UC Irvine professor to help design the most powerful laser in the world

The NSF-funded effort would help the U.S. to reclaim lead in laser technology.
Tuesday, November 07, 2023
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Steve Zylius / UCI

Irvine, Calif., Nov. 7, 2023 — The National Science Foundation recently awarded an $18-million grant to a team of scientists to design the most powerful laser in the world. The team includes Franklin Dollar, a professor of physics & astronomy at the University of California, Irvine.

“The idea is that this will be a premier scientific facility for the world to address all kinds of things in science and all kinds of applications that such a powerful laser can do,” said Dollar, who uses lasers to research particle acceleration and light sources.

The new laser, called EP-OPAL (Optical Parametric Amplifier Lines), will, if completed, consist of two separate 25-petawatt lasers. That means that, for the millionths of a billionth of a second that the laser will fire, it will be over a thousand times more powerful than the global power grid. The plan is to build EP-OPAL in a new building at the University of Rochester, with funding from the NSF’s Mid-Scale Research Infrastructure-1 Program.

Right now, the most powerful laser in the U.S. is the new ZEUS laser at the University of Michigan, which will have a power of three petawatts.

“That’s a ridiculously huge number, and it might seem like, how much more do you need?” Dollar said. “But with just a bit more power, we can unlock many things that had previously been closed. And with two laser beams, you can get a lot of different options with how you can combine these different beams and the experiments you can do.”

The extra power will allow scientists to explore new research territory in four defined areas: particle acceleration and advanced light sources, laser-driven nuclear physics, laboratory astrophysics and planetary physics, and high-field physics and quantum electrodynamics.

High-field physics and quantum electrodynamics deal with understanding the way subatomic particles like electrons behave, and the high-energy states EP-OPAL will achieve will help researchers understand the quantum electrodynamics of the Big Bang. EP-OPAL will be able to emulate the kinds of conditions thought to exist in the first moments of the existence of the universe, when energy levels were likely very high.

“We’d like to test all aspects of this. Some of the things that happen in quantum electrodynamics can only be tested at extremely high electric fields, and one of the ways of making such a field is by using these very high intense lasers,” said Dollar.

Dollar’s team will lead the scientific thrust related to particle acceleration and light sources, which, he explained, is the research area that enables the other three to happen, because researchers first need things like high-energy electron beams – which are the purview of particle acceleration and light sources – to explore fields like quantum electrodynamics.

“With OPAL, electrons with energies higher than can be produced even at the current largest particle accelerator facilities will be possible,” said Dollar. “High-brightness X-ray beams on the fastest timescales will also be developed, an area that resulted in the recent 2023 Nobel Prize in Physics. High energy electrons, ions, neutrons, positrons, light and X-rays are not only useful for probing new states of matter but also have numerous applications in medical imaging and radioisotope production and manufacturing.”

EP-OPAL could also one day help treat cancer patients by helping to develop techniques to deliver hyper-targeted radiation dosages to cancerous regions of a patient’s body.

“Laser technology is advancing and changing very rapidly, and there’s not a clear limit of where we can push it,” said Dollar.

About UCI’s Brilliant Future campaign: Publicly launched on Oct. 4, 2019, the Brilliant Future campaign aims to raise awareness and support for UCI. By engaging 75,000 alumni and garnering $2 billion in philanthropic investment, UCI seeks to reach new heights of excellence in student success, health and wellness, research and more. The School of Physical Sciences plays a vital role in the success of the campaign. Learn more by visiting https://brilliantfuture.uci.edu/uci-school-of-physical-sciences/.

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