Scientists capture the speediest ever motion in a molecule

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The fastest ever observations of protons moving within a molecule open a new window on fundamental processes in chemistry and biology, researchers report today in the journal *Science*.

Their capturing of the movements of the lightest and therefore speediest components of a molecule will allow scientists to study molecular behaviour previously too fast to be detected. It gives a new in-depth understanding of how molecules behave in chemical processes, providing opportunities for greater study and control of molecules, including the organic molecules that are the building blocks of life.

The high speed at which protons can travel during chemical reactions means their motion needs to be measured in units of time called 'attoseconds', with one attosecond equating to one billion-billionth of a second. The team's observation of proton motion with an accuracy of 100 attoseconds in hydrogen and methane molecules is the fastest ever recorded.

Dr John Tisch of Imperial College London says: "Slicing up a second into intervals as miniscule as 100 attoseconds, as our new technique enables us to do, is extremely hard to conceptualise. It's like chopping up the 630 million kilometres from here to Jupiter into pieces as wide as a human hair."

Professor Jon Marangos, Director of the Blackett Laboratory Laser Consortium at Imperial, says this new technique means scientists will now be able to measure and control the ultra-fast dynamics of molecules.

He says: "Control of this kind underpins an array of future technologies, such as control of chemical reactions, quantum computing and high brightness x-ray light sources for material processing. We now have a much clearer insight into what is happening within molecules and this allows us to carry out more stringent testing of theories of molecular structure and motion. This is likely to lead to improved methods of molecular synthesis and the nano-fabrication of a new generation of materials."

Lead author Dr Sarah Baker of Imperial College believes that the technique is also exciting because of its experimental simplicity. She says: "We are very excited by these results, not only because we have 'watched' motion occurring faster than was previously possible, but because we have achieved this using a compact and simple technique that will make such study accessible to scientists around the world."

To make this breakthrough, scientists used a specially built laser system capable of producing extremely brief pulses of light. This pulsed light has an oscillating electrical field that exerts a powerful force on the electrons surrounding the protons, repeatedly tearing them from the molecule and driving them back into it.

This process causes the electrons to carry a large amount of energy, which they release as an x-ray photon before returning to their original state. How bright this x-ray is depends on how far the protons move in the time between the electrons' removal and return. The further the proton moves, the lower the intensity of the x-ray, allowing the team to measure how far a proton has moved during the electron oscillation period.

Source: Imperial College London