Physicists make first 'molecular movie' of light

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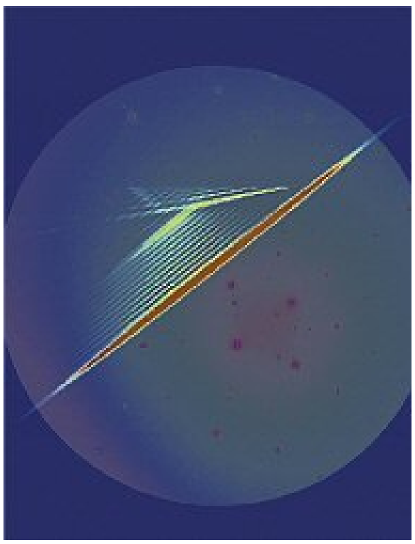

Femtosecond x-ray pulses are used to detect the ultra-fast motion of charged atoms in a THz light field. Credit: University of Oxford

Scientists have made the first ‘molecular movie’ of the elementary interaction between light and matter. They measured what happens on a microscopic level when light travels through a medium in a collaborative project involving Oxford University, the Lawrence Berkeley Laboratory in California, and the Massachusetts Institute of Technology.

The lead author of the study published in *Nature*, Dr Andrea Cavalleri at the Oxford University Department of Physics, said: ‘We’ve all seen how a stick in a pond appears to be at a different angle depending on whether we look at it from outside or inside the water. At a microscopic level, this effect depends on how stiff atomic bonds are, and with how much delay atoms and electrons respond when they are placed in the rapidly wiggling electric field of light.

'If you want to understand the propagation of light at microscopic level, especially in some the complex materials that are of interest for modern opto-electronic applications, you need to make a 'molecular movie' of how the atoms and electrons wiggle in the light field. To do so, you need to find a camera with an extremely quick shutter speed – that of a handful of femtoseconds (which is less than one thousandth of a billionth of a second).

'This very fast timescale can be reached with modern laser technology – but lasers can't see where the constituents atoms actually are. If you want to see this 'shape' of a molecule you need x-rays, but there are currently no x++-ray beams with short enough pulses to take snapshots of atomic motions.

'What we have managed to do is combine ultra-fast laser pulses with electron beams in a particle accelerator, deflecting a small slice of the long electron pulse on a separate orbit of the accelerator. Thus, these electrons radiated short enough x-ray pulses to measure elementary atomic motions on the femtosecond timescale. This enabled us to measure the motion of charged atoms on the ultra-fast timescale with an accuracy of less than one thousandth of one billionth of a meter. This means we are capable of resolving in time the displacements of atoms by less than one atomic nucleus.

'This technology can now be applied to other elementary processes at the microscopic level, and we can measure their displacements with unprecedented speed and resolution.'

Source: University of Oxford