Towards electron-impact dissociation dynamics of biologically relevant molecules in a reaction microscope

Thomas Pflüger[†,*,1], **Xueguang Ren**[†,*], **Marvin Weyland**[†,*], **Alexander Arndt**[†], **Woonyong Baek**[†], **Hans Rabus**[†], **and Alexander Dorn**[*]

[†] Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

[*] Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany

Synopsis A new design of an advanced reaction microscope (REMI) is presented for electron collisions with biologically relevant molecules. Its purpose is to combine advancements that have been implemented for (e, 2e)-experiments, e.g. multi-hit detectors with a high detection efficiency, with new features for target creation and increased fragment acceptance.

Following the investigation of ionization dynamics in simple systems like atoms and small molecules, which have been performed over decades, studies on more complex targets up to biologically relevant molecules (i.e. DNA building blocks or their substitutes) have gained significant progress (e.g. [1, 2, 3]). The basis for this work is to provide highly differential ionization cross sections – and thereby detailed insight into the fragmentation dynamics – of the main constituents of DNA. Experimental results which can successfully reach the low energy regime have a high importance in cancer treatment and the modeling of radiation damages of biological tissue [4].

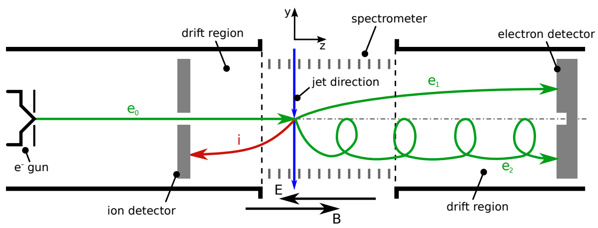

Figure 1. Schematic view of a REMI.

The employed experimental technique is an advanced REMI which was modified for electron impact experiments [5]. The basic principle of operation can be seen in Figure 1. Explained briefly, a pulsed, monoenergetic electron beam is crossed with a target beam containing the desired molecules. After ionization (and dissociation), all charged fragments are detected and their individual momentum vectors are reconstructed. Simultaneous detection of ions and electrons has the advantage that electronic – e.g. differential cross-sections – and at the same time fragmentation information like molecular orientation and dissociation energy can be acquired. Since this technique pioneered for simple targets, dissociation of complex molecules invokes several constrains which have to be overcome. Foremost, the generally large momenta from the dissociation can lead to fragments escaping the spectrometer region, a short detector distance and/or a pulsed high-voltage extraction is required. Secondly, the REMI technique relies on a gaseous target. Broken down in its constituents, few of the DNA building blocks meets this severe requirement. Therefore, either volatile surrogates, which can be used in a seeded supersonic expansion or evaporated in an oven, or other means of preparation have to be found. One possibility is laser-induced acoustic desorption (LIAD) from a foil [6]. Finally, since most complex molecules have an inherently small energy spacing of their outermost orbitals, a good energy resolution is paramount. The projectile beam creation requires special attention. Here, several measures, such as electron creation through photo-electric effect, have been taken to create sharp projectile pulses.

A detailed overview of the project and the employed methods and their performance will be presented.

References

[1] M. Dampc *et al.* J. Phys. B **44** (2011), 055206

[2] S. M. Bellm *et al.* J. Chem. Phys. **136** (2012), 244301

[3] W. Y. Baek *et al.* Phys. Rev. A **86** (2012), 032702

[4] M. U. Bug *et al.* Int. J. Rad. Biol. **88** (2012), 137

[5] J. Ullrich *et al.* Rep. Prog. Phys. **66** (2003), 1463

[6] V.V. Golovlev *et al.* Int. J. Mas. Spectr. Ion Proc. **169** (1997), 69

[1]E-mail: thomas.pflueger@ptb.de