Catching Electrons with Light?

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In this, the 50th anniversary of the laser's creation, we are in the midst of a revolution affecting one of the most important aspects of laser technology. During the last decade, a factor of 50 has been shaved from the duration of the world's shortest pulse, reaching 80 attoseconds (80/1,000,000,000,000,000,000 of a second). Pulses now are short enough to freeze the motion of the most important electrons in atoms and molecules.

At the heart of the attosecond revolution is an interferometer constructed from an electron extracted from an atom or molecule. Tunneling is the beam splitter – the field of an intense laser pulse splits an electron wave packet from a bound-state orbital. The laser field also serves as the mirror, driving the wave packet back to overlap the initial wavefunction. In addition to making attosecond pulses, the interferometer can "photograph" a molecule's electrons, bringing time and space together -- the first frame in a molecular movie which we plan to produce.

But laser tunneling has other applications. Analogous to a Scanning Tunneling Microscope (STM), a molecular orbital can be scanned with the "laser STM". One translates a tip to image surface structure of a solid while one rotates the laser field around the molecular axis to image a molecular orbital. The laser STM also images electronic correlations in atoms or molecules.

It has been a century and a half since the first movies were made. Today we stand on the verge of making quantum movies that film chemical and biological processes. These films will give us unprecedented insight into the molecular world.