# Experiments at ATTOLab: Towards time resolved MFPADs

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Molecular frame photoelectron angular distributions (MFPADs) provide most sensitive observables in the study of the photoionization dynamics of molecules. Combining electron-ion coincidence 3D momentum spectroscopy of dissociative ionization processes with the use of advanced light sources delivering attosecond pulses in the extreme ultraviolet (XUV) region, MFPADs can be probed at the attosecond to picosecond time scales. These developments open up new areas of studies on ultrafast electron and nuclear dynamics, e.g., electron motion, relaxation dynamics of autoionizing states, excited states, control of dynamics of chemical processes, measurement of attosecond photoemission time delays[1,2] in the molecular frame[3], as addressed in this work. In the current study performed at the ATTOLab-FAB10 (rep. rate 10 kHz) beamline (Equipex, L'Orme des Merisiers, CEA) using the CIEL COLTRIMS set-up, we employed the XUV-IR interferometric RABBITT technique, where the target is ionized by an XUV attosecond pulse train and a coherent IR pulse interacts with the electron in the continuum. Resulting from the interferences between two different coherent pathways populating the same final electronic state, sidebands are generated in the photoelectron spectrum, whose intensity oscillates sinusoidally as a function of the delay between the XUV and IR pulses. The phase of these oscillations gives information on the Wigner time delay[4], which quantifies the emission delay for XUV photoionization. We report first time-resolved photoelectron angular distributions measured at ATTOLab using the COLTRIMS type spectrometer for photoionization of noble gases (Ar, Ne) (Lab. Frame, LF) and molecules (NO, $O_2$) (Mol. Frame, MF), within the limits of the present development of the FAB10 beamline. The reported results, which address notably LF and MF angularly resolved photoemission delays, are compared to recent experimental[5] and theoretical[6] results for Argon. The experiments at ATTOLab are supported by complementary spectrally resolved photoionization studies at Synchrotron SOLEIL in collaboration with the PLEIADES and DESIRS beamlines.

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