LEAK-OUT SPECTROSCOPY: A NEW TOOL FOR HIGH-RESOLUTION SPECTROSCOPY

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Action spectroscopy in combination with cryogenic ion traps is a very powerful technique for recording high-resolution spectra of molecular ions[1]. Thereby the spectrum is recorded as a change of the ion mass by fragmentation upon photon absorption, pre-dissociation of tagged ions or via laser induced chemical reactions. Although all these techniques have their advantages and are well established, many molecular ions cannot be measured using aforementioned methods.

Here, we present a new method of action spectroscopy, leak-out spectroscopy (LOS)[2]. In LOS the spectral information does not rely on a change of the mass of the ion, but on the transfer of internal energy of an excited ion to its translational energy upon collision with a neutral partner. The now fast ion can escape the trapping potentials and thus its spectrum can be recorded. Based on the underlying principle, LOS is intrinsically background free and a suitable technique for virtually any ion. Here we will present LOS in detail and discuss recent measurements on ro-vibrational resolved spectra.

As the ions escape the trapping potentials based on their ro-vibrational transitions, LOS can also be used to selectively eject a specific structural isomer or nuclear spin isomer within the ion trap. This opens up the possibility to use LOS to prepare a pure ion sample of a single isomer. Here we show the nuclear spin and additionally structural isomer specific preparation of a trapped ion sample. In particular, we were able to produce a clean sample of ortho- and para-H_3^+ in our cryogenic ion trap. The addition of H_2 as a reaction partner then allowed to study the state-specific reaction of H_3^+ + H_2. Apart from nuclear spin isomers, LOS allows the preparation of an ion sample in a single structural isomer as well. Then the influence of the molecular structure on reactions like HCO^+/HOC^+ + H_2 or HCN^+/HNC^+ + H_2 can be investigated - experiments which will be performed in the near future in Cologne.

[1]B.A. McGuire et al., Nature Review Physics 2(2020)402.
[2]P.C. Schmid et al., J. Phys. Chem. A 126(2022)8111.