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Microscopic optical model potential for triton

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Abstract

Triton microscopic optical model potential is obtained by Green function method through nuclear matter approximation and local density approximation based on the Skyrme nucleon–nucleon effective interaction. The microscopic optical model potential is analyzed and used to calculate the reaction cross sections and elastic scattering angular distributions for some target nuclei in the mass range $6 \leqslant A \leqslant 232$. The theoretical results are in reasonable agreement with the available experimental data except some elastic scattering angular distributions for backward angle.

Keywords: Microscopic optical model potential; Triton reaction cross section; Triton elastic scattering angular distribution

1. Introduction

Optical model is one of the most important theoretical models in nuclear reaction theory. It is the basis and starting point of nuclear reaction calculations, which can calculate total, nonelastic, elastic scattering cross sections and elastic scattering angular distribution, and plays an essential role in the description of inelastic scattering process, transfer reaction and compound nucleus reaction. Since the microscopic optical potential (MOP) is generated theoretically based on the nucleon–nucleon (NN) interaction and does not need to adjust parameters to fit the available experimental data like the phenomenological optical model potential does, it has great significance

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in nuclear reaction physics, especially in the study of the colliding systems for which the elastic scattering measurement is absent or difficult, such as in the case of unstable nuclei. There are two approaches to get the MOP. One is based on the realistic nuclear force [1–3], but up to now, we have not found that a MOP based on the realistic nuclear force can give good agreement between the calculation and experimental data in a wide energy and nucleus region without the help of free normalization factors which are added to the real and imaginary parts of the MOP to improve the agreement. These normalization factors make the MOP less reliable for the unstable nucleus reaction calculation. The other one is based on the effective nuclear force [4,5]. Although the realistic nuclear force MOP has better theoretical basis compared with the effective nuclear force MOP, the effective nuclear force MOP can reproduce experimental data well without the normalization factors after a certain of effective nuclear force is selected.

Triton is one of the lightest nuclei, which is easy to be emitted from various nuclear reactions. Therefore, triton optical potential is important for not only the calculation of triton-induced reactions but also the analysis of some other reactions in which triton is produced. However, since triton is an unstable nucleus, there are very few triton scattering experimental data which can be used to determine the triton phenomenological optical potential parameters. Li et al. [6] and Pang et al. [7] obtained two global phenomenological optical model potentials for triton, respectively. However, they did not investigate the triton reaction cross section which is sensitive to the imaginary part of the optical potential. The optical potential given by Li et al. is only applicable as the incident energy below 40 MeV, and both global phenomenological optical potentials cannot describe the elastic scattering angular distribution for backward angles well.

Folding model and double-folding model are often used to generate optical potentials for composite particles from nucleon optical potential and NN interaction. There are some optical potentials [8–14] for deuteron, ^{3}He and ^{4}He constructed by folding model and double-folding model, but all of them include some free parameters. In our previous work [5,15–18], we have obtained the MOPs for nucleon, deuteron, ^{3}He and ^{4}He which have no free parameters. However, there is no available MOP for triton until now. The purpose of this paper is to obtain a MOP for triton based on Skyrme NN effective interaction.

The MOPs for nucleon [5], deuteron [15], ^{3}He [16] and ^{4}He [17] are obtained by the Green function method. For nucleon, since the optical potential is identified with the mass operator of the one-particle Green function [19], the nucleon microscopic optical potential is obtained by calculating the mass operator through nuclear matter approximation and local density approximation based on some Skyrme NN effective interactions. The MOPs for deuteron, ^{3}He and ^{4}He are also obtained from the mass operator of Green function. It is shown that the theoretical results calculated by the MOPs for nucleon, deuteron, ^{3}He and ^{4}He are in reasonable agreement with the experimental data. Encouraged by these results, the Green function method is utilized to obtain the triton MOP in this paper. By this method, the triton MOP is obtained from the three-particle Green function based on Skyrme interaction, and the nuclear matter approximation and local density approximation are also used. The first-order mass operator of the three-particle Green function denotes the real part of the triton MOP, and the imaginary part of the second-order mass operator denotes the imaginary part potential. The triton MOP obtained is used to calculate the reaction cross sections and the elastic scattering angular distributions for the target nuclei from ^{6}Li to ^{232}Th, and the results are compared with experimental data.

This article is arranged as follows. In Section 2, the formulation of the triton MOP is presented. Section 3 gives the comparison and analysis of the calculated results and experimental data. Finally, Section 4 is a summary.