Extreme Lightwave Driven Quantum Dynamics

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Since the invention of the laser more than 50 years ago, scientists have learned to harness intense light waves to control electron motion in atoms, molecules and solids akin to a powerful nanometer-size accelerator. This level of control has led to astonishing new possibilities to image structure with atomic resolution or to investigate matter from within. I will describe how these effects can be leveraged to "teach" molecules to take a selfie while undergoing structural change. This permits visualizing for the first time, with combined attosecond temporal and atomic spatial resolution, molecular transformations. Using the recollision of electrons, attosecond bursts of x-rays can be generated which provide an unprecedented view into the quantum world of materials. These new capabilities are already impacting nano and material science and they show great promise to address fundamental and long-standing questions such as molecular isomerization, phase transitions and superconductivity.

Fecha: martes 10 de diciembre
Hora: 10:30