Study of ^{27}Al(p,d) ^{26}Al Reaction at 42 MeV

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Abstract

The continuum spectra (Double differential cross section) of the ^{27}Al(p,d) ^{26}Al reactions have been studied with 42 MeV protons for the 45^o, 60^o, 75^o and 90^o laboratory scattering angles. Theoretical calculations of the spectra have been developed based on the DWBA approach and an asymmetry Lorentzian function having energy dependent spreading width. The values of the calculated double differential cross sections are in good agreement with those of experimental ones.

***Keywords*:** Double differential cross section, (p,d), nuclear reactions, direct reaction model, DWBA analysis

1. Introduction

Authentic nuclear data are greatly utilized in various fields of nuclear science and application. Several analyzations, are therefore, necessary for authentication of nuclear data.

The present study, In continuation of analyzation of nuclear data, is focused on the (p,d) reaction on ^{27}Al using a beam at 42 MeV for the 45^o, 60^o, 75^o and 90^o laboratory scattering angles. Experimental double differential cross sections for the ^{27}Al(p,d)^{26}Al reactions have been analyzed by the theoretical calculated double differential cross sections in the direct reaction region.

For the theoretical investigation of the double differential cross section of the (p,d) reaction, the approach suggested by Lewis [1], which is based on the DWBA and an asymmetric Lorentzian form strength function has been adopted in this study. According to this model, the continuum spectra in the direct reaction scheme are given as a result of nuclear damping. From several studies on the direct reaction scheme, Matoba *et al* reached eventually to a conclusion to solve this problem [2, 3]. They assumed the continuum spectra as an incoherent sum of all shell contribution and in parallel with Lewis [1], adopted an asymmetric Lorentzian form for the response function in the DWBA-based cross sections calculation. This model has been successfully applied for the (p,d) reaction [4-10] and with a slight modification it has been then applied for the (n,d) reaction [11-13] and the model has demonstrated its reasonable ability. The present study is a follow up of these studies. In order to make it a global model over a wide range of scattering angles, a work [10] was done earlier for the same reaction and at the same energy, as considered in the present study, but at different Laboratory angles [25^o, 30^o, 35^o and 40^o]. The application of seniority scheme to the present model for odd target nucleus [i.e, ^{27}Al(p,d) ^{26}Al] makes this model more reliable.

2. Materials and Methods

2.1 Experimental

The results obtained from the study have been compared with these obtained by the experiment, which was performed at the TIARA facility of JAEA of Japan. A proton beam of 42 MeV from the AVF cyclotron was led to the HB-1 beam line. Energy distributions of light ions emitted from the target were measured using a ΔẼE counter telescope, which consisted of two thin silicon ΔẼdetectors and a CsI(T1) E-detector with photo-diode readout. Details of the experimental procedure and the results have been reported in ref. [14].

2.2 Theoretical Basis

Generally, the spectrum of the emitted particles from one nucleon transfer reaction can be divided into three parts, because the mechanism of this type of reaction are classified to three types, i.e. direct, pre-equilibrium and evaporation processes. Spectrum observed as the evaporation process results from three processes. These are absorption of the incident particle by the target nucleus, formation of a compound nucleus, and emission of nucleons or light particles from a highly excited state of the compound nucleus or fission of the compound nucleus. The direct reaction process is generated as a reaction occurring under low momentum transfer condition by interactions between the incident particle and surface nucleons in the target nucleus. Then the energy of the emitted particle is higher and the residual nucleus is in lower excitation energy. Between the evaporation and direct reaction regions, a rather flat spectrum is observed, known as the pre-equilibrium region, which results from multi-step, direct and/ or compound reactions. Principally these processes progress step by step under interactions between nucleon and nucleon within the nucleus.

In this method, the theoretical calculation of the double differential cross-sections has been done by considering a direct reaction model as an incoherent sum of the direct reaction components, which is based on the DWBA predictions and expressed as follows:

$$\frac{d^2\sigma}{d\Omega dE} = 2.30\sum_{l,j}\left[\frac{C^2 s_{l,j}(E)}{2j+1}\times\left(\left.\frac{d\sigma}{d\Omega}\right|_{l,j}^{DW}(E)\right)\right] \quad (1)$$

where $d\sigma/d\Omega|_{l,j}^{DW}(E)$ is the cross-section calculated by the

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