Stopping and charge state revolution of low-energy ion beam in plasma

Y.Zhao*, †, 1, R.Cheng†, X.Zhou†, Y.Wang†, Y.Lei†, G. Xu*, J. Ren*, D.Hoffmann‡, , S.Savin§, R.Gavrilin§, A.Golubev§, Z. Hu¶, F. Gao¶, Y.N. Wang¶ and G.Xiao*

*School of Science, Xi'an Jiaotong University, Xi'an 710049, China
† Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China
‡ Technique University Darmstadt, Darmstadt 64289, Germany
§Institute of Theoretical and Experimental Physics, Moscow, Russia
¶Dalian University of Technology, Dalian, China

Synopsis We have studied the energy loss and charge state revolution of ions in plasma, the beam energy was ranging from 50-200keV/u. In future, the charge exchanging process of ion in plasma will be investigated.

Due to the strong non-linear effects and the special importance in ICF research, ion-beam and plasma interaction has attracted a lot of attentions, especially for ion-beam in low energy range and/or for plasma with high intensity. Herein we address the recent progress on the energy loss measurement in case of hundreds keV proton and helium beams passing a gas-discharging plasma target.

The experiments were carried out at the HV-ECR (High Voltage Electronic Cyclotron Resonance ion source) platform at IMP, where both proton and heavy ion beams with energy up to 320*q keV (q is the charge state of the ions) can be provided. After passing through the plasma target, the ion beam is analyzed by a bending magnet and reaches a fast-gated position-sensitive detector with minimum gate of 10ns (in experiments the gate was set as 100-1000ns to ensure sufficient statistics). The energy resolution of the setup is around 1%, depending on the beam size and the beam divergence (see details in references [1-3]).

Figure 1 shows the experimental result of the energy loss for 400keV helium beam penetrating the hydrogen gas-discharge plasma target (with initial gas pressure of 3mbar, and discharging high-Voltage of 3kV) in terms of time after discharging, the energy loss calculated with different models were shown as well. As we can see in the figure that, the measurements of energy loss in plasma were much lower that the theoretical predicts.

It was also found that, there were quite a few fraction of He^{1+} after the He^{2+} ion beam passing though the plasma, so that the effective charge state for the calculations should not take simply the nuclear charge 2. By fitting the date with effective charge state of 1.7, the Bethe the model will fit well with the experimental data.

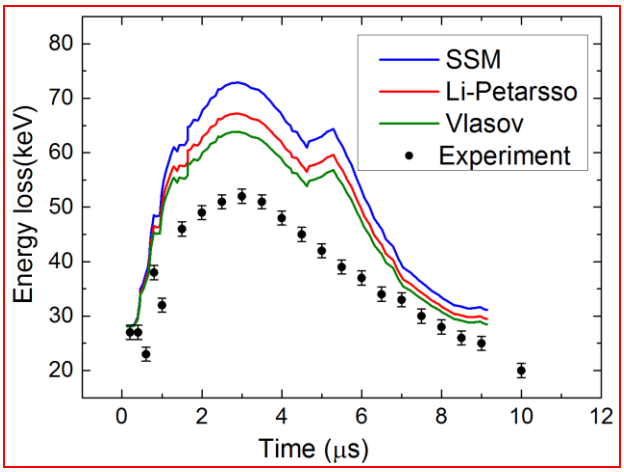

Figure 1. Energy loss for 400keV helium ion beam penetrating the hydrogen gas-discharge plasma target

In future, we plan to measure the charge state distribution for the ion beam after pass though the plasma, and study the equilibrium time and the equilibrium charge state by varying the plasma density in a lower density regime.

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References

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[1]E-mail: zhaoyt@impcas.ac.cn