

## Liquid-jet Velocity Map Imaging

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Liquid-jet photoelectron spectroscopy (LJ-PES)<sup>1</sup> enables the direct study of the electronic structure of both solutes and solvents and has greatly advanced chemical analyses in aqueous solutions. The LJ facilitates in-vacuo continuous liquid-sample replacement and the detection of photoelectrons with minimal collisions with evaporating water molecules.

Velocity map imaging (VMI)<sup>2</sup> provides optimal photoelectron collection efficiency, generally with a full  $4\pi$ -steradian collection range, enabling the collection of photoelectron spectra and photoelectron angular distributions (PADs) in a single measurement. While VMI is widely applied in the gas phase<sup>3</sup>, its intriguing extension to liquid-phase studies (particularly on aqueous solutions) remains highly challenging. Major experimental and technical difficulties include the disturbance of the focusing electric fields due to the presence of the dielectric LJ, the background resulting from scattering of the photoelectrons within and around the (aqueous) solution, and the balance between the required high electric fields and the risk of electrical breakdown in a high-vapor-pressure environment.

We have recently overcome these critical technical issues and have successfully utilized our custom-designed LJ-VMI setup. This system offers a broad dynamic energy range, allowing for the detection of photoelectron kinetic energies up to approximately 40 eV. Following initial lab-experiments using laser and ultraviolet light sources, we present here our recent LJ-VMI results obtained at the bending-magnet beamline PM3 of the BESSY-II synchrotron-radiation facility. We demonstrate the ability to identify core-level and valence electron photoionization features of the solute and solvent, and determine the electron binding energies. The associated photoemission spectra and PADs from organic and volatile aqueous solutions are analyzed, with the goal of identifying the principal effects of a LJ on VMI-instrument performance.

We will discuss the next steps in our ongoing development of LJ-VMI, including perspectives for future applications towards near-ionization-threshold phenomena, as well as time-resolved photo-induced reactions and electron dynamics in (aqueous) solutions.

<sup>1</sup> B. Winter, M. Faubel, “*Photoemission from liquid aqueous solutions*”, Chemical Reviews (106) 1176-1211 (2006).

<sup>2</sup> A. T. J. B. Eppink, D. H. Parker, “*Velocity map imaging of ions and electrons using electrostatic lenses: Application in photoelectron and photofragment ion imaging of molecular oxygen*”, Review of Scientific Instruments (68) 3477-3484 (1997).

<sup>3</sup> D. M. Neumark, “*Spectroscopy of Radicals, Clusters, and Transition States Using Slow Electron Velocity-Map Imaging of Cryogenically Cooled Anions*”, The Journal of Physical Chemistry A (107), 4207-4223 (2003).