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PhotoIonization and Velocity Map Imaging spectroscopy of atoms, molecules and clusters with synchrotron and Free Electron Laser Radiation at ELETTRA

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Advances in laser and synchrotron radiation instrumentation are continuously boosting fundamental research on the electronic structure of matter.

At ELETTRA the collaboration between several groups active in the field of atomic, molecular and cluster physics and the Instrumentation and Detector Laboratory has resulted in a set-up for Velocity Map Imaging (VMI) of charged particles [1,2]. It successfully tackles the challenges posed by the investigation of the electronic structure of isolated species in the gas phase by means of Synchrotron Radiation (SR) and Free Electron Laser (FEL) light.

The core of the setup scheme is the VMI system allowing the analysis of the kinetic energy and the angular distribution of the charged particles produced by photo ionization.

The unique combination here at ELETTRA of access to both SR and FEL sources, and of the realization of the setup described above allow to explore new frontiers in the study of matter, covering a wide spectrum of targets from energetic to dynamics. In fact our firs VMI setup was born for the SR application, but, by changing position sensitive detectors, tests with the FEL light source have been performed. Based on this successful preliminary tests a permanent setup has been realized also for FEL applications. I will present the two different setups for SR and FEL applications:

– In SR experiments, at the GasPhase beamline [3], a crossed delay line detector is used, coupled to a four-channel time-to-digital converter that reconstructs the position of the electrons. Simultaneously, a Time-of-Flight (TOF) mass spectrometer allows to acquire photoion spectra. In such a configuration Photo-Electron-PhotoIon-Coincidence detection (PEPICo) allows correlating the kinetic energy and exit angle of photo-emitted electrons with the mass of photo-ions, i.e., to the specific ionic state produced by photon absorption.
– In FEL experiments (notably differing from SR experiments in the much higher rate of events produced and detected, which forces one to forfeit coincidence detection), at the LDM beamline [4], a Micro Channel Plate (MCP) a phosphor screen and a CCD camera are used instead, allowing shot-by-shot collection of practically all events, albeit without time resolution. Femtosecond pump and probe experiments can also be performed to access the electron dynamics.

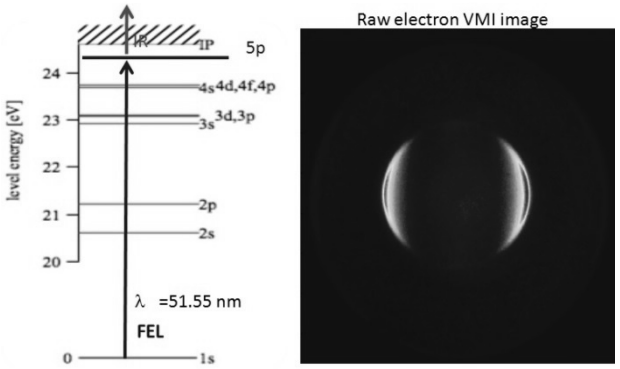

Figure 1: Two color experiments at the LDM beamline on atomic Helium photoemission, FEL at 24.05 eV and IR at 1.5 eV. On the right: a raw electron VMI image.

Recent results of experiments on rare-gas atoms and clusters performed at the GasPhase beamline of ELETTRA and at the LDM beamline (Low Density Matter, one recent result in fig.1) of the FEL FERMI [5,6] will be presented.

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