SCIENTIFIC ACHIEVEMENTS

With the generation and measurement of the first light pulse on the attosecond scale [1] and its use for observing electron motion deep in the interior of atoms in real time [2], Ferenc Krausz, his co-workers, and collaborators have extended femtosecond laser technology, which they previously advanced to its ultimate frontier set by the light wave cycle [3], into the attosecond domain. Based on shapeable attosecond forces (of laser light with controlled waveform [4]), they established a precision attosecond metrology [5], for real-time observation and control of electronic processes [6], in all forms of matter: atoms, molecules, and solid-state systems [7].

1. M. Hentschel *et al*. **Attosecond metrology.** *Nature* **414**, 509 (2001): generation and measurement of a light pulse shorter than 1 femtosecond.

2. M. Drescher *et al*. **Time-resolved atomic inner-shell spectroscopy.** *Nature* **419**, 803 (2002): real-time observation of electron dynamics in inner shells of atoms.

3. T. Brabec & F. Krausz. **Intense few-cycle laser fields: frontiers of nonlinear optics.** *Rev. Mod. Phys.* **72**, 545 (2000): reviews the technologies Ferenc Krausz and his group developed for the generation of few-cycle, few-femtosecond laser light in the 90s.

4. A. Baltuška *et al*. **Attosecond control of electronic processes by intense light fields.** *Nature* **421**, 611 (2003): generation of laser light with controlled waveform and its use for controlling atomic-scale electron motion.

5. R. Kienberger *et al*. **Atomic transient recorder.** *Nature* **427**, 817 (2004): demonstration of a light-field-driven "streak camera", now the gold standard in attosecond metrology. ■ E. Goulielmakis *et al*. **Direct measurement of light waves.** *Science* **305**, 1267 (2004): measurement of the oscillating electric field of a the waveform-controlled near-single-cycle laser pulse, providing, together with the isolated attosecond pulse it can generate, the basic tools for attosecond time-resolved spectroscopy.

6. F. Krausz & M. Ivanov. **Attosecond Physics.** *Rev. Mod. Phys.* **81**, 163 (2009): reviews the basic concepts and techniques of attosecond measurements, pioneered in the groups of F. Krausz and P. Corkum.

7. M. Kling *et al*. **Control of electron localization in molecular dissociation.** *Science* **312**, 246 (2006): electron steering inside a molecule with the controlled electric field of light. ■ M. Uiberacker *et al*. **Attosecond real-time observation of electron tunnelling in atoms.** *Nature* **446**, 627 (2007): tracking electron tunnelling and intra-atomic electron interactions. ■ A. Cavalieri *et al*. **Attosecond spectroscopy in condensed matter.** *Nature* **449**, 1029 (2007): real-time observation of electron transport through atomic layers of a crystal. ■ E. Goulielmakis *et al*. **Single-cycle nonlinear optics.** *Science* **320**, 1614 (2008): breaking the 100-attosecond barrier in light pulse generation. ■ M. Schultze *et al*. **Delay in photoemission.** *Science* **328**, 1658 (2010): discovery of a delay in the photoeffect, measured with a resolution better than the atomic unit of time. ■ E. Goulielmakis *et al*. **Real-time observation of valence electron motion.** *Nature* **466**, 739 (2010): tracking the sub-femtosecond oscillatory motion of an electron inside an atom. ■ A. Wirth *et al*. **Synthesized light transients.** *Science* **334**, 195 (2011): super-octave light waveform synthesis, observation of sub-femtosecond Stark shift and ionization. ■ A Schiffrin *et al*. **Optical-field-induced current in dielectrics.** *Nature* **493**, 70 (2013): turning an insulator into a conductor within 1 femtosecond → prospect of petahertz-bandwidth solid-state signal metrology. ■ M. Schultze *et al*. **Controlling dielectrics with the electric field of light.** *Nature* **493**, 75 (2013): manipulation of the electric and optical properties of solids at light frequencies → paving the way towards petahertz signal processing. ■ S. Neppl *et al*. **Direct observation of electron propagation and dielectric screening on the atomic length scale.** *Nature* **517**, 342 (2015): real-time observation of electron transport through atomic layers in a solid.