Breakup Threshold Anomaly Analysis of Weakly Bound Systems ^{6,7}Li + ^{28}Si Near Coulomb Barrier Energies

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Scattering of the target nuclei with the projectiles helps to probe the nucleus and understand the nuclear properties in the most significant way. The effective nuclear interactions have been widely studied using many different approaches. One of the best ways to reduce the many-body nuclear interactions into a one-body problem is by using the Optical Model (OM) analysis. In this paper the nuclear potential generated from the versatile Ginnochio Potential is used.At higher energies the depth of the potential remains the same.At the coulomb barrier energies the weakly bound systems show a distinct behavior where the real part of the potential shows a "valley," and the imaginary part shows a "sharp increase". This is due to the coupling of the elastic channels with the breakup channels, and this phenomenon is known as Breakup Threshold Anomaly (BTA). In this work, we studied the energy dependence of weakly bound systems at various energies and BTA is investigated for both the weakly bound systems $Li^{6,7}$ on the light mass target Si^{28}. The Ginnochio potential offers significant advantages over traditional models like the Woods-Saxon (WS) potential by incorporating smooth real and imaginary parts, which handle surface behavior and energy dependence without needing additional terms like the Dynamic Polarization Potential (DPP). This makes it particularly useful for weakly bound systems such as ^{6,7}Li, where phenomena like the Breakup Threshold Anomaly (BTA) occur.

Methodology: The energy dependence of weakly bound systems was studied by fitting elastic scattering data using the Ginnochio potential. Key parameters like V_B, V_{BW} and W_0 were employed to model the energy-dependent real and imaginary parts, allowing for accurate analysis across various energy levels, as demonstrated in previous studies on ^{6,7}Li [1, 2]. The analytic junction shown in the FIG. 1 represents the smooth transition between the surface and volume regions of the real potential, a key feature of the Ginnochio potential which enables a precise fit to experimental elastic scattering data.

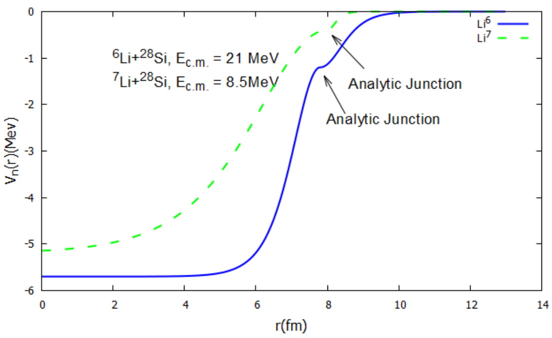

FIG. 1: Real part $V_n(r)$ of the nuclear potential for ^{6}Li + ^{28}Si at $E_{c.m.} = 21$ MeV and ^{7}Li + ^{28}Si at $E_{c.m.} = 8.5$ MeV.

Physical Implications of BTA: The Breakup Threshold Anomaly (BTA) plays an important role in the scattering dynamics of weakly bound systems near Coulomb barrier energies. In FIG. 3 the sharp rise in the imaginary potential and the 'valley' in the real potential indicate the flux redistribution from elastic to inelastic channels, impacting scattering cross-sections by weakening the binding energy. This is particularly significant for nuclear structure in systems undergoing nucleosynthesis or fusion reactions in astrophysical environments. The coupling of elastic and breakup channels alters the potential landscape, offering insights into reaction pathways under extreme conditions, such as in stars or supernovae[4, 5].

Results: In FIG.2 the elastic scattering an-

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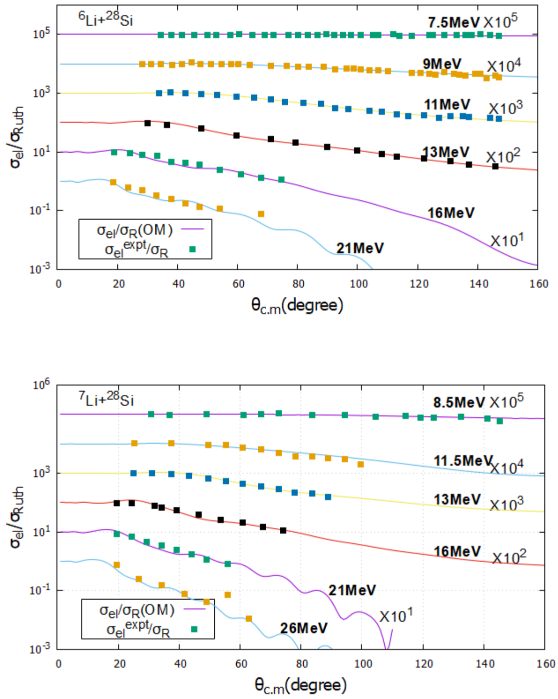

FIG. 2: Elastic scattering angular distributions for the ^{6,7}Li + ^{28}Si system at different center-of-mass energies. Data obtained from Ref [6].

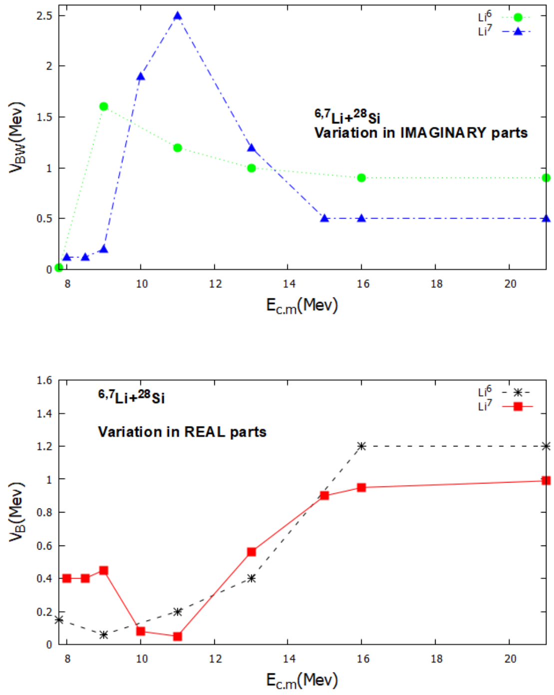

FIG. 3: Variation in the real(V_B) and imaginary (V_{BW}) parts of the interaction potential for ^{6,7}Li + ^{28}Si as a function of center-of-mass energy.

gular distributions for the ^{6,7}Li + ^{28}Si systems at various center-of-mass energies, fitted using the Ginnochio potential.Both the ^{6,7}Li isotopes in FIG.3 shows an imaginary potential V_{BW} peaks around $E_{C.M}$=10–11MeV, with a stronger peak for ^{6}Li.Beyond this V_{BW} decreases and stabilizes near 0.5 MeV at higher energies.The real potential exhibits a valley around 10 MeV before rising, peaking near 16 MeV.These features highlight the presence of the Breakup Threshold Anomaly (BTA) in the ^{6,7}Li + ^{28}Si system. These results have important implications for nuclear astrophysical studies, particularly for element formation in stars and supernovae, where weakly bound systems like lithium [4, 5] play a key role. Accurate modeling of breakup dynamics is vital for precise nucleosynthesis predictions.

Conclusion: This study highlights the importance of BTA in nuclear reactions with weakly bound systems near Coulomb barrier energies. Our findings, consistent with previous studies on ^{9}Be, ^{6}Li and ^{7}Li [1–3] and the BTA is successfully investigated in this Ginnochio potential like other nuclear potentials which provide deeper insights into breakup mechanisms and improve nuclear reaction models. Additionally, these findings are relevant for experiments with weakly bound radioactive ion beams, where accurate cross-section predictions are important for planning and interpreting results.

References

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