ionic crystal lithium borohydride.[3] The group concluded that the crystal's interaction with an intense, femtosecond optical pulse distorts the ionic potentials and generates a new quantum state that is a superposition of the valence- and conduction-band states of the unperturbed system and mimics a transition between them. The superposition state, which the group mapped by x-ray diffraction, is manifest as a shift of electronic charge from BH_4^- toward Li^+ over the large interatomic distance between them.

According to Krausz, that sort of reversible charge relocation is likely to be closely related to his own group's observations. The current that's seen in an external circuit is thought to arise from a similar shift of electrons from constituent atoms closest to each metal electrode. But his collaboration can't yet prove it based on the simplified model of a one-dimensional atomic chain.

The fields used to excite electrons in silica are so strong—some 10 times the fields used to excite $LiBH_4$—that the material teeters on the edge of breakdown. A central question for future applications, then, is the extent to which virtual transitions are accompanied by real ones that produce a conduction-band population not reversed by the laser field. Answering that and discerning the detailed microscopic nature of the conduction is likely to require more experiments and a more realistic theory, Elsaesser says. "Silica isn't ionic, but there's certainly an interaction energy between O and Si. If local lattice structure matters, as it does in our work, then the picture of a 1D band used to model silica becomes tricky."

An optically induced conductivity offers promise that electron-based signal processing may be pushed to its ultimate limit: light-speed frequencies. But don't expect a petahertz FET any-time soon. "For that to become reality," Krausz admits, "the full reversibility of the demonstrated femtosecond current switching cycle will have to be verified at much higher rates than the 3 kHz of the laser used in our first experiments."

In the short term, he envisions that the team's demonstration will bear fruit for high-speed metrology and waveform diagnostics: "A solid-state detector that records electromagnetic transients up to the frequency of visible light—a kind of petahertz oscilloscope—is pretty realistic."

Mark Wilson

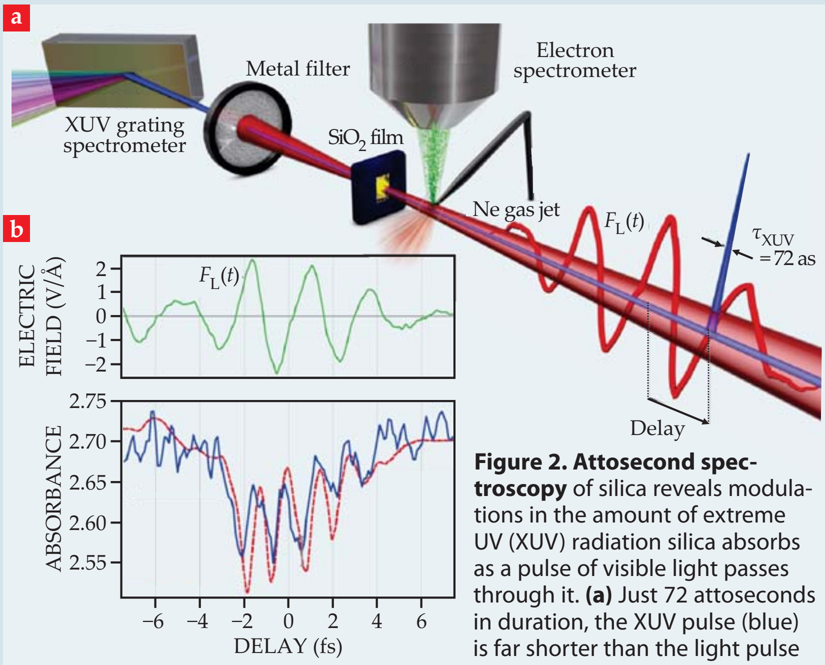

Figure 2. Attosecond spectroscopy of silica reveals modulations in the amount of extreme UV (XUV) radiation silica absorbs as a pulse of visible light passes through it. **(a)** Just 72 attoseconds in duration, the XUV pulse (blue) is far shorter than the light pulse (red) and can be delayed by a controllable amount to monitor the absorption at different instants in the light's waveform. Both pulses travel from right to left. Some of the XUV photons excite a neon gas jet whose spray of photoelectrons can be used to map the light's electric field as a function of delay (see PHYSICS TODAY, October 2004, page 21). The rest of the XUV and visible photons then interact with silica and continue downstream. A metal film filters out the visible and transmits the XUV, which is then spectrally dispersed and measured. **(b)** The XUV absorbance (blue) drops whenever the electric field F_L (green) peaks and is a maximum whenever the F_L goes to zero. The near-instantaneous response to the oscillating electric field corroborates an ultrafast rise and fall in conductivity. Reassuringly, the experimental data follow theoretical prediction (red). (Adapted from ref. 2.)

References

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physics update

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The Hoyle state of carbon-12 unmasked. The early, starless universe held only hydrogen and helium (with perhaps a trace of lithium) synthesized in the Big Bang. All other elements were forged in stellar furnaces. Carbon has a special status: Its fusion with helium nuclei (*α* particles) leads to nitrogen, oxygen, and eventually to the chemistry of life. But forming carbon is no simple task. In 1954 Fred Hoyle realized that after two *α* particles fuse to form beryllium-8 there is a finite chance that a third will join them in a three-body resonance. That near-ground-state resonance—now called the Hoyle state—usually falls apart but occasionally lasts long enough to decay to the ground state of ^{12}C. The smoking-gun gamma ray from the decay was detected a few years later. A German–American group has now performed new ab initio lattice calculations, including third-order corrections in chiral effective field theory, that reveal the lowest-energy configurations of the ^{12}C nucleus. In the ground state, the *α* particles retain their individuality but cluster tightly in a compact triangle, which seems reasonable for the lowest energy. The Hoyle state was more surprising in that the *α* particles were in neither a tight cluster nor a straight chain. Instead they form an open obtuse angle, somewhat like a water molecule. The numerical results dovetail well with the available experimental data. Next on the group's agenda is a higher-resolution lattice. (E. Epelbaum et al., *Phys. Rev. Lett.* **109**, 252501, 2012.) —SGB