A gas source at 4 Kelvin – injection and charge breeding simulations of Ar gas

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We have designed and built a cold source for gases to be injected in cryogenic surroundings. It is based on a hollow metal structure with interior baffles which at cryogenic temperatures like presently 4 Kelvin act as a cryopump and prevent gas from flowing through, as depicted in figure 1. A resistive heating element is used to temporarily warm up the source to a well-defined temperature where adsorption to the inner surfaces is small enough for gas to flow through and in the present case enter an ionization chamber where the gas atoms are charge-bred in an electron beam to form highly charged ions [1].

We have performed simulations of the gas flow through the cold source as a function of temperature using the Molflow+ simulation software [2]. It allows to trace particle trajectories through a user-defined geometry when the gas pressure is in the molecular flow regime where only particle-wall interactions like adsorption and desorption are relevant. These processes depend on both the gas and wall temperatures as well as on the type of gas and wall material and have been taken into account appropriately [3]. Additionally, the subsequent charge breeding process by

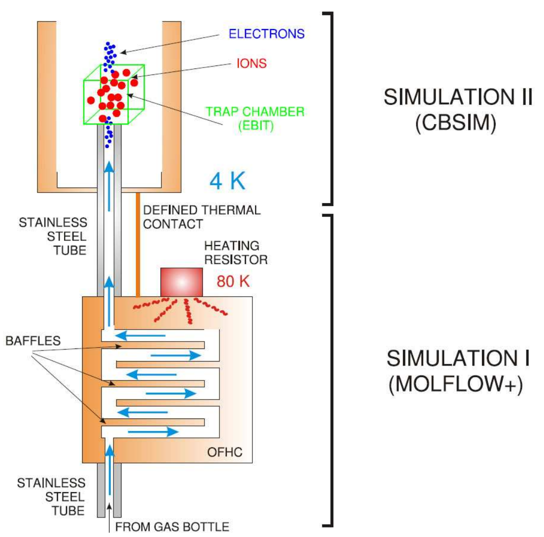

Figure 1: Schematic view of the cold gas source (bottom) and the attached ionization chamber (top) where the gas atoms are ionized by electron impact ionization. The structure shown is a few cm high.

electron impact ionization of the injected gas atoms by an attached mini-EBIS (miniature electron beam ion source) has been simulated by use of the CBSIM simulation software [4], see figure 2. The aim of the present study was to find the proper working parameters for an efficient production process of defined amounts of order 10^5 Ar^{13+} ions, which are going to be used in laser spectroscopy studies in the framework of the HITRAP project. We have found that a structure as depicted in figure 1 needs to be heated to about 200 K before gas output becomes significant enough for our subsequent electron impact ionization. The optimum electron beam energy has been found to be 1855 eV, about 2.7 times the ionization potential for Ar^{13+}.

This type of cold source attached to an EBIS-like ionizer will be installed in a 4-K-cryostat inserted into the warm bore of a superconducting magnet and will deliver highly charged ions for our Penning trap experiment [5].

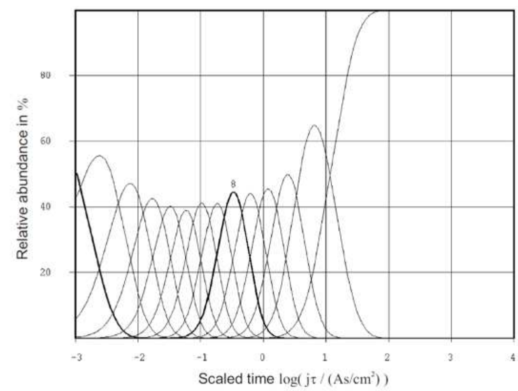

Figure 2: Example of a simulation result for optimal charge breeding of Ar^{13+} under the present experimental conditions.

Tests of the cold source will be undertaken soon using an offline cryocooler. Charge breeding tests will be performed during the upcoming year.

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