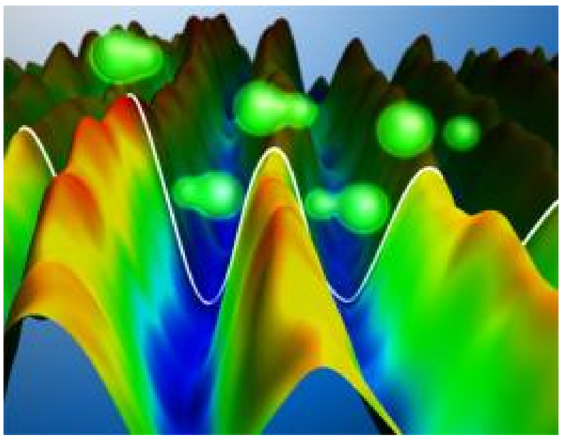
Scientists track electrons in molecules

June 13 2010



Electron dynamics in molecular hydrogen following photoionisation by an attosecond laser pulse. The remaining electron in the molecule (depicted in green) is measured experimentally and shown as a mountain landscape. Hills and valleys correspond to a higher probability of finding the electron on the left and right side of the molecule respectively. © Christian Hackenberger

(PhysOrg.com) -- Physicists in Europe have successfully glimpsed the motion of electrons in molecules. The results are a major boon for the research world. Knowing how electrons move within molecules will facilitate observations and fuel our understanding of chemical reactions.

Presented in the journal *Nature*, the study is supported via three EU-funded projects.

The physicists, led by Professor Marc Vrakking, Director of the Max

Born Institute for Nonlinear Optics and Short Pulse Spectroscopy in Germany, used attosecond laser pulses to clinch this latest technical feat. Scientists were unable to observe this motion in the past because of the extreme speediness of electrons.

An attosecond is a billionth of a billionth of a second. Light covers a distance of less than 1 millionth of a millimetre during an attosecond. This is basically equal to the distance from one end of a small molecule to the other. By creating attosecond laser pulses, the scientists could snap 'pictures' of electrons' movements within molecules.

For the purposes of this study, the physicists looked at the hydrogen molecule (H_2) - with just two protons and two electrons, experts call H2 the 'simplest molecule'. The team used their attosecond laser to determine how ionisation occurs within a hydrogen molecule. During ionisation, one electron is removed from the molecule while the energy status of the other electron changes.

'In our experiment we were able to show for the first time that with the help of an attosecond laser we really have the ability to observe the movement of electrons in molecules,' Professor Vrakking explained. 'First we irradiated a hydrogen molecule with an attosecond laser pulse. This led to the removal of an electron from the molecule - the molecule was ionised. In addition, we split the molecule into two parts using an infrared laser beam, just like with a tiny pair of scissors,' he added. 'This allowed us to examine how the charge distributed itself between the two fragments - since one electron is missing, one fragment will be neutral and the other positively charged. We knew where the remaining electron could be found namely in the neutral part.'

For the last 30 years or so, scientists have been using femtosecond lasers to look at molecules and atoms. A femtosecond is one millionth of one billionth of a second, so it makes it 1,000 times slower than an attosecond. It is easy to track the movement of molecules and atoms when femtosecond lasers are used.

Scientists helped drive this technology forward by developing attosecond lasers, which are benefitting diverse studies in natural sciences including the study outlined here.

Commenting on the calculations and the complexity of the problem, co-author Dr Matthias Kling of the Max-Planck Institut für Quantenoptik in Germany, said: 'We found out that also doubly excited states, i.e. with excitation of both electrons of molecular hydrogen, can contribute to the observed dynamics.'

Professor Vrakking concluded: 'We have not - as we originally expected - solved the problem. On the contrary, we have merely opened a door. But in fact this makes the entire project much more important and interesting.'

More information: Sansone, G., et al. (2010) Electron localization following attosecond molecular photoionization. Nature, published online 10 June. DOI:10.1038/nature09084

Provided by Cordis

Citation: Scientists track electrons in molecules (2010, June 13) retrieved 29 June 2024 from https://phys.org/news/2010-06-scientists-track-electrons-molecules.html