

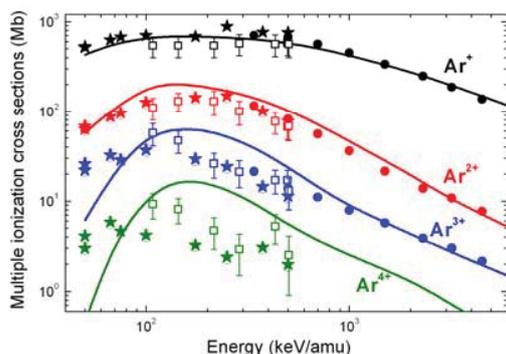
## Multiple ionization of Ar by alpha particles

C. C. Montanari\* <sup>1</sup>, J. E. Miraglia\* <sup>2</sup>

\* Instituto de Astronomía y Física del Espacio, Consejo Nacional de Investigaciones Científicas y Técnicas, Universidad de Buenos Aires, Ciudad Universitaria, C1428EGA, Buenos Aires, Argentina

**Synopsis** We present theoretical results on multiple ionization of Ar by He<sup>2+</sup> by employing the continuum distorted-wave eikonal initial state together with photoionization branching ratios to include Auger-type contributions. We also analyze the inner-shell ionization cross sections (K and L-shells of Ar). The high energy experimental data is correctly described, showing differences with proton impact tendency in the post-collisional region. At intermediate impact energies (direct ionization region) the single and double ionization are described rather well, but we note certain overestimation for higher final charge states.

We present new results for single to quadruple ionization cross sections of Ar bombarded by He<sup>2+</sup> ions in the intermediate and high energy range. Different experimental measurements involve the He-Ar system, i.e [1-2]. Also of interest are the very recent measurements on multiple ionization of Ar by Li<sup>+2</sup> ions by the Rio de Janeiro group [3]. Our goal is to analyze the +2 charge projectiles in view of previous double ionization results by proton impact, which show an overestimation at high energies (post-collisional region). Our results are compared with the experimental data available considering only pure multiple-ionization cross sections (no capture contribution). Ionization cross sections of specific deep shells (L and M) are also evaluated, in order to test the values that contribute to the post-collisional ionization (PCI) via Auger processes.

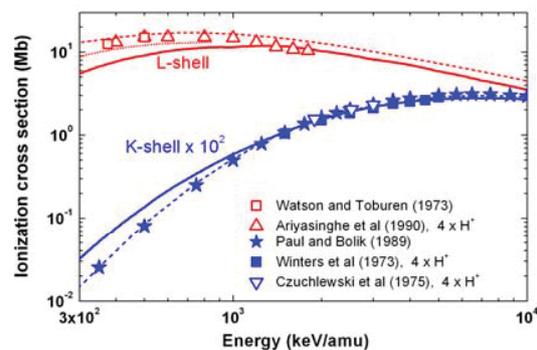


**Figure 1.** Multiple ionization of Ar by He<sup>2+</sup>. Symbols: filled stars [1], filled circles [2], hollow squares [3] for Li<sup>+2</sup> on Ar.

The comparison with the highly-charged ion production data requires the calculation of total ionization cross sections (direct plus PCI). We follow previous works [4] by employing the CDW-EIS [5], and including the PCI through

the experimental branching ratios of single to multiple vacancy production.

In figure 1 we display single to quadruple ionization cross sections, together with the experimental data available. Only pure multiple-ionization cross sections are considered (no capture contribution). We also analyze the ionization of specific deep shells of Ar (K and L). In figure 2 we display these results and compare with the ECPSSR predictions [6] obtained with the ISICS11 code by Cipolla [7], and with the coupled-state results for L-shell ionization by Martir *et al* [8].



**Figure 2.** K and L-shell ionization cross sections of Ar by He<sup>2+</sup>. Present results (solid lines), ECPSSR values [6-7] (dashed-lines), coupled state calculations by Martir *et al* [8] (dotted line). Details of the symbols in the inset.

### References

- [1] DuBois R D 1987, Phys. Rev A **36**, 2585
- [2] Andersen *et al* 1987, Phys. Rev A **36**, 3612
- [3] Losqui *et al* 2014, J. Phys. B **47** 045247
- [4] Montanari C C *et al* 2012, J. Phys. Conf. Ser. **388** 012036
- [5] Fainstein P D *et al* 1988, J. Phys. B **21** 287
- [6] Lapicki G 2002, Nucl. Instrum. and Meth. B **189** 8
- [7] Cipolla S J 2013, Comp. Phys. Comm **184** 2230.
- [8] Martir M H *et al* 1982, J. Phys. B **15** 2405

<sup>1</sup>E-mail: [mclaudia@iafe.uba.ar](mailto:mclaudia@iafe.uba.ar)

<sup>2</sup>E-mail: [miraglia@iafe.uba.ar](mailto:miraglia@iafe.uba.ar)

