Virtual National Laboratory for Heavy Ion Fusion

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HIF News

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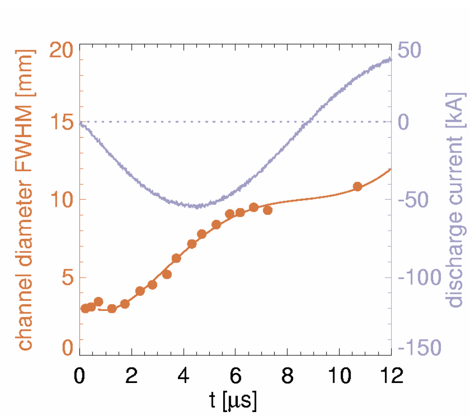
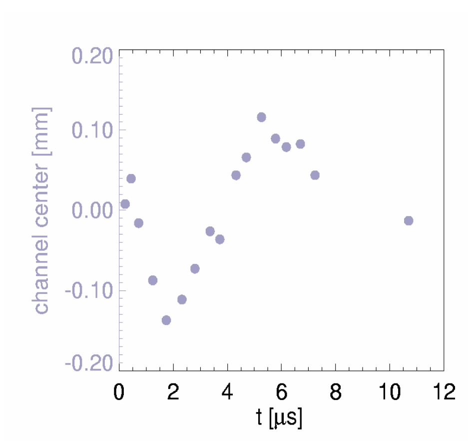
Beam initiated transport channels at GSI

Final ion-beam transport in a power-plant chamber with discharge channels has been studied at LBNL and GSI for a number of years. For an alternative chamber concept using dry walls, this is considered the leading transport technique. Most of the crucial problems of this concept have been resolved in previous proof-of-principle experiments. Two remaining problems are hydro-stability and sufficiently small channel diameters. In a recent experimental run at the GSI UNILAC accelerator, both stability and diameter were significantly improved by increasing the discharge current to 55 kA and changing the discharge gas to pure argon. Instead of laser initiation the UNILAC ion beam itself initiated the discharge. Ion beam currents as low as 50 μA of a Ni beam at 11.4 MeV/nucleon were sufficient to reproducibly initiate stable discharges of 50 cm length. Hydro-instabilities of the channel typically led to less than ± 150 μm movement of the channel axis, over a 10 μs period. (Stability over 0.1-0.2 μs is sufficient.) The channel diameter expanded from an initial 3 mm to 10 mm after 10 μs, while channels with laser initiated discharges in ammonia had expanded from 8 to 40 mm for the same discharge current. These preliminary results of ion-beam-initiated-transport channels increase the attractiveness of the concept because of the improved channel properties, the flexibility in choosing the chamber fill gas, and the simple discharge initiation mechanism by a low intensity ion bunch. – *A. Tauschwitz and C. Niemann*

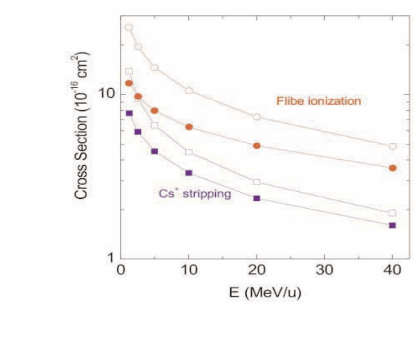




Cs^+ Stripping Cross Sections Computed

Heavy ion beams reach the target at energies of 10-40 MeV/nucleon. The ion beam has a low charge state to minimize space charge forces in the accelerator and the reaction chamber. To model transport in the chamber, it is necessary to know the beam charge state evolution, as it penetrates 3-5 meters of Flibe vapor (mostly BeF_2, traces of LiF), having a typical density of $5 \times 10^{13}/cm^3$. This is determined from stripping cross sections for candidate ions such as Cs^+, Xe^+, and Bi^+. Also important to modelers are the Flibe ionization cross sections since the total electron production affects beam neutralization.

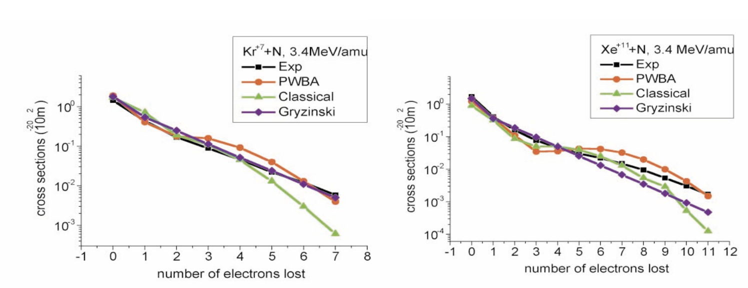
We have developed an n-body code that incorporates all Coulomb interactions between the ion and target. Our non-perturbative method yields multiple, as well as single, ionization cross sections. Results for Cs^+ stripping and Flibe target ionization are given in the Figure for 1 to 40 MeV/nucleon. The solid points are the sum of the single and multiple ionization cross sections, while the open symbols are the corresponding total electron production values. The difference between them indicates the importance of the multiple ionization processes.



Presently, there are no experimental data for low-charge-state heavy ions at energies of interest to the HIF program. However, in late summer a team being lead by Stoehlker at GSI and DuBois at UMR will make the first measurements at the Darmstadt accelerator. – *Ron Olson*

Multiple electron stripping measurements

Heavy-ion fusion science needs experimental atomic physics studies to complement theoretical studies. These will bench-mark the theory and enable determination of the rate at which the charge state of the incident



beam evolves while passing through the background gas. In particular, assessment of multi-electron-loss events, events in which a beam ion loses more than one electron in a single ionization event, is important. However, accelerators were designed primarily with Nuclear or High Energy Physics experiments in mind, and they rely on accelerating already highly stripped ions in order to achieve high energies economically, so no heavy ion beams of 10 to 20 Mev/amu with charge state 1 currently exist. As a currently feasible first step, we investigated the stripping of 3.4 Mev/amu Kr^{7+} and Xe^{11+} as reasonable compromises between high energy and low-charge state. The figures show the cross sections for electron loss from Kr and Xe in N_2 per one nitrogen atom. The average number of electrons lost per single collision is 1.87 for Kr and 1.97 for Xe. This indicates that multi-electron loss events can be important factors in the charge state evolution of the beam and these data provide benchmarking validation of modeling techniques. See our paper to be published in the May 2001 issue of Physics of Plasmas for a more complete discussion.

— *Dennis Mueller and Larry Grisham*

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