Scientists tame electron beams, bringing 'table top' particle accelerators a step closer

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Scientists from the UK and the USA have successfully demonstrated **a new technique that could help to shrink the size and cost of future** particle accelerators for fundamental physics experiments and applications in materials and biomedicine.
Using the huge electric fields in laser-produced plasmas, they have accelerated beams of electrons close to the speed of light, in an important step towards the development of a working laser electron accelerator that could sit on a table top.
The researchers from Imperial College London, CCLRC Rutherford Appleton Laboratory (RAL), University of Strathclyde, UK, and University of California Los Angeles, USA, report their findings in *Nature* today (30 September).

"It's the first time that a real electron beam has been generated by these methods," said Professor Karl Krushelnick of Imperial College London, leader of the research group.

The next generation of particle accelerators using existing technology will be many kilometres in size and likely cost billions of pounds, but laser electron accelerators may offer a cheaper and smaller alternative says Professor Krushelnick.

"Ultimately our work could lead to the development of an accelerator that scientists could put in a university basement," he says. "Such a small-scale local facility would give many scientists the ability to run experiments that currently they can only do at national or international centres."

"Who knows, one day you might even do high energy physics in a university laboratory. It would be strange but it's not impossible to imagine."

Electrons in accelerators travel so close to the speed of light that their 'speed' is referred to in terms of energy. Electrons clocked closest to the speed of light are said to be at 'relativistic energies'.

Using a high power, short-pulse laser system the researchers demonstrated they could accelerate beams of electrons directly from the plasma to energies up to 100MeV, over a distance of only one mm.

Previous measurements of electrons accelerated by lasers had shown that they had a large spread in energy, making them useless for applications requiring any degree of precision.

"It is imperative you know the energy of the electron beam for much use to be made of it," says Stuart Mangles, Imperial College post-graduate student and lead author on the Nature paper.

"Now we've shown we can make good quality electron beams with a narrow energy spread. They have incredibly short pulse duration and also have very low emittance, which means that they are very focusable."

Using RAL's short-pulse high power laser system, ASTRA, the team showed that for particular plasma densities and laser focusing conditions, the plasma waves produced during the interaction could grow so large that they 'break' and inject short bunches of electrons into the adjacent wave. Just like a surfer picking up energy from an ocean wave, the electrons in the laser pick up energy from waves in the plasma.

"It was serendipity," said Professor Krushelnick. "We found the laser pulses actually self-inject electrons at the right phase."

The latest developments are propelled by advances in laser technology. The power in the ASTRA 20 terawatt laser is many times the power generation capacity of the UK but the pulse length is only a tiny fraction of a second, about 40 femtoseconds. The ratio of a femtosecond to a minute is about the same as the ratio of a second to the age of the universe, added Professor Krushelnick.

Source: Imperial College of Science, Technology and Medicine

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