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A glimpse into the science and technology of attosecond light sources

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The femtosecond barrier was broken in 2001 when the first isolated, attosecond-duration (1as=10-18s) light pulses were generated by firing extremely intense laser pulses with carefully controlled waveforms into neon gas atoms. The origin of attosecond photon emission is the laser-driven acceleration of ionised electrons; an atomic-scale accelerator. The duration of those first attosecond pulses was 650as. The current world record stands at 53as. To put this into some kind of perspective, this is the time required for light to travel a distance equal to the size of the smallest virus.

Attosecond light pulses provide scientists with the shortest controllable probes currently available. Such pulses, used as exquisitely sharp temporal "scalpels", are allowing previously immeasurably fast dynamics in matter to be tracked and, potentially, even controlled at a fundamental level.

Though a relatively new field, a growing number of groups around the world have established attosecond measurement capabilities in their laboratories, and are employing these powerful new tools to conduct groundbreaking experiments in atoms, molecules and condensed phase matter. Attosecond measurements have been made of photo-ionisation dynamics, multi-electron relaxation processes, and ultrafast nuclear rearrangements in molecules. The attosecond time-delays in photoemission from surfaces has been measured for the first time –effectively "timing the photoelectric effect"–and recently, attosecond control of the electrical and optical properties of dielectrics at optical frequencies has been demonstrated, with implications for PHz signal processing.

Using the attosecond facilities in the Laser Consortium in the Physics Department as an exemplar, this talk will provide an accessible introduction to the science and technology behind the generation, characterisation and application of attosecond light pulses.

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