

PHYSICS

Attosecond Laser Pulses Illuminate Fleeting Dance of Electrons

Like a prisoner trapped behind the wall of a fortress, an electron faces a huge barrier in escaping the confines of an atom. Yet when hit by a burst of intense light, it can set itself free in just a few hundred attoseconds (10^{-18} s), thanks to a quantum-mechanical phenomenon known as tunneling. In essence, it seeps through the barrier—the binding energy that normally holds it in place. Now, for the first time, scientists have seen this blindingly fast escape act happen in real time.

This week in *Nature*, Ferenc Krausz of the Max Planck Institute of Quantum Optics in Garching, Germany, along with researchers in Austria and the Netherlands, reports watching electrons in neon atoms burrowing their way to freedom. The team says the findings—made possible by the use of 250-attosecond pulses of ultraviolet (UV) radiation—confirm theoretical predictions about the tunneling process.

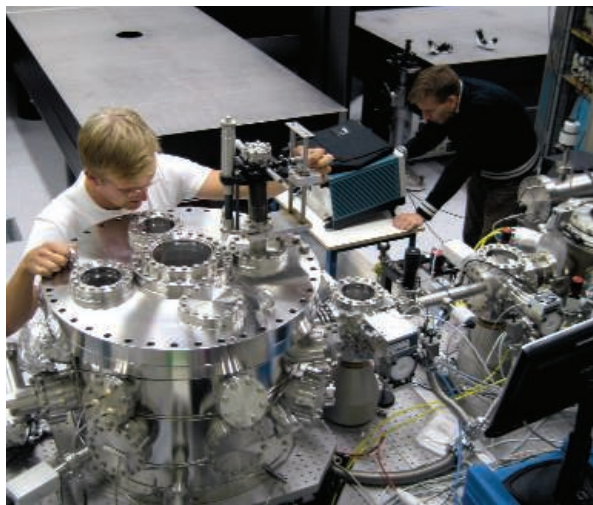
The researchers also report using tunneling itself to image the acrobatics of electrons jumping from one orbital to another in neon and xenon atoms that have been excited by light. The work shows how “the powerful tools of attosecond science” can be used to understand atomic-level phenomena, says Paul Corkum, a physicist at the Steacie Institute for Molecular Sciences in Ottawa, Canada, who did not take part in the work.

To produce attosecond UV pulses, researchers bombard a cloud of neon atoms with a short burst of laser light that wrenches an electron out from deep inside the atom and smashes it back toward the atomic core. The most energetic photons emitted in this process are filtered out to yield a UV burst lasting a few hundred attoseconds.

In their experiment, Krausz and his colleagues trained an attosecond pulse as well as the laser wave used to generate it toward a second chamber of neon atoms. First, the attosecond pulse yanked electrons out from the atoms’ inner shells to their outer edges, preparing the atoms for ionization and the electrons for escape. The laser

wave then took them the rest of the way.

When the laser’s oscillating electric field reached its peak, it suppressed the atom’s binding potential—in effect, thinning the



Looking in. In the Garching experiments, atoms in the cylindrical chamber were blasted with attosecond pulses and laser waves.

wall holding the electron in. At precisely those points in the laser’s oscillation cycle, which lasted several hundred attoseconds, the researchers saw a marked increase in the number of ionized atoms in the chamber as the outer electrons tunneled their way through the lowered binding potential.

In other experiments, the researchers used tunneling to probe the intra-atomic dynamics of neon and xenon atoms. In the xenon study, they blasted atoms with an attosecond pulse powerful enough to knock an electron out of the element’s innermost shell, causing electrons in the outer shells to rearrange themselves in an adjustment known as Auger decay. By targeting the atoms with the laser wave and noting how the number of ions created by tunneling changed over time, the team was able to trace the details of the Auger decay.

Researchers say the ability to control atomic-scale motion of electrons would have numerous applications. “Even simple-seeming processes such as laser surgery have attosecond phenomena at their core that have never been resolved,” says Corkum. In the longer term, Krausz says, such work could lead to better compact x-ray light sources for biological imaging and radiation therapies.

—YUDHIJIT BHATTACHARJEE

Going Against the Flow

Notwithstanding the laws of gravity, construction money this year at the National Science Foundation (NSF) is flowing from the bottom of the ocean to the top of a 5-km mountain. NSF has shifted \$15 million from the budgets of its fledgling oceans and ecological observatories networks to the Atacama Large Millimeter Array in the Chilean Andes, in tune with ALMA’s rising costs and the agency’s continued tinkering with the two networks.

The changes have touched a nerve in NSF’s oversight body, the National Science Board. Speaking up at last week’s board meeting, several members said that the long time between approval and the start of a project has left them feeling out of the loop. “We’re just asking NSF to explain how things have changed and whether the science still justifies that level of support,” says Mark Abbott of Oregon State University in Corvallis, noting that NSF now plans to spend \$20 million less during the first 2 years of the ocean observatories initiative than when the board gave it the green light in 2002, for example, whereas ALMA is costing \$125 million more than originally planned. The board has asked NSF Director Arden Bement for more frequent updates on the \$240-million-a-year account and better estimates of the lifetime costs of operating each facility. —JEFFREY MERVIS

Pathology Institute Gets Lifeline

Congressional supporters of the U.S. Armed Forces Institute of Pathology (AFIP), which the Defense Department is planning to “de-establish,” are making a last-ditch attempt to salvage its functions. Last week, the Senate voted to delay the move until after the department has responded to a pending report on the impact of AFIP’s closing. Last month, the House voted to prevent the use of federal funds for the planned closing of Walter Reed Army Medical Center, where AFIP resides, in its version of the bill, which funds military operations in Iraq and Afghanistan.

“This gives AFIP some breathing room,” says a Senate staffer about legislation that President George W. Bush has promised to veto because of the inclusion of nonmilitary items. Pathology groups oppose the dispersal of AFIP’s functions, particularly the possible mothballing of its renowned tissue repository (*Science*, 20 May 2005, p. 1101), and Senator Edward Kennedy (D-MA) is also hoping to slow the current outflow of talent. Advocates want to move the repository to the Uniformed Services University of the Health Sciences in nearby Bethesda, Maryland. —CONSTANCE HOLDEN