Cross sections for low mass nuclei using Glauber model

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Introduction

Many astrophysical processes rely on reactions involving unstable nuclei. Studying the properties, structure and reactions of such nuclei is crucial for understanding the processes like, nucleosynthesis and explosive events like supernovae. Glauber model [1] is a microscopic reaction theory used to describe high energy nuclear collisions. It is based on the eikonal approximation and focuses on independent nucleon-nucleon collisions. To calculate cross sections using the Glauber model information of nuclear structure of targets and projectiles is required. In the present work, ground state properties are calculated from the relativistic mean field model [2]. We have considered some light nuclei, namely Li, Be, B, C, and their stable and unstable isotopes. Our aim is to analyze the effect of nuclear densities obtained for the four parameter sets, SINPA, SINPB, DD-ME2 and DD-PC1 [3], on the reaction and differential cross sections.

Results and Discussion

The results of ground state properties, such as binding energies and charge radii of the considered nuclei are found in a good correspondence with the experimental values. Therefore, the nuclear densities are used into the Glauber model calculations to study the cross sections. In our present calculation, we study reaction and differential cross sections for different target-projectile combinations. We have considered the projectile nucleus as a core plus one valence nucleon [4].

Total reaction cross sections (σ_r) are presented in Fig. (1). The plots illustrate variation of σ_r with the mass number. We have considered the isotopes of Li, Be and B as projectiles at an incident energy of 800 MeV/nucleon and ^{12}C nucleus as target. For the considered parameter sets, the plots exhibit consistent behavior. The experimental values [5] are also seen to follow the same trend and lie close to the calculated values.

The elastic scattering angular distribution for ^{12}C+^{12}C is plotted in Fig. (2). At low incident energy and small scattering angles the differential cross section is more uniform as compared to the high incident energy and large scattering angles . High incident energies favour forward scattering and less probability of interaction is thus seen at larger scattering angles. The minima are also finely produced. Our calculated values align well with the experimental results for scattering of ^{12}C+^{12}C at 85 MeV/nucleon and 120 MeV/nucleon [6].

This study demonstrates that the four chosen parameter sets, despite their distinct theoretical frameworks, consistently show similar results for ground state properties as well as reaction and differential cross sections for light nuclei and their isotopes. Furthermore, similar outcomes for heavier target-projectile combinations are expected.

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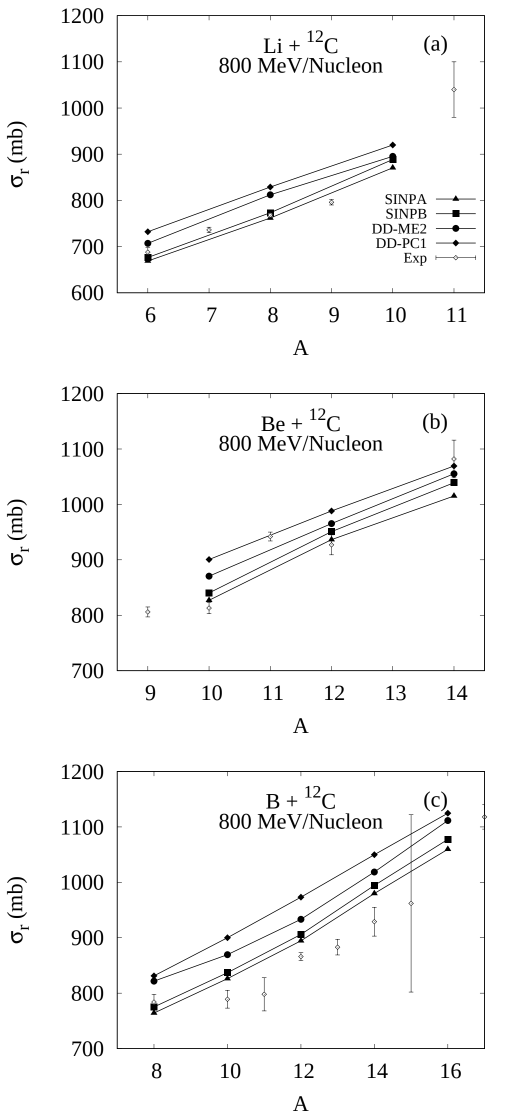

FIG. 1: Total reaction cross section, σ_r (mb) at 800 MeV/Nucleon for ^{12}C as target, (a) Li, (b) Be and (c) B isotopes as projectile.

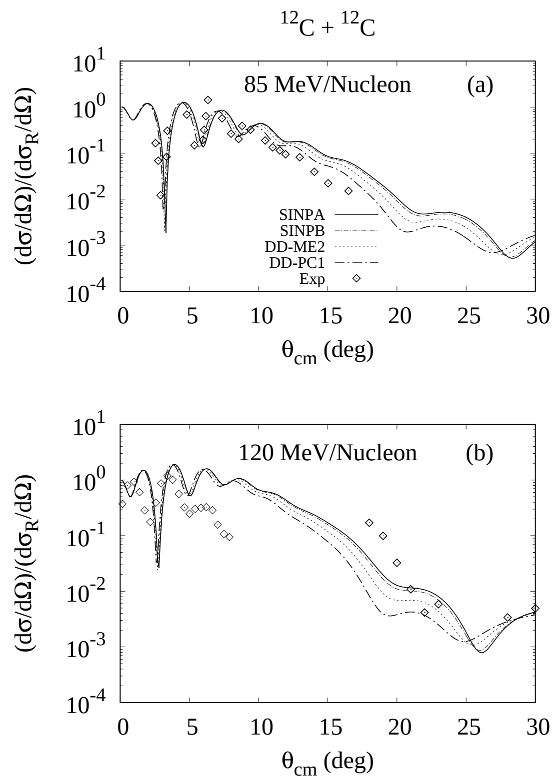

FIG. 2: Differential cross section is plotted against the scattering angle for ^{12}C + ^{12}C at incident energy (a) 85 MeV/nucleon and (b) 120 MeV/nucleon.

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