

Charge Breeding with Dresden EBIS/T systems

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Electron Beam Ion Sources and Traps (EBIS/T) of the Dresden EBIS/T type have been proven to be efficient and reliable sources of highly charged ions in many applications [1]. At GSI, a Dresden EBIT named SPARC-EBIT is currently being installed as an ion injector at the HITRAP facility. It will serve as an off line ion source for test runs and experiments. Plans for the future also envision the application of the SPARC-EBIT or other Dresden EBIS/T systems for charge breeding purposes. In this regard, the project presented here focuses on testing the performance of these sources as charge breeders.

Charge breeding with EBIS/T facilities using superconducting solenoid coils for the compression of the electron beam has been achieved successfully with breeding efficiencies into one charge state of more than 10 % [2]. The Dresden EBIS/T concept, however, is based on the usage of permanent magnets. The absence of refrigeration technology or liquid cooling gases results in many advantages such as low initial and running costs, easy operation, and a compact design which allows for transportation of the sources. On the other hand, their relatively short ion trap regions, shallow trap potentials, and low magnetic field strengths create challenges in trapping injected ions.

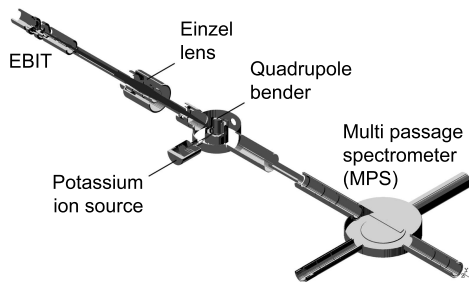


Figure 1: Main setup of the GSI MAXEBIS test bench including a SIMION simulation of the K^{1+} beam injected into the SPARC-EBIT.

The main components of the GSI MAXEBIS test bench which had been redesigned for charge breeding experiments with the SPARC-EBIT are shown in figure 1. The injection of externally produced singly charged potassium ions into the EBIT was realized with the help of a quadrupole bender and an einzel lens. After extraction from the source the ions were guided straight through the quadrupole to the multi passage spectrometer (MPS) where various beam analysis techniques could be per-

formed. SIMION [3] simulations of the K^{1+} ion beam as well as Field Precision TriComp calculations of the fields and ion trajectories inside the source were carried out predicting an achievable capture efficiency of 1-2 %. Therefore, with the equipment available at the test facility, charge breeding was forecast to be difficult but possible.

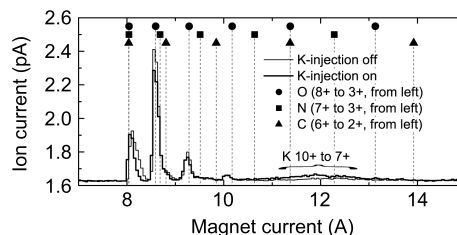


Figure 2: Extraction spectra of the beam from the EBIT without and with potassium injection measured with the MPS used as a 90° bending magnet.

In fact, the corresponding experiments showed that for charge breeding with the Dresden EBIT precision is essential. X-ray spectroscopy as well as time-of-flight spectroscopy and 90° magnetic scanning were used to identify the ion species trapped inside and extracted from the source. Hints on potassium reaching the trap region were found, as presented in figure 2. Herein, it is shown how an extraction spectrum changed when K^{1+} was injected into the EBIT. The peaks referring to the residual gas mainly consisting of oxygen, nitrogen, and carbon decreased in height. The light ions acted as a cooling gas for the heavier potassium. Meanwhile, a weak signal was detected where one would expect potassium peaks to appear in the spectrum. However, a clear identification or investigation of charge bred potassium ions could not be achieved.

A new setup for further attempts is currently under construction at GSI's HITRAP facility. In Dresden, a test facility for charge breeding will be assembled as soon as ongoing tests of its components will have finished. The plans of this facility include the application of a pepperpot emittance measurement system for advanced ion beam characterization which recently has been taken into operation.

References

- [1] See www.dreebit.com for a list of publications.
- [2] D. Voulot et al., Nucl. Instr. and Meth. in Phys. Res. B 266 (2008) 4103
- [3] D. A. Dahl, Int. J. Mass Spectrom. 200 (2000) 3

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