

Can we freeze time? Using lasers to film the secret lives of atoms -- frame by frame



Visitors to the exhibit are able to record a slow motion film of a water balloon bursting in their hands

Cutting edge laser 'cameras' which can film the super-fast movements of electrons inside materials are the subject of an Imperial College exhibit at the Royal Society Summer Science Exhibition 2008, which opens to the public today (1 July).

The exhibit, run by a team of Imperial physicists, explains how they use incredibly short flashes of laser light in their London lab to record images of electrons in atoms as they move around at about 10 million kilometres per hour.

To put their research into context, the hands-on exhibit also explains the history of high-speed photography. Over the last century the technology has evolved to enable people to view the details of ever faster events, from a galloping horse and a bullet passing through a card, to electrons moving in matter today.

Visitors to the exhibit can be filmed with a water balloon bursting in their hand in slow motion, and can blow raspberries into a super slow motion camera which captures all the comical movements of their lips and face. The movies will be burned onto CDs for visitors to take home.

The aim of the exhibit is to demonstrate how incredibly quick the team's laser cameras are. The commercial slow motion cameras visitors can try out at the event run at about 1000 frames per second, fast enough to film the details of a bursting water balloon. The team's laboratory cameras, in comparison, use flashes of laser light to achieve an effect equivalent to 10-million-billion frames per second, allowing them to highlight the movement of electrons and to observe how small molecules change shape during chemical reactions.

Imperial's Dr John Tisch, who is heading up the exhibit, explains: "The incredibly short timescales we use to take pictures in our lab, known as 'attoseconds' which are one billion-billionth of a second, are very hard to imagine. We hope that playing around with different kinds of high speed cameras at the exhibition will give the public a good introduction to the ideas behind the work we do, and will put the short timescales we work at in context – and hopefully they'll have fun pulling silly faces and bursting balloons at the same time!"

The laser 'camera' used by Dr Tisch and his colleagues harnesses some unusual physics in order to take pictures of electrons moving around inside a material. The camera consists of a high powered laser one million-billion times more intense than bright sunlight which rips atoms apart, causing the emission an ultra-short burst of light.

This very bright burst of light lasts for just 100 attoseconds or so, and during this time it illuminates and freeze-frames the motion of the electrons, allowing the scientists to record images of them as they move around extremely quickly.

Dr Tisch explains the science behind his research to exhibition visitors
Being able to watch electrons move around like this is important because they play an important role in many aspects of everyday life. Electrons form the bonds that hold biological molecules together, move around to make chemical reactions happen, and are the engine of all modern electronics.

Understanding more about how electrons move around will give scientists a greater insight into how some of these processes work, and could eventually lead to future research in which scientists will be able to manipulate and control the electrons themselves.

Dr Tisch explains: "At the moment our work is like that of a movie cameraman, recording the movements of the electrons. One day, we would like to become like movie directors, making the electrons move where we want. If we could do this, we could control chemical reactions, design new materials and create faster, more efficient electronic devices."

Imperial scientists will also contribute to a second stand at the Summer Science Exhibition. This exhibit, titled, "From hard-disk to healthcare: what can spintronics do for you?" will explain the science behind a new technology called spintronics, which promises to revolutionise modern day electronics.

Conventional electronic devices, from iPods and laptops to medical equipment, use the electrical charge of electrons to process information. Spintronics aims to use another property of electrons, known as their spin, or 'magnetic moment' to do this instead. Scientists predict that this technology will mean much more information could be stored on much smaller computer chips.

Dr Ola Wessely from Imperial's Department of Physics said: "Our exhibition stand will introduce people to the fundamental principles of spintronics, and will show how we're trying to control the magnetic structure of tiny strips of metal. In the future, several of these strips will make up a 'magnetic memory' which could be used in all kinds of electrical devices."

Source: Imperial College London

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