Laser Acceleration of Electrons Excites Physicists

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Chris Sears leans over the experimental chamber where researchers hope to accelerate electrons with laser light.

A new experiment aims to accelerate electrons using dark red light.

Physicists on experiment E163 are replacing microwave power from klystrons with laser-generated visible light to boost the energy of particles. The laser could give particles up to 30 times more energy per meter than they gain from microwave power in the SLAC linac.

What's more, the researchers aspire to revolutionize accelerator design by one day placing major components—the laser and the accelerator structures in which particles travel—on mass-produced silicon chips. This accelerator-on-a-chip idea would allow for shorter and cheaper accelerators.

"This is a distant dream, it's not something we even know how to do in 10 years," said experiment spokesman Eric Colby. "But companies already know how to deposit microscopic lasers on silicon, and they can write optics and mirrors onto chips, too. A microscopic accelerator structure could be printed out of the silicon itself."

LLined up, tens of thousands of these chips could potentially accelerate a particle beam on its way to a conventionally sized detector.

For now, researchers have set up a full-sized laser whose beam is focused down to fit through the prototype accelerator structure—a tiny photonic crystal fiber, similar to telecommunications optical fibers, ordered from a catalog that Colby describes as the K-Mart of optics. Electrons and light pulses will travel through a hole in the photonic crystal that is 10,000 times narrower than the accelerator structures at SLAC.

Housed in End Station B, the experiment uses the first part of the Next Linear Collider Test Accelerator (NLCTA) plus new laser and experiment rooms. This laser acceleration research originated 12 years ago with Stanford Professor Robert Byer. SLAC's Advanced Accelerator Research group joined in when the need for complex instruments grew.

Earlier experiments on campus showed that acceleration with visible light is possible using very simple accelerator structures. These experiments also met the difficult challenge of making micron-sized laser and electron beams, and of synchronizing them with each other within a trillionth of a second. Unfortunately, these structures used the laser power inefficiently.

The challenge now is to examine structures, such as photonic crystals, which can operate much more efficiently. "No one's ever shown that you can really accelerate particles in these photonic crystals. We hope to show proof of principle, and to demonstrate efficient energy transfer," Colby said.

The laser both generates electrons—which are first accelerated in the NLCTA—and also pushes the electrons once they reach the experimental chamber, which is slightly bigger than a cooler. A miniature undulator and chicane—types of magnets that wiggle and bend electron bunches to break them into smaller pulses—make the electrons short enough to catch a ride on each laser pulse, which only lasts one trillionth of a second.

Approved for operation on March 1, the experiment just finished its commissioning phase. Starting in May, E163 will run one week a month for the next two and a half years. The facility in End Station B is now available to users working on advanced accelerator research and development. The NLCTA Operations Group provided indispensable support to get E-163 and the user facility ready.

Source: by Heather Rock Woods, Stanford Linear Accelerator Center

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