Seminar: Thursday Nov 19 starting at 13:15.

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Cold and controlled collisions using tamed molecular beams

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The study of molecular collisions with the highest possible detail has been an important research theme in physical chemistry for decades. Experimentally, the level of detail obtained in these studies depends on the quality of preparation of the collision partners before the collision, and on how accurately the products are analyzed afterward.

Over the last years, methods have been developed to get improved control over molecules in a molecular beam. With the Stark decelerator, a part of a molecular beam can be selected to produce bunches of molecules with a computer-controlled velocity and with longitudinal temperatures as low as a few mK [1]. The molecular packets that emerge from the decelerator have small spatial and angular spreads, and have almost perfect quantum state purity. These tamed molecular beams are excellent starting points for high-resolution crossed beam scattering experiments.

I will illustrate the possibilities this new technology offers to study molecular collisions with unprecedented precision. I will discuss our most recent results on the combination of Stark deceleration and velocity map imaging. The narrow velocity spread of Stark-decelerated beams results in scattering images with an unprecedented sharpness and angular resolution. This has facilitated the observation of diffraction oscillations in the state-to-state differential cross sections for collisions of NO with rare gas atoms [2,3], the observation of scattering resonances at low-energy inelastic [4-6] collisions that reveal the influence of individual partial waves to the scattering dynamics, and product-pair correlations for bimolecular scattering processes [7]. Finally, I will present a new Zeeman decelerator, the magnetic analogue of the Stark decelerator, which we specifically developed for applications in crossed beam experiments [8].

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[4] S. Vogels et al., *Science* **350**, 787 (2015)

[5] S. Vogels et al., *Nature Chemistry* **10**, 435 (2018)
[6] T. de Jongh et al., *Science* **368**, 626 (2020)
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[8] T. Cremers et al., *Phys. Rev. A* **95**, 043415 (2017)