New tuning method via center drift tube at ZD-MRTOF

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One of the many challenges of the ZeroDegree spectrometer multi-reflection time-of-flight mass spectrograph (ZD-MRTOF)[1)] is the interference of off-lap masses that overlap with other masses in the time-of-flight (TOF) spectrum. A simple solution to solve this is to change the ion trapping duration in ZD-MRTOF, thereby changing the number of ion revolutions in the ZD-MRTOF, which is also known as the lap number. However, this method has a non-trivial disadvantage.

Figure 1 shows the electric potential in the ZD-MRTOF in the ion trapping phase. In a uniform electric field, such as the region in the center drift tube, higher energy ions from a single species have shorter TOFs. This causes the ions to spread out in the axial position over multiple laps based on its energy distribution. In MRTOF spectroscopy, this effect is countered by shaping the electric potentials at the mirror, such that higher energy ions have a longer travel path. To achieve a high resolving power, the mirror potentials are fine-tuned at a specific lap number, and is sensitive to any changes to the lap number. Thus, if the lap number is changed, a significant time must be allocated to optimize the resolving power of the MRTOF, as tuning the mirror potentials involve adjusting several ring electrode potentials simultaneously.

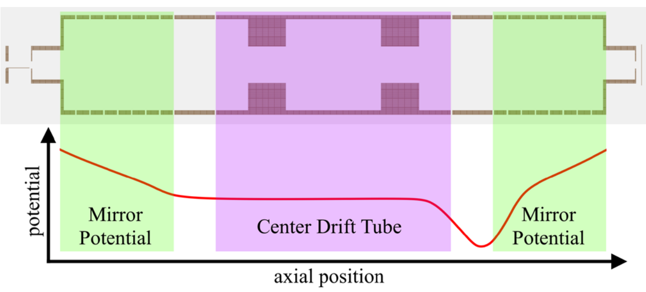

Fig. 1. Shape of the ZD-MRTOF potential in SIMION. To rotate the phase space of the ions, a voltage bias is applied to the center drift tube region (in purple).

In an attempt to solve this issue, we simulated the ZD-MRTOF setup in SIMION[2)] with several voltage biases at the center drift tube. Figure 2 shows the TOF of singly-charged ^{39}K ions between 1620 to 1730 keV for several voltage biases at the center drift tube. For a relatively linear initial distribution of ions in the energy against the TOF phase space, we showed that biasing the center drift tube serves as a good approximation to a clean phase space rotation without changing the optical properties of the mirrors. This enables the optimization

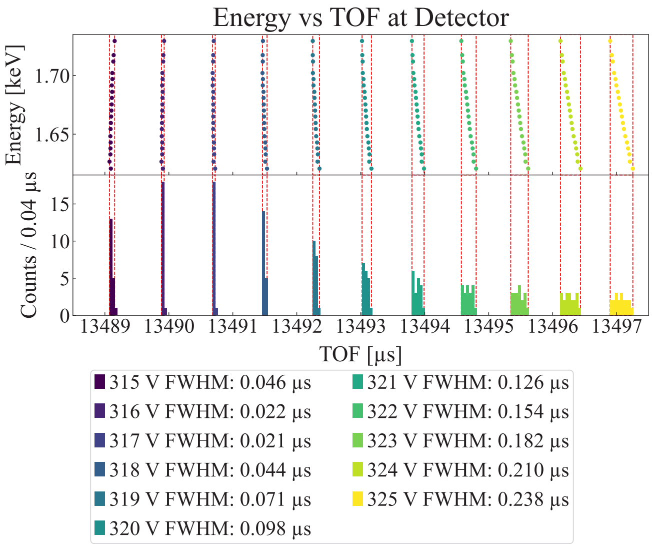

Fig. 2. (Top) Distribution of ions in the energy vs. TOF phase space after 852 laps in ZD-MRTOF for several center drift tube voltages simulated in SIMION. (Bottom) Histogram of the TOF spectrum from above, showing maximum resolving power at 317 V. Red dashed lines mark the edges of the TOF spread.

of the resolving power of MRTOF via only one electrode, significantly reducing the tuning complexity. However, it should also be noted that due to the relatively low voltages applied compared to the mirror potentials, this effect is significant only in lap numbers of 100 or higher.

To implement the center drift tube tuning method, a high-stability, high-voltage power supply[3)] was added to the center drift tube of the ZD-MRTOF. The power supply is designed to produce highly stable voltages in the range of ±500 V and can be remotely controlled via a TCP/IP interface. The new tuning method was tested by optimizing the resolving power of ZD-MRTOF exclusively with the center drift tube across several different lap numbers. An FWHM of 15 μs was achieved for all lap numbers. With the addition of this new tuning method, the ZD-MRTOF can be tuned faster after changing lap numbers in the future, especially during time-sensitive online experiments. Further investigations will be conducted to improve the resolving power of the ZD-MRTOF.

References
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