

SYPS 2: Velocity map imaging - focusing on intra- and interatomic dynamics 2

Time: Thursday 16:30–18:30

Location: Audimax

Invited Talk

SYPS 2.1 Thu 16:30 Audimax

Unraveling the dynamics of state- and conformer selected molecules fixed in space with the VMI — ●JOCHEN KÜPPER — Center for Free-Electron Laser Science, DESY, Hamburg — Department of Physics, University of Hamburg — The Hamburg Center for Ultrafast Imaging, Hamburg

Velocity-map imaging (VMI) provides a powerful detection scheme for the dynamics of complex molecules. In this tutorial, I will introduce the methods to spatially separate different species present in molecular beams, to fix these molecules in space, and to investigate their structures and dynamics using VMI.

Inhomogeneous electric fields enable the spatial separation of conformers (structural isomers), nuclear spin isomers, and individual quantum states. These experiments exploit the neutral-molecule analogues of the electric bender, the ion guide, and the linear accelerator. The created state-selected molecular samples provide unprecedented options to fix molecules in space. The VMI spectrometer allows to unravel the resulting rotational dynamics of molecules in the applied electric and laser fields of vastly different strength and duration. The detailed analysis of these rotational dynamics and the prepared penular states is an instructive example of quantum control.

VMI is also used to image photoelectron angular distributions (PAD). Utilizing the described controlled samples one can observe molecular frame (MF) PADs that provide direct images of electronic and geometric structures of molecules, potentially with femtosecond time resolution.

SYPS 2.2 Thu 17:00 Audimax

Quantification of the Photoelectron Circular Dichroism from Multiphoton Ionization with Femtosecond Laser Pulses

— ●CHRISTIAN LUX¹, STEFANIE ZÜLLIGHOVEN¹, CRISTIAN SARPE¹, MATTHIAS WOLLENHAUPT², and THOMAS BAUMERT¹ — ¹Universität Kassel, Institut für Physik und CINSaT, D-34132 Kassel, Germany — ²Carl von Ossietzky Universität Oldenburg, Institut für Physik, D-26129 Oldenburg, Germany

The asymmetry of photoelectron angular distributions from randomly oriented enantiomers of chiral molecules in the ionization with circularly polarized light arises in forward/backward direction with respect to the light propagation. This effect was termed Photoelectron Circular Dichroism (PECD) and so far investigated using synchrotron radiation [1]. In our recent publication [2] we have demonstrated that PECD is accessible via a Resonance Enhanced Multi-Photon Ionization (REMPI) using femtosecond laser pulses. We observed highly structured asymmetries in the range of $\pm 10\%$. Attributed to the MPI high order odd Legendre polynomials appear in the measured PECD. In this talk we show our recent findings on the bicyclic Ketones Camphor, Fenchone and Norcamphor. In order to quantify this data we want to introduce quantitative measures. These measures will be used to distinguish the three bicyclic Ketones and to quantify ellipticity dependences on Camphor as well as the enantiomeric excess in mixtures of R- and S-Fenchone.

[1] I. Powis in S. A. Rice (Ed.): *Adv. Chem. Phys.* **138**, 267-329 (2008)

[2] C. Lux et al., *Angew. Chem. Int. Ed.* **51**, 5001-5005 (2012)

Invited Talk

SYPS 2.3 Thu 17:15 Audimax

Velocity map imaging: from molecules to clusters, nanoparti-

cles and aerosols — ●MICHAL FARNIK, VIKTORIYA POTERYA, JOZEF LENGYEL, ANDRIY PYSANENKO, PAVLA SVRCKOVA, and JAROSLAV KO-CISEK — J. Heyrovsky Institute of Physical Chemistry, ASCR, Dolejskova 3, 18223 Prague 8

We will present several experiments with large clusters and nanoparticles performed with our cluster beam (CLUB) apparatus which has recently been upgraded with velocity map imaging (VMI) system. The unique and versatile apparatus allows for various experiments besides VMI including, e.g., high resolution mass spectrometry, particle cross section measurements etc. Combination of these experiments can lead to unprecedented detailed information about the dynamics of photochemistry and photophysics even in large clusters. This will be illustrated for systems of atmospheric relevance such as hydrogen halides and freons on/in ice nanoparticles.

SYPS 2.4 Thu 17:45 Audimax

Imaging Cold Molecules on a Chip — ●SILVIO MARX¹, DAVID ADU SMITH¹, MARK ABEL¹, THOMAS ZEHENTBAUER¹, GERARD MEIJER^{1,2}, and GABRIELE SANTAMBROGIO¹ — ¹Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — ²Radboud University of Nijmegen, Nijmegen, The Netherlands

We recently reported the manipulation of the external and internal degrees of freedom of cold molecules using a chip-based Stark decelerator. This comprised the trapping, guiding and deceleration of packets of polar molecules as well as the excitation of the molecules' rotational and vibrational degrees of freedom while they were on the chip. Now we present the final crucial component for a fully integrated molecule chip: on-chip detection.[1] By means of resonance-enhanced multiphoton ionization (REMPI) and ion optics we image the molecules in the microtraps of our chip and use this resolution to analyze the phase space distribution of the molecules. This is done by taking time-resolved snapshots of the molecules' ballistic expansion after release from their traps, in a similar fashion as for the time-of-flight imaging of atomic ensembles on atom chips. Moreover, with this detection method we investigate the effect of a phase-space manipulation sequence applied to the trapped molecules.

[1] S. Marx et al., *Phys. Rev. Lett.* **111**, 243007 (2013)

Invited Talk

SYPS 2.5 Thu 18:00 Audimax

Velocity map imaging studies of quantum state resolved scattering at gas-solid and gas-SAMs surfaces — ●DAVID J. NESBITT¹, MONIKA GRUETTER³, J. ROBERT ROSCIOLI², CARL HOFFMAN¹, and DANIEL J. NELSON¹ — ¹JILA/University of Colorado, Boulder, CO, USA — ²Aerodyne Research Inc., 45 Manning Road, Billerica, MA, USA — ³University of Goettingen, Goettingen, Germany

This talk describes results from a novel surface-scattering technique which combines resonance enhanced multiphoton ionization (REMPI) with velocity-map imaging (VMI) to yield quantum-state and 2D velocity component resolved distributions in the scattered molecular flux. We will discuss work in hyperthermal scattering ($E_{inc} = 21(5)$ kcal/mol) of jet cooled HCl from i) Au(111) on flat mica surfaces and ii) -CH₃ terminated self-assembled monolayers (SAM). These first data establish an exciting new class of experimental tools for exploring energy transfer and reactive scattering events on SAMs, liquid, and metal interfaces with quantum state resolved information on correlated internal and translational distributions.