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Laser-and Beam-Driven Plasma Accelerators[1]

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Scientists have been trying to use the tremendous electric fields in relativistic plasma waves to accelerate charged particles, and are now making substantial progress. If they succeed, future high energy accelerators will use plasma waves rather than microwave cavities as accelerating structures.Some accelerators, such as those used for radiation therapy will fit on a tabletop. Research on using plasma waves to accelerate particles began in earnest following the suggestion by John Dawson and his colleagues [1-3] that a relativistically propagating plasma wave or a wake field could be excited by using a powerful but short laser -or electron -beam as a driver pulse.Since their original suggestion the research on plasma –based accelerators has spread worldwide A series of experiments by the UCLA/USC/SLAC collaboration ,using the 30 GeV beam of the Stanford Linear Accelerator Center (SLAC), has demonstrated high-gradient acceleration of electrons and positrons using the the wake left by the SLAC beam as it passes through a lithium plasma. Electrons have been accelerated by more than 30 GeV in less than one meter. This acceleration gradient is about a thousand times larger than in conventional microwave-driven accelerators. It is a first step toward a "plasma afterburner," which would be placed at the end of a kilometers-long conventional accelerator and double its beam energy in a few tens of meters. In addition to the acceleration of particle beams, these experiments have demonstrated the rich physics bounty to be reaped from relativistic beam-plasma interactions. This includes the generation of intense and narrowly collimated x-ray beams, refraction of particles at a plasma interface, and the creation of intense beams of positrons. These results are leading the way to similar tabletop accelerators based on plasma wakes excited by lasers rather than electron beams. Applications for tabletop accelerators include gamma radiography, radiation therapy, and ultra-fast materials science.

[1] T.Tajima and J.M.Dawson Phys.Rev.Lett. 43,267.(1979)
[2] P.Chen et.al. Phys.Rev.Lett.54,693,(1985)
[3]C.Joshi et.al. Nature 311,525,(1984)

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