Two-body description for the radiative capture reaction ^{6}Li$(p, \gamma)^7$Be

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The ^{6}Li abundance measured in the atmosphere of metal-poor stars is three orders of magnitude larger than predicted by the theory of Standard Big Bang Nucleosythesis (SBBN) predictions [1]. Even if the results of the astronomical measurements are still under debate [2]–[4], the knowledge of the cross section (or astrophysical S-factor) of the reactions that contribute to determine the ^{6}Li abundance is fundamental in order to distinguish between different explanations. Among these reactions, the radiative capture ^{6}Li$(p, \gamma)^7$Be plays an important role.

Although this reaction was extensively studied experimentally [5]–[8], very large uncertainties in the S-factor in the BBN energies (50-400 keV) are still present. A recent work [9] pointed out the presence of a possible resonance in the BBN energy window, that reduces the S-factor at zero energy. In order to solve this puzzle, a new campaign of measurement was performed by the LUNA collaboration.

From the theoretical side many studies were performed using different approaches and inputs, like a two-body a phenomenological potential [10], an optical potential [11], a cluster model [12] and the Gamow shell model [13]. In this work, we try to improve the model used in Ref. [10]. We treat the problem as a two-body problem, using phenomenological potentials to predict the S-factor. We fit the parameters of our potentials in order to reproduce the elastic scattering data of ^{6}Li$(p, p)^6$Li and the bound states properties of the ^{7}Be. Solving the two-body Schrödinger equation, we evaluate the wave functions for the scattering and the bound states, which we use to predict the S-factor of the radiative capture reaction. The calculated S-factor can reproduce the energy behavior, but in order to agree with the experimental data we need to multiply the results by a spectroscopic factor. This is not surprisingly, since in this simple study we have neglected the internal structure of both ^{6}Li and ^{7}Be. The final results are in nice agreement with the available experimental data at stellar energies.

References

[1] M. Asplund *et al.*, Astrophys. J. **644**, 229 (2006).

[2] R. Cayrel *et al.*, Astron. Astrophys. **473**, L37 (2007).

[3] A. E. García Peréz *et al.*, Astron. Astrophys. **504**, 213 (2009).

[4] K. Lind *et al.*, Astron. Astrophys. **554**, A96 (2013).

[5] S. Bashkin and R. R. Carlson, Phys. Rev. Lett. **97**, 5 (1995).

[6] Z. E. Switkowski *et al.*, Nucl. Phys. A **331**, 50 (1979).

[7] F. E. Cecil *et al.*, Nucl. Phys. A **539**, 75 (1992).

[8] R. M. Prior *et al.*, Phys. Rev. C **70**, 055801 (2004).

[9] J.J. He *et al.*, Phys. Lett. B **725**, 287 (2013).

[10] S. B. Dubovichenko *et al.*, Phys. Atom. Nucl. **74**, 1013 (2011).

[11] F. C. Barker, Aust. J. Phys. **33**, 159 (1980).

[12] K. Arai, D. Baye, and P. Descouvemont, Nucl. Phys. A **699**, 963 (2002).

[13] G. X. Dong *et al.*, J. Phys. G: Nucl. Part. Phys. **44**, 045201 (2017).