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Isolated attosecond pulses for the investigation of electron localization processes in molecules

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Attosecond Science represents one of the frontiers in Ultrafast Optics since it offers the possibility to influence, control and monitor the motion of electronic waves. Particularly interesting is the generation of isolated attosecond pulses: in this case significant progress has been achieved thanks to the stabilization of the carrier-envelope phase of amplified light pulses and to the control of the temporal evolution of the pulse polarization state by the polarization gating technique with phase-stabilized few-cycle pulses.

In this presentation I will report on various temporal gating schemes for the generation of isolated attosecond pulses. In particular the polarization gating technique and a novel scheme based on the use of few-optical-cycle driving pulses with above saturation intensity will be discussed.

I will discuss two novel experimental approaches for attosecond measurements. We have used isolated attosecond pulses to photo-ionize He atoms in the presence of a 5-fs infrared (IR) pulse. Part of the XUV spectrum is below the ionization threshold of He and photo-ionization can take place only in the presence of an intense IR field. We have acquired complete scans vs. delay between IR and XUV pulses showing an interference effect between the direct single XUV photon ionization channel (due to photons with energy above the ionization threshold) and a second channel given by XUV ionization assisted by the IR field. From the experimental data the energies and amplitudes of the states in the bound electron wave packet can be obtained.

We have then used isolated attosecond pulses to achieve control of electron localization in the process of dissociative ionization of D_2, induced by a sequence of an isolated attosecond pulse and an intense few-cycle IR pulse. A localization of the electronic charge distribution in the molecule has been measured with attosecond temporal resolution, as a function of the delay between the attosecond and the IR pulses. We have demonstrated that such electron localization is due to two different physical mechanisms.