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Numerical simulations of purification and final charge state analysis of the slow ion beam for the FISIC project

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Synopsis The Fast Ion –Slow Ion Collisions (FISIC) project consists of a crossed-beam arrangement to study ion-ion collisions in the intermediate velocity regime. For the low energy channel, ion trajectory simulations has been used to develop a complete beam line that includes a new Omega type purification system located just before the collision point and a charge state analyzer after interaction.

Knowledge of fundamental electronic mechanisms at play in ion-ion collisions can provide a real breakthrough in the understanding of energy transfer in various plasmas such as inertial confinement fusion plasmas, stellar/interstellar plasmas and also in material damages.

The Fast Ion (MeV/u) - Slow Ion (keV/u) collisions (FISIC) project aims to measure absolute electronic cross sections in the intermediate velocity regime, a regime in which ion stopping power is maximum and where all the primary electronic processes (electron capture, loss and excitation) reach their optimum. So far, no experiments have been performed in this regime mainly due to experimental issues, like the requirement of very high ion beam intensities of good optical quality and a perfect charge state control of both ion beams. The forthcoming availability of GANIL/SPIRAL2 and FAIR/CRYRING facilities opens new opportunities to study such atomic collisions.

Here, we focus on the low-energy part of the FISIC project that is partially based on what has been designed for the study of ion-ion collisions in the low velocity regime by the Giessen group [1]. Based on ion trajectory simulations, we present i) a new Omega type purification system [2] to prevent pollution from electron-capture from the residual gas located just before the collision point, ii) a collision zone sets at high voltage to tag the signals coming from the true physical events of interest and iii) a charge state/energy electrostatic analyzer. The purification system (Figure 1) consists of four cylindrical deflectors with Matsuda plates generating a toroidal electric field. This “Omega” arrangement allows also to get the exit beam back on the initial beam axis. Using the SIMION software, numerical simulations have been done for different ion masses and charge states like C^{5+}, N^{6+}, O^{7+}, Ne^{9+} and Ar^{17+} with a 20 qkeV ion energy and a large emittance (60 π mm.mrad).

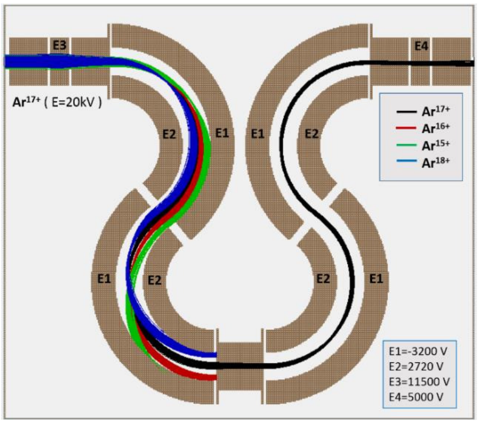

Figure 1. Ion trajectory simulations through the Omega purification system. The voltage values are chosen to drive 340 keV Ar^{17+} ions while the other charge states are blocked.

Results show that the resolving power of the collision zone at high voltage associated to the charge state analyzer after interaction should permit the separation of single electron capture and ionization processes for parent ion charge states q ≤ 17. For instance, in the case of incoming Ne^{9+} ion beam, the estimated degree of separation between the main beam and Ne^{10+} ions (produced via the single ionization of Ne^{9+}) is found to be around 14 σ (where σ is the standard deviation in the transverse direction).

References

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