Measurement of Proton Induced Reactions on Lithium at Ultra Low Energies*

Sreelakshmi T[1], R. Dubey[1], Gokul Das H[1], K. Czerski[1], M. Kaczmarski[1], A. Kowalska[2], N. Targosz–Ślęczka[1], and M. Valat[1]
[1] *Institute of Physics, University of Szczecin, 70-451 Szczecin, Poland and*
[2] *Institute of Mathematics, Physics and Chemistry, Maritime University of Szczecin, Poland*

Nuclear processes occurring at extremely low energies, characteristic of the interiors of stars, are essential for understanding stellar development and the sources of elemental distributions in the universe. In particular, reactions involving lithium isotopes are important, as they help address unresolved questions, such as the mechanisms behind the nucleosynthesis of the Big Bang and the persistent lithium depletion observed in the low-metallic stars [1]. The cross sections of reactions such as ^{6}Li(p,α)^{3}He and ^{7}Li(p,α)^{4}He were already studied before [2,3]. However, accurate measurements of cross sections, branching ratios, and astrophysical S-factors are not available for energies below 20 keV, the energy range most relevant to stellar environments. At such low energies, one of the major challenges is understanding the effect of electron screening, which strongly enhances fusion cross sections at lower projectile energies [4]. This enhancement is especially noticeable in metallic targets and is influenced by local electron density and microstructure properties, including oxidation and lattice defects [5].

Experiments have been conducted using a magnesium-lithium alloy target (Mg-55% Li-45%) at the Ultra High Vacuum (UHV) accelerator facility of the University of Szczecin. Thick target yields and the branching ratio of both reactions have been measured with a proton beam up to 1 mA current for energies ranging between 13 and 26 keV. An extremely high screening energy of about 3.9 $\pm$ 0.6 keV could be determined. To verify this result, we have also measured the ^{2}H(d,p)^{3}H reaction in the same MgLi environment and observed a screening energy of approximately 0.8 $\pm$ 0.2 keV, which is in good agreement with the predicted dependence on the atomic number, $Z_{\mathrm{Li}} : Z_{\mathrm{H}} = 3 : 1$.

Compared with previous measurements conducted with the UHV facility using various metallic targets, the MgLi alloy exhibits the highest observed electron screening energy. This result suggests that lattice defects play a significant role in modifying the electronic band structure and the effective electron mass. Furthermore, it indicates that MgLi is a promising candidate material for studying light ion low-energy fusion reactions in fundamental and applied research.

[1] C. Rolfs and W.S. Rodney, *Cauldrons in the Cosmos*, University of Chicago Press (1989).
[2] J. Cruz et al., *J. Phys. G: Nucl. Part. Phys.* **35**, 014004 (2008).
[3] A. Cvetinovic et al., *Phys. Lett. B* **838**, 137684 (2023).
[4] K. Czerski et al., *Europhys. Lett.* **54**, 449 (2001).
[5] A. Kowalska et al., *Materials* **16**, 6255 (2023).

*This project has received partial funding from the Energy Group of the Anthropocene Institute.