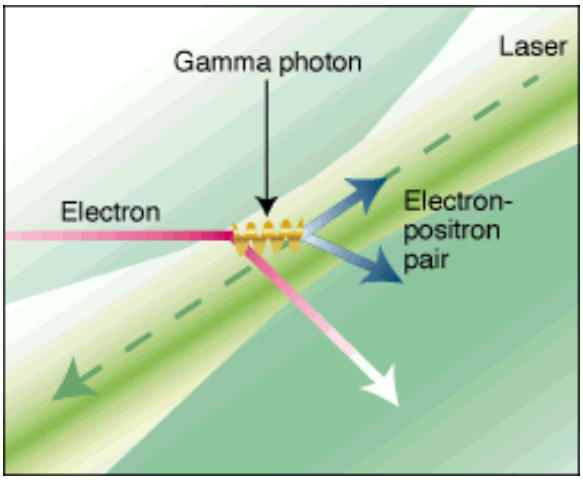
# The Light Fantastic

The SLAC e144 Collaboration
(January 30, 2018)

The feature article *The Light Fantastic* by Edwin Cartlidge in the 26 January 2018 issue of *Science* [1] reviews exciting prospects for new experiments that "could rip apart empty space." The article mentions that one way to accomplish this with a laser beam is to first collide it with a fast-moving electron, which leads to a high-energy gamma ray that can then be collided with the laser beam, as illustrated below [2].




Flash dance. An electron beam intersects a laser pulse, boosting photons to gamma energies and triggering an interaction that spawns particles.
*Source: A. Melissinos, Illustration: D. PUGH*

This technique was successfully used by the E144 Collaboration at the SLAC National Accelerator Laboratory in the mid 1990's to "spark the vacuum," producing electron-positron pairs in the collision of four or more laser photons with a gamma ray, a nonlinear QED effect [3, 4].

This experiment has never been repeated, and we welcome future efforts to confirm and extend our results. [1]

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[1] Physics opportunities in intense ultrafast lasers are reviewed in the recent report at [5], which includes the figure below on p. 15.

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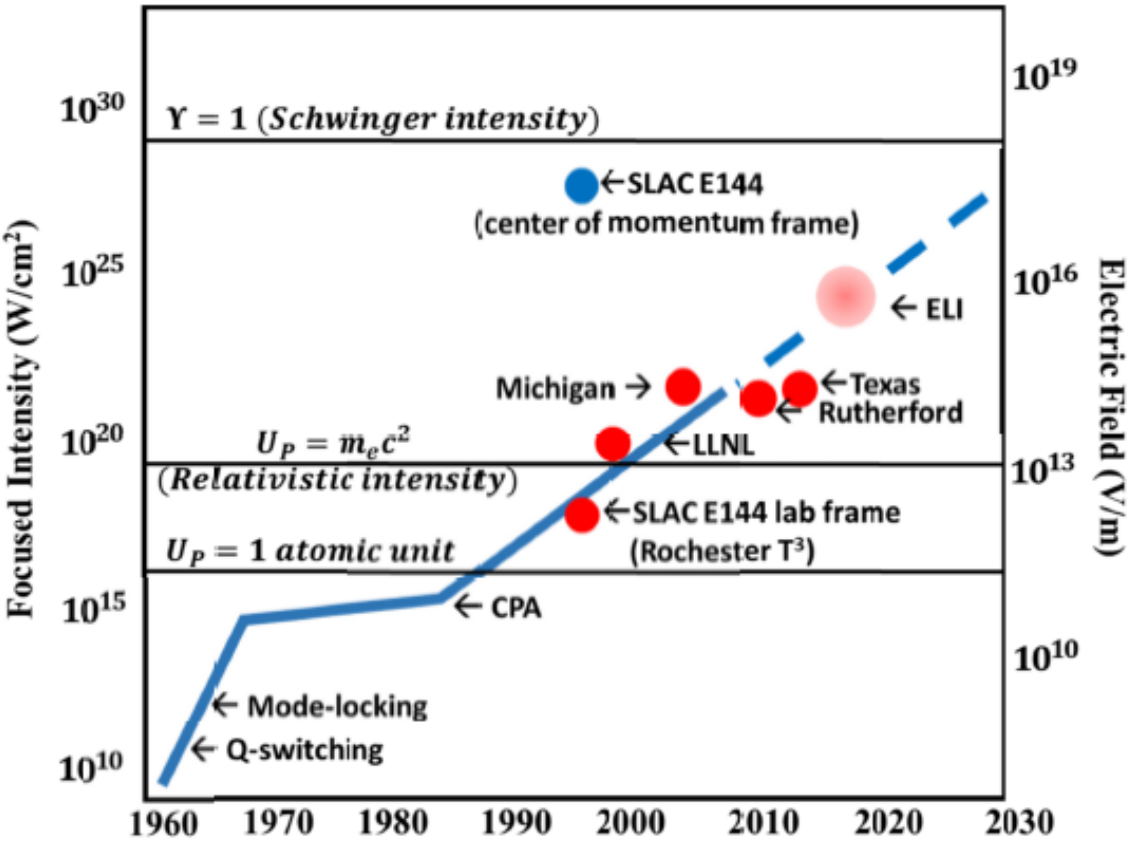


Highest focused intensities over time. CPA and solid-state laser technology have pushed the present peak intensity to the range of $10^{22}$ W/cm$^2$. The European ELI project will scale this up more than one order of magnitude in the near future. Also shown is a blue dot for the SLAC E144 experi-ment that achieved high intensity by boosting the laser-matter interaction into a relativistic frame. The three horizontal lines show the intensity for the ponderomotive (quiver) energy $U_p$ of an electron in the focus of an 800 nm (Ti:Sapphire) laser to be equal to one atomic unit; or for $U_p$ to be equal to the electron rest mass; or for the Schwinger intensity $\Upsilon = 1$ where the vacuum becomes unstable and light is directly converted to matter. *Source: Philip Bucksbaum, Stanford University.*

# References


[1] E. Cartlidge, *The Light Fantastic*, Science **359**, 382 (2018),
http://physics.princeton.edu/~mcdonald/examples/QED/cartlidge_science_359_382_18.pdf

[2] D. Ehrenstein, *Conjuring Matter from Light*, Science **277**, 1202 (1997),
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[3] D.L. Burke *et al.*, *Positron Production in Multiphoton Light-by-Light Scattering*, Phys. Rev. Lett. **79**, 1626 (1997),
http://physics.princeton.edu/~mcdonald/examples/QED/burke_prl_79_1626_97.pdf

[4] C. Bamber *et al.*, *Studies of nonlinear QED in collisions of 46.6 GeV electrons with intense laser pulses*, Phys. Rev. d **60**, 092004 (1999),
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[5] Committee on Opportunities in the Science, Applications, and Technology of Intense Ultrafast Lasers, *Opportunities in Iintense Ultrafast Lasers. Reaching for the Brightest Light* National Academies of Sci. Eng. Med. (Dec. 2017),
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