Fully differential study of few-body dynamics in multi-electron atomic fragmentation processes

Y Gao[1], S F Zhang[12], M Schulz[3], X L Zhu[12], D L Guo[1], and X Ma[12*]

[1]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China
[2]University of Chinese Academy of Sciences, Beijing 100049
[3]Department of Physics and LAMOR, Missouri University of Science & Technology, Rolla, Missouri 65409, USA

Synopsis We performed a kinematically complete experiment on double ionization accompanied by single capture in 30 keV/u He^{2+} + Ar collisions. Fully differential cross sections of the 5-body processes were obtained for the first time. To a large extent the data can be reproduced by an independent electron model. However, a surprisingly strong correlation was observed between the electron momenta and the projectile momentum transfer.

A kinematiclly complete experiment on double ionization accompanied by single capture (DISC) in 30 keV/u He^{2+} + Ar collisions has been conducted on the reaction microscope at Lanzhou. The data were systematically analyzed using three different techniques, namely, fully differential cross sections (FDCS), the correlation function, and four-particle Dalitz (4-D) plots.

FDCS for two electrons ejected into the scattering plane, each with an energy of 10±5 eV are plotted as a function of the polar ejection angles (θ_{el}) in Figure 1 with the transverse momentum transfer fixed at 5±1 a.u. [2]. It should be noted that the area along the line $\theta_{el1}= \theta_{el2}$ is significantly suppressed by the multi-hit deadtime. The coarse structures are a nearly horizontal and a nearly vertical line of maximized intensity occurring near θ_{el}=0. To a large extent this result can be reproduced by an independent electron model.

In addition, the binary peak and the recoil peak (with their expected location indicated by black arrows in figure 1) are observed. This shows a strong correlations between each emitted electron momentum and the transverse momentum transfer. This is a surprising observation because after integration over the momentum transferred to the recoil ion (which is very large due to the capture step) and the other electron momentum one would expect any such correlation to be strongly weakened. At present, we cannot offer any explanation for this observation which call for rigorous theoretical treatment.

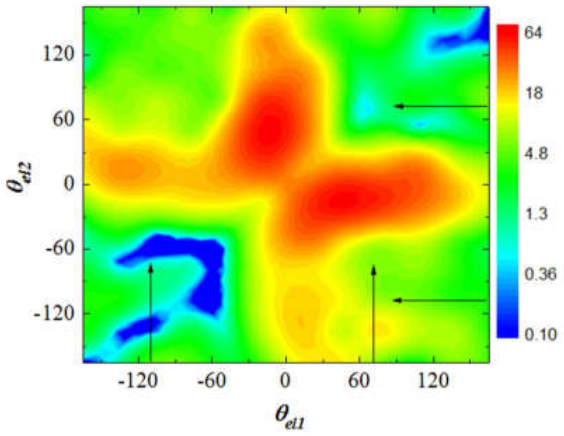

Figure 1. Fully differential cross sections as a function of the polar ejection angles of both electrons.

4-D plots of 4 particles in the final state [3] were also generated. It was found that the momentum exchange in DISC occurs predominantly between the nuclei of the collision system, both in the longitudinal and in the transverse directions.

Furthermore, electron-electron correlation effects were analyzed in terms of the correlation function. The correlation function reveals small but significant effects from correlations in the initial target state. These correlations are significantly more pronounced if events are selected in which the strength of the interaction between the nuclei of the collision partners is minimized.

References

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* E-mail: x.ma@impcas.ac.cn