Fastest movie camera in the world could study the dynamics of atomic nuclei

March 13 2013

A technique to create the shortest X-ray pulses ever made is proposed in *Physical Review Letters*. The capability would generate a deeper understanding of how medicines interact within the body and of catalytic processes in new materials for energy storage.

Developed by researchers at the Science and Technology Facilities Council (STFC) at its Daresbury Laboratory, in close association with the University of Strathclyde, the proposed technique is expected to generate

X-ray laser pulses shorter than one millionth of a millionth of a millionth of a second, known as an attosecond, and would open the possibility of directly studying the dynamics of atomic nuclei. Presently the shortest pulse of laser light ever generated is 67 attoseconds.

Lead author David Dunning, an accelerator scientist at STFC's Accelerator Science and Technology Centre (ASTeC), said: "Such pulses will be important for observing and influencing processes within molecules, atoms and nuclei which occur at progressively smaller sizes and faster time scales. Such short timescales are difficult to conceive. To put them into context, stretching out one attosecond to one second is the equivalent to stretching out one second to 30 billion years - or more than twice the age of the universe."

Although further development is needed to put this theory into practice, this is a significant step in the long-standing drive to film with atomic resolution, which can then be combined to produce movies.

The concept has been extensively computer modelled at STFC and it would only require a modest addition to an existing X-ray Free-Electron Laser (FEL), such as the LCLS in the USA or SACLA in Japan, for the idea to be implemented. However, a more likely scenario might be that the idea be first proven in practice on a dedicated FEL test facility, such as the proposed CLARA project, an upgrade to the existing Electron Beam Test Facility at Daresbury Laboratory.

By using magnets to manipulate electrons from a particle accelerator, FELs generate intense light of exceptional quality. FELs operate across a much broader range of wavelengths than conventional lasers, and this ability to reach very short wavelengths (e.g. X-rays) is part of the key to generating ultra-short pulses. Currently, FEL pulses flash on and off quickly enough to `freeze-frame' the motion of electrons within atoms or molecules. By using the new technique to move to the scale of less than an attosecond, it may be possible to probe deeper and observe the much faster dynamics of electrons interacting with the nucleus, or even the dynamics of the nucleus itself.

David Dunning continued "Our proposed techniques can be applied to any present or future particle accelerator FELs."

More information: Dunning, D., McNeil, W. and Thompson, N. Few-cycle pulse generation in an x-ray free-electron laser, *Physical Review Letters*. DOI: 10.1103/PhysRevLett.110.104801

Provided by Science and Technology Facilities Council

March 13) retrieved 18 April 2024 from https://phys.org/news/2013-03-fastest-movie-camera-world-dynamics.html