Temporally Resolved Characterization of a Pulsed Ion Source using a Synchronized oaTOF-MS

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Introduction

Application of pulsed ion sources in combination with orthogonally accelerating time-of-flight mass spectrometers (oaTOF-MS):

- Unfavorable performance of such systems when the ion source is not synchronized with the oa-stage of the MS
- Spectra are generally recorded at high repetition rates in the kHz regime, even though the ion source does not release any ions

Synchronization of the pulsed ion source and the oaTOF-MS enables:

- Improvement of the signal-to-noise ratio
- Increase in sensitivity
- Temporally + kinetic energy resolved measurements for mass selected ions
- Characterization of the ion source and ion-molecular gas-phase processes

Experimental Set-Up and Methods

Gas Supply

- 400 ppm NO in N_2 are fed into a vacuum chamber via a gas chromatography (GC) capillary

Ionization

- (1 + 1) REMPI ([A(v = 0) ← X(v = 0)] [1] using a Nd:YAG pumped optical parametric oscillator (OPO) laser system (NT342 Series, EKSPLA) at 226.2 nm
- Pulse duration: 5 ns, repetition rate: 10 Hz

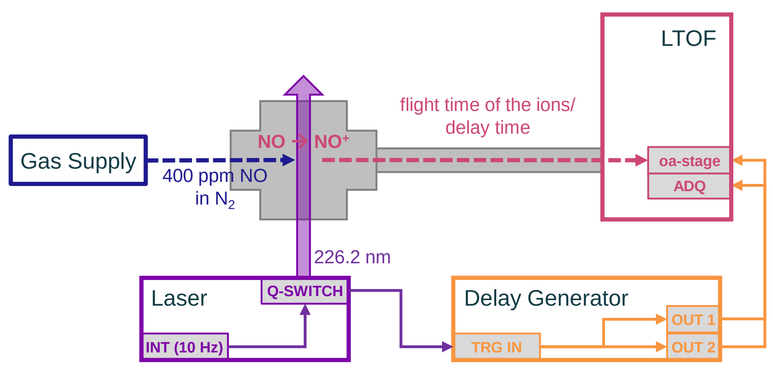

Fig. 1: Schematic of the experimental set-up for the synchronization

Ion Detection

- High resolution oaTOF-MS (LTOF, Tofwerk AG)

Synchronization

- Using the ‘‘trigger out’’ signal of the Nd:YAG laser’s Pockels cell driving unit
- Adjusting time interval between laser pulse and push pulse of the oa-stage of the LTOF as well as the data acquisition system with a delay generator (81150A, Keysight Technologies)

Experimental Results

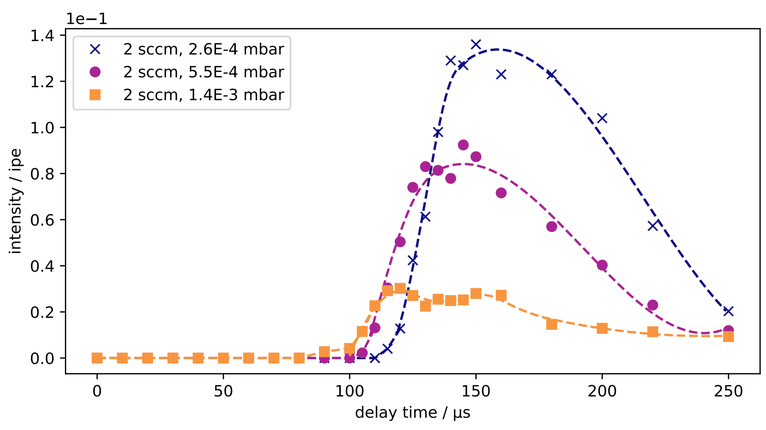

Fig. 2: Detected ions as a function of the delay time for different chamber pressures at constant gas flow

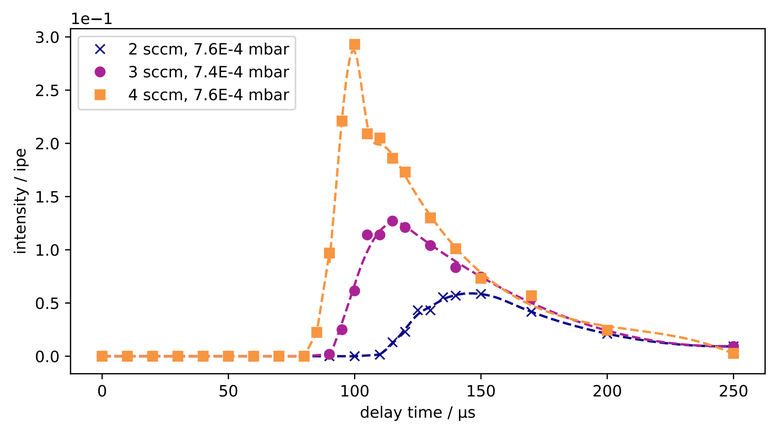

Fig. 3: Detected ions as a function of the delay time for different gas flows at constant chamber pressure

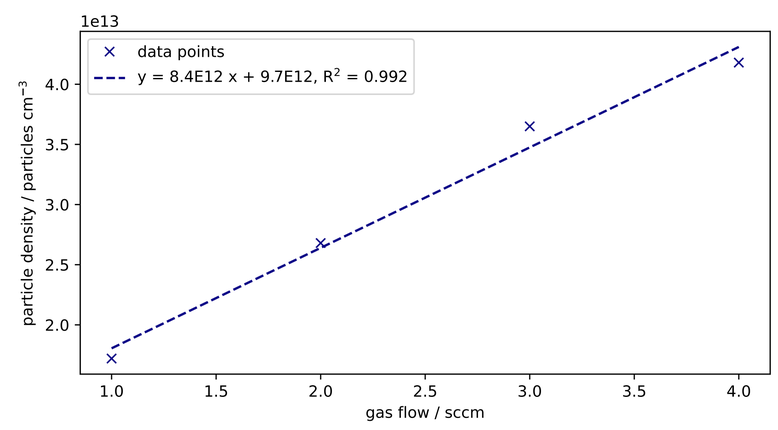

Fig. 4: Particle densities calculated via the blocking pressures [2] for different gas flows

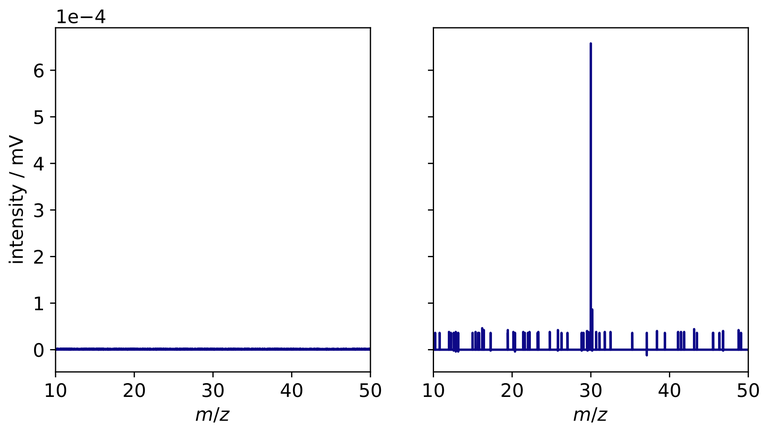

Fig. 5: Mass Spectrum without (left) and with synchronization (right) of the laser and oa-stage

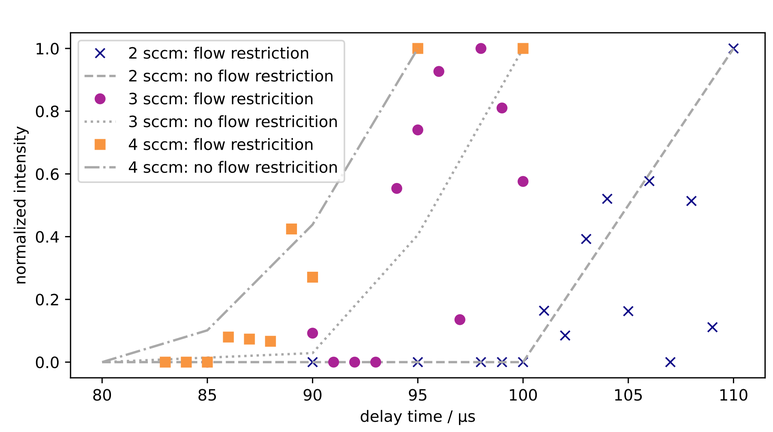

Fig. 6: Comparison of the ion signal intensity with and without flow restriction

Determination ion flight time → Yielding information about velocity and kinetic energy distribution

- A delay time of 100 µs corresponds to a velocity of 2400 m/s and a kinetic energy 1.0 eV

Installation of a flow restriction at the entrance of the flight path:

- **Fig. 5:** Synchronization is required to increase sensitivity
- **Fig. 6:** Flight times of the ions correspond to those recorded without flow restriction

Conclusion

- Successful synchronization of a low repetition rate pulsed ion source and an oaTOF-MS
- Measurement of the ion flight time → velocity and kinetic energy

Outlook

- Implementation of an ion transfer unit (segmented hexapole) for ion sampling in close vicinity to the ion origin region
- Time-resolved characterization of different pulsed plasma ion sources

References and Acknowledgment

[1] R. M. Garnica, M. F. Appel, L. Eagan, J. R. McKeachie, Th. Benter, *Anal. Chem.* **2000**, *72*, 5639–5646.

[2] M. Wutz, H. Adam, W. Walcher, *Theorie und Praxis der Vakuumtechnik*, Friedr. Vieweg & Sohn, **1989**.

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