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Taming molecular collisions

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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. Over the last years we have developed methods 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. 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 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 [1,2] in the state-to-state differential cross sections for collisions of NO with rare gas atoms, the observation of scattering resonances at low-energy inelastic NO-He [3] and NO-H2 [4] collisions that reveal the influence of individual partial waves to the scattering dynamics, and product-pair correlations for bimolecular scattering processes [5].

[1] A. von Zastrow et al., Nature Chemistry 6, 216 (2014)
[2] J. Onvlee et al., Nature Chemistry 9, 226 (2017)
[3] S. Vogels et al., Science 350, 787 (2015)
[4] S. Vogels et al., Nature Chemistry (in press, 2018), DOI: 10.1038/s41557-018-0001-3
[5] Z. Gao et al., Nature Chemistry (in press, 2018), DOI: 10.1038/s41557-018-0004-0