

Ionization of Helium by neutronic impact

M.J. Ambrosio^{*1}, D.M. Mitnik^{*}, G. Gasaneo[†], and F.D. Colavecchia[°]

^{*} Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA), Buenos Aires, Argentina.

[†] Departamento de Física, Universidad Nacional del Sur and Consejo Nacional de Investigaciones Científicas y Técnicas, 8000 Bahía Blanca, Buenos Aires, Argentina.

[°] División Física Atómica, Molecular y Óptica, Centro Atómico Bariloche and Consejo Nacional de Investigaciones Científicas y Técnicas, 8400 S. C. de Bariloche, Río Negro, Argentina.

Synopsis We present fully differentiated cross sections for the Helium double ionization by neutronic impact. From our theoretical results we observe the underlying mechanisms that lead to the breakup of the target.

The ionization of two-electron atoms has been studied in numerous publications, both from chiefly theoretical and experimental standpoints. See Ref. [1] for a very complete review. In particular, a significant ammount of discussion revolved around the issue of the First Born Approximation validity even when fast projectiles. In the case of neutronic projectiles, the extremely short range of the projectile-target interaction makes additional Born orders completely irrelevant.

However, attempting to ionize an atom by quickly removing the core is not very efficient way, because the comparatively low electron mass allows them to react and follow their parent core. Large ammounts of momentum transfer are needed to accelerate the core to a velocity such that results in the electrons detachment [2].

In this contribution we wanted to delve into the ionization mechanisms present; this information can be extracted from a fully differentiated cross section. The interaction between the nucleus and the neutron is considered deltiform in the their relative vector \mathbf{r}_n : $V_{PT} = g\delta(\mathbf{r}_n)$ [2]. The resulting equation, which rules the behaviour of the target electrons is, within the First Born regime, as follows [2, 3]:

$$[E_a - h_{He}] \Phi_{sc}^+(\mathbf{r}_2, \mathbf{r}_3) = \frac{g}{(2\pi)^3} \left(e^{-i\mathbf{q}\cdot\mathbf{r}_2/(m_\alpha+1)} + e^{-i\mathbf{q}\cdot\mathbf{r}_3/(m_\alpha+2)} \right) \Phi_i(\mathbf{r}_2, \mathbf{r}_3), \quad (1)$$

and we solved with the Generalize Sturmian Functions method [4]. There factor m_α is the mass of the Helium core in atomic units.

Two main structures (and their symmetric counterparts) can be observed in Fig. 1. One corresponds to a binary emission, implying that one electron collides with the other one, sending them in directions nearly orthogonal. These, however, are afterwards widened by the interelec-

tronic repulsion.

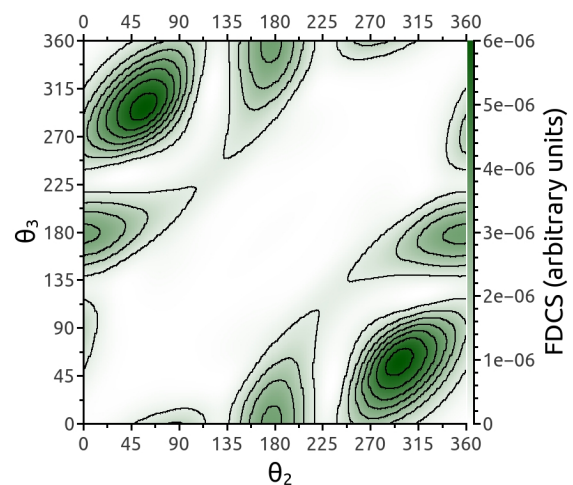


Figure 1. Fully differential cross section for the Helium double ionization by — eV neutrons. Momentum transfer $q = 9000$ a.u. and $E_2 = E_3 = 50$ eV. The neutrons carry an incident energy of 150 keV and get deflected at 178° .

The other type of structure in Fig. 1 implies a back-to-back emission. The core is suddenly removed from between the electrons, and their repulsion gains the most relevance. However, this emission type is important only when one of the electrons is pulled towards the same direction as the momentum transfer vector, i.e., one electron is partially dragged by the ejected core, while the other is emitted in the opposite direction.

References

- [1] J. Berakdar *et al* 2003 *Phys. Rep.* **374** 91-164
- [2] J Berakdar 2002 *J. Phys. B* **35** L31
- [3] M.J. Ambrosio *et al* 2015 *J. Phys. B* **48** 055204
- [4] G. Gasaneo *et al* 2013 *Adv. Quant. Chem.* **67** 153-216

¹E-mail: mja1984@gmail.com

