The influence of impurities on the ion temperature measured by a retarding field analyzer

Junren Shao¹, Hai Liu¹, Yuhong Xu¹, Jie Huang¹, Haifeng Liu¹, Xianqu Wang¹, Xin Zhang¹, Jun Cheng¹ and Changjian Tang¹,²

¹ Institute of Fusion Science, School of Physical Science and Technology, Southwest Jiaotong University, Chengdu 610031, China
² Physics Department, Sichuan University, Chengdu 610065, China
e-mail: Junren_Shao@my.swjtu.edu.cn

Abstract

In the magnetically confined plasma, the ion temperature \(T_i\) is one of the basic characteristic parameters. Hence, how to develop an effective method to measure the \(T_i\) is still an open issue for the plasma researches. The retarding field analyzer (RFA) is considered as one of the most effective tools to measure the ion temperature \(T_i\) in the plasma boundary [1]. However, there are some inaccuracies in the measured \(T_i\) by the RFA due to impurities in the plasma. Kǒcan and Gunn [2] have simulated the influence of impurities on the ion temperature measured by the RFA, and found that the simulated \(T_i\) is about 20% lower than real one due to the impact of impurities. However, in their simulation, only a single impurity has been considered. The effect of the charge and mass of diverse impurities on the \(T_i\) measurement has not yet been mentioned.

In this work, the influences of impurities on the \(T_i\) measured by RFA have been analyzed in hydrogen isotope plasmas with both low-Z and high-Z impurities [3]. The analytical results show that \(T_i\) is underestimated in \(H^+\) (also \(D^+\) and \(T^+\)) plasma when the fuel ion charge is taken as the charge number and the analyzed \(T_i\) in \(H^+\) plasma are all larger than that in \(D^+\) and \(T^+\) plasmas, exhibiting the isotope effect. With the increase of the concentration of low-Z impurity \((\eta_l = n_l/n_f\), \(n_l\) and \(n_f\) are the densities of the impurity ion and the main ion, respectively\), the analyzed \(T_i\) decreases and the \(T_i\) is about 20% underestimated with \(\eta_l\sim12\%\). Comparison of different charge numbers and masses of low-Z impurities shows that larger charge number and smaller mass of low-Z impurities lead to the analyzed \(T_i\) being more underestimated. The high-Z impurities impose almost no impact on the \(T_i\) because of their small current contribution. Moreover, experimental measurements of \(T_i\) by the RFA and edge rotational diagnostic (ERD) system [4] have been compared, which displays good agreement with the analytical results.

References