responsible for particle acceleration, hard X-rays, gamma rays, the white-light flare, and the acceleration of coronal mass ejections that may impact the Earth. Most of the extensive phenomenology of solar flares thus derives from this impulsive phase, which despite its name may extend for tens of minutes in some important events. The impulsive phase is always characterized by the powerful acceleration of energetic particles, both at the Sun and further out in the heliosphere, as a result of the formation of a global shock wave. These aspects of solar activity are the ones that can have damaging effects on satellites, communications and power systems on Earth. ❒

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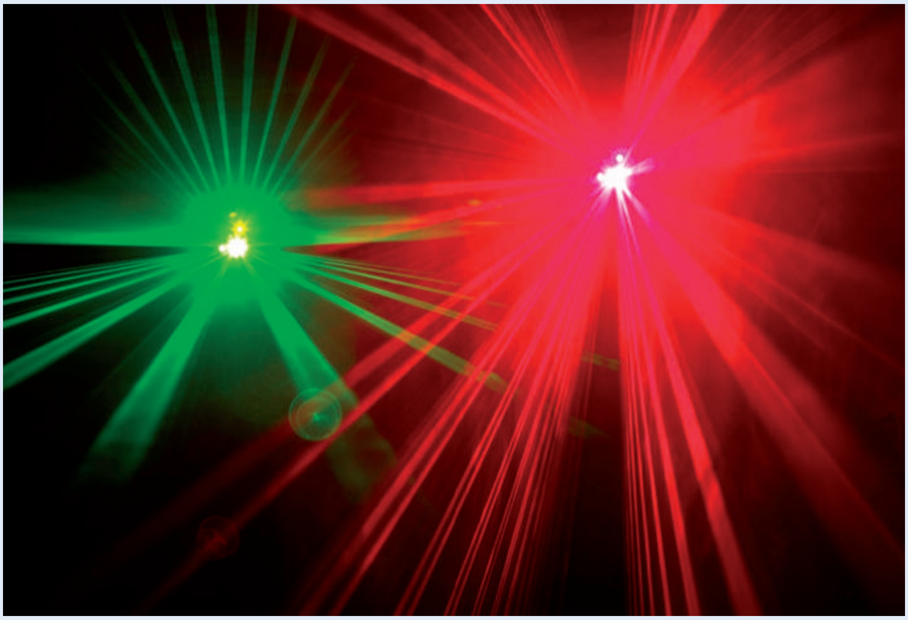
LASER PHYSICS

Lasing at the limit

The peak intensity that conventional solid-state lasers can achieve is limited by the dielectric strength of their lasing media. However, the invention of chirped-pulse amplification (CPA) means that this limit can be exceeded by many orders of magnitude. CPA works by using a diffraction grating to split a seed pulse into an arbitrary number of components, which are then amplified individually and recombined to produce a much more intense pulse in free space. Pulsed-laser powers can exceed a petawatt, and could soon reach up to an exawatt.

CPA is limited only by the ability to build bigger diffraction gratings to split and then recombine a pulse in sufficiently small chunks to avoid damaging any of the lasers' optical components during amplification. This suggests that we might eventually be able to generate laser intensities at the so-called Schwinger limit, where the dielectric response of the vacuum itself becomes strongly nonlinear and a host of exotic quantum phenomena are expected to emerge. But according to a new analysis carried out by Alexander Fedotov and co-workers — who include Gerard Mourou, co-inventor of CPA — this limit may occur at much lower laser intensity than had previously been thought (*Phys. Rev. Lett.* **105,** 080402; 2010).



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At the Schwinger limit — named after theoretical physicist Julian Schwinger — the electric field is strong enough to split electron–positron pairs that are spontaneously created by quantum fluctuations of the vacuum. The conversion of virtual electrons and positrons into real electrons and positrons saps energy from the field, making it difficult to increase the field much further. The limit is expected to be reached at a critical laser intensity of about 10^{29} W cm^{-2}.

But it has been suggested recently that collisional effects arising at the focal point of one or more laser beams could lead to pair production at intensities two orders of magnitude lower than the Schwinger limit (*Phys. Rev. Lett.* **104,** 220404; 2010). Fedotov *et al.* build on this suggestion to consider what happens immediately after a pair is created.

They point out that electrons and positrons are not only created by the laser field but rapidly accelerated to extreme relativistic velocities by it. Their inevitable collision with photons in the field results in the emission of gamma particles of sufficient energy to decay into further electron–positron pairs and other exotic high-energy particles. This leads to a quantum electrodynamic cascade similar to the avalanche processes that limit the laser intensities supported by conventional dielectrics.

The authors' calculations suggest that such breakdown of the vacuum could become a problem at focused laser intensities of around 10^{26} W cm^{-2} — well below the Schwinger limit, and just a few orders of magnitude greater than the intensities expected to be attained by several laser facilities that are currently under construction.

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