Stopping power and energy loss for protons in Be plasmas

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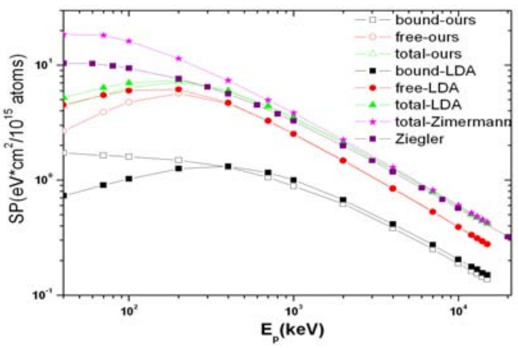
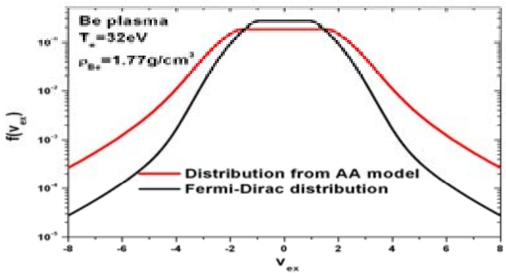
Stopping power (SP) for ions in plasmas is a basic and old problem, which data is important for heavy ion driven inertial fusion and heavy ion transport in hot matters. So far there are some relevant experiments and many theoretical researches. Last year [1] the energy loss of proton at projectile energy E_p = 15MeV was measured in cold and partially ionized Be materials at sold density with temperature T_e =32eV and length L= 532 μm. Energy loss was found a little higher than that in cold targets.

Ab initio calculation of SP is necessary for partially ionized plasmas. At 1998 Wang *et al* [2] made the first such work in Au plasmas by the local density approximation (LDA) based on average atom model (AA model) [3]. In the model the stopping power can be divided into two part the inelastic and plasma wave stopping although the inelastic part is not obtained by the calculation of inelastic processes. Sometimes at high E_p Bethe equation is used to get the inelastic contribution, where the average ionization energy <I> obtained by some phenomenal methods [4], as well as the plasma wave stopping, where <I> replaced by electron plasma frequency [5]. In recent year some improvements are made by us [6] for *ab initio* calculation of SP in plasmas where the inelastic processes are calculated in detail and velocity distribution for free electrons in plasmas is revised. In the present work our results are compared with the experimental data together with the other models. The above figure gives the SP as a function of E_p for proton in Be plasmas, where the words bound, free and total mean the contribution from inelastic and electron plasma wave and their total result, respectively.



Difference between ours and LDA fro plasma wave contribution at lower E_p is found mainly come from different velocity distribution of free electron at plasmas, which is shown in the following figure.



The following table presents the energy loss from experiment and different models. New experiments are suggested to test which one is better for LDA and our model.

Table I Energy loss ΔE (MeV) for E_p=15MeV, 1.77g/cc and L=532 μm

T_e	Expt	Simulation				
		Our	LDA		Zimermann	
		model	Ref.[1]	Ours	Ref.[1]	Ours
Cold	2.71 ~ 2.72	2.71	2.80	2.81		
32eV	2.85 ~ 2.98	2.87	2.85	2.89	2.90	2.94

Acknowledgement: Bin He acknowledges the useful discussions with Prof. Claude Deutsch. This work was supported by the Science and Technology Foundation of Chinese Academy of Engeering Physics under grant No. 2014B09036, the Chinese National Foundation of Sciences (Grants Nos. 111574034, U1530142, 11474031, and 11371218).

References

[1] A.B. Zylstra *et al. Phys. Rev. Lett.* **114** 215002
[2] P. Wang *et al.* 1998 *Phys. Plasmas* **5** 2977
[3] B. F. Rozsnayai 1972 *Phys. Rev. A*.**5** 1137
[4] G. Zimermann 1990 *LLNL* UCRL-JC-105616
[5] G. Maynard, C. Deutsch 1985 *J. Physique* **46** 1113
[6] B. He, J.G. Wang 2013 *Nucl.Fusion* **53** 093009