetic radiation on a different wavelength spectrum from the original sunlight. It's a lot of fancy physics. But if you think about in on a fundamental level, it's pretty simple.

Increasing the conversion efficiency of the laser driver that drives miniaturized fuel pellets to nuclear ignition, Vu said, is also critical.

"Ideally, we would like to point the laser exactly and with precision on the wall and the energy would drive the ignition target exactly symmetrically in 3D," he said. "The minute you heat up the wall, plasma starts coming off the wall and interferes with how the laser is coming through. The plasma changes the way the laser propagates, so you can't point the laser with precision anymore. You hope that it's going to go to a certain place but it doesn't, and the energy that's coming in gets redirected in a rather unpredictable way. So you have two problems - you don't get energy where you want it to go and you don't get as much energy as you hope. In addition, the laser-plasma interaction produces highly energetic electrons that preheat the fuel pellets, making it harder to compress them to nuclear ignition. That's where our study comes in. We would like to find a way to get more laser energy in and going in as precisely as we need it to."

Vu is one of 28 researchers around the country who received a total of $20 million in grants from the NNSA as part of its High Energy-Density Laboratory Plasmas, a joint program with the Department of Energy (DOE). UCSD physics professor Brian Maple also received a grant for a project entitled "Novel d-and f-electron Materials Under Extreme Conditions of Pressure, Temperature, and Magnetic Field."

"NNSA is committed to funding research that will increase the safety, security and reliability of our nuclear stockpile and further President Obama's commitment to securing nuclear material around the world," said NNSA Administrator Thomas D'Agostino. "These grant recipients are working on cutting-edge research that is the bedrock of our future as a nuclear security enterprise. The money we invest today will advance scientific and national security goals, and I want to personally congratulate the recipients of these awards for their involvement in our mission."

Besides applications in the science-based stockpile stewardship, Vu's research project for the NNSA, entitled "Study of Laser Plasma Generation of Hot Electrons That Adversely Affect Fusion Target Compression," could also lead to the further development of nuclear fusion as an alternative energy source. Vu, who spent 10 years as a Technical Staff Member in the Applied Physics Division at Los Alamos National Laboratory before coming to UCSD in 2002, specializes in the study of inertia confinement fusion. Vu and colleagues have developed novel and efficient kinetic simulation capabilities for studying laser-plasma interactions. These tools are at the forefront of this area of research, he said.

Vu said there has been a big push over the last several decades from the Department of Energy to find alternative energy sources. One of the mainstream concepts is tokamaks, magnetic confinement devices used for producing controlled thermonuclear fusion power (UCSD's Center for Energy Research currently does fusion energy research using a tokomak). Another concept the DOE is looking toward for producing alternative energy sources is inertial confinement fusion, which is Vu's expertise. This concept is still in early stages of development, he said.

"I strongly believe in a strong national defense. At the same time, I see our dependence on foreign oil and fossil fuels in general as not the way of the future," Vu said. "Eventually, it's going to run out. Research, as you know, takes a long time to culminate into something useful. Unless we're forward-looking, by the time we need alternative energy, it's not going to be there. I'm in this field to try to help develop alternative solutions."

Source: University of California - San Diego (news : web)

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