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Observation and control of ultrafast quantum interferences in atoms and molecules.

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I will present several examples of ultrafast interferences in atoms and molecules, at the femtosecond and picosecond time scale. In a two level atom, real-time quantum state holography is performed through interferences between quantum states created by a reference pulse and a chirped pulse resulting in coherent transients. A sequence of several measurements allows one to measure the real and imaginary parts of the excited state wave function. These measurements are performed during the interaction with the ultrashort laser pulse. The extreme sensitivity of this method to the pulse shape provides a tool for electric field measurement. In a molecule, the transient interferences between two oscillating wave-packets have been observed and controlled. In a first experiment, a vibrational wave packet is created in the iodine B state. Due to anharmonicity, the wave-packet spreads and recombines in one single wave packet (revival time) or two wave-packets (half revival time). When these two wave packets cross, they transiently create a stationary wave which is observed. In a second experiment, the same situation is created by launching two wave packets in the same potential well with an ultrastable relative phase. The delay, set to 1.5 vibrational periods, is stabilized with sub 100 attosecond precision. The same transient interference pattern is observed. Moreover, the relative phase between the counterpropagating wave packets can now be controlled by scanning the interpulse delay on an optical period.