Influence of two-temperature effect on the ionization potential depression in hot dense plasma

Qingbo Luo[1], **Yong hou**[1 *], **Cheng Gao**[1], **and Jianmin Yuan**[1,2]

[1]College of Science, National University of Defense Technology, Changsha Hunan 410073, People's Republic of China;
[2]Institute of Atomic and Molecular Physics, Jilin University, Changchun Jilin 130012, People's Republic of China

The interaction between charged particles in hot dense plasma will cause ionic energy level shift and broadening, resulting in reduction of ionization potential, which alter the electronic structures and physical properties of hot dense plasma, such as opacity and equation of state. The experiment~(O. Ciricosta, et al. Nat. Commun. 7:11713)~on ionization potential depression (IPD) of solid-density Al plasma have indicated that present theoretical models cannot give reasonable desciption of the IPD in hot dense plasma, especially for highly charged ions where the discrepancy between experiment and theory is even greater. The reasonable theoretical methods are needed to describe the effects of dense environments on IPD, and the process of generating hot dense plasmas through the interaction between ultrashort laser pulse and solid-density matter also needs to be carefully considered. Here, the electronic structure is computed by the modified flexible atomic code~(FAC), which has included the correlations of free electrons and other ions by correlaiton functions from the hypernetted chain (HNC) approximation. A self-consistent-field method is used to calculate the electronic structures, and the temperatures for electron and ion in hot dense plasma are considered, seperately. Based on the calculations, the IPD is obtained through two-step model. Considering the interaction of the femeto-second laser on the solid-density Al plasma of Circosta's experiment, we use the two-temperature model to calculate the IPD with increasing the ionic temperature. The theoretical results are good agreement with the experimental results.

References

[1] O. Ciricosta, S.M. Vinko, B. Barbrel, et al., Measurements of continuum lower ing in solid-density plasmas created from elements and compounds, Nature communications 7, 11713 (2016)

[2] P. Zhang, Y. Jin, X. Zan, P. Liu, Y. Li, C. Gao, Y. Hou, J. Zeng, and J. Yuan, Enhancement of electron-impact ionization induced by warm dense environments, Physical Review E 104, 035204 (2021).

* E-mail: yonghou@nudt.edu.cn