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(LNS Experiment: #2373, #2416)

Study on $^{24}\text{Mg}(e, e' \alpha)$ Reaction

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The angular correlation of $^{24}\text{Mg}(e, e' \alpha)$ reaction was measured for a momentum transfer of 0.51fm^{-1} and energy transfers of 15.5-24.5 MeV. Emitted particles were detected with nine ΔE - E telescopes located out of plane, rotated around the q axis by 90° . As about a half of approved machine time has been carried, we briefly report a current status of analysis.

§ 1. Introduction

This work mainly aimed to identify the isoscalar monopole strength observed through the $(e, e' \alpha_0)$ channel. The isoscalar giant monopole resonance (ISGMR) has been investigated with special interest because the central energy of the ISGMR is related to the compressibility of nuclear matter [1,2]. The ISGMR has been established in medium and heavy nuclei [3], and its strength distribution is known to form the Lorentzian shape, while, in light nuclei, some experiments using alpha scattering reported the considerable amount of isoscalar E0 strengths whose distributions fragmented over a wide range of excitation energy [4-6]. Concerning ^{24}Mg , the result from alpha inelastic scattering [4] provided a large amount of isoscalar E0 strength at the energy centroid of 21 MeV exhausting 72% of the energy weighted sum rule (EWSR).

On the other hand, a noticeable amount of E0 strengths were also found by the electron scattering coincident experiments [7,8]. Although, in general, a relatively small fraction of the transition strength can be observed by the $(e, e' x)$ experiment, it has such advantages that there is no background in principal, and the reaction is less dependent on assumptions, where the data analysis of the experiments with hadron probes is largely affected by choice of the optical potential parameters. Therefore the electron scattering experiments can be an alternative tool for searching the isoscalar E0 strength.

§ 2. Experiments

The experiment was performed using a continuous electron beam from STB at LNS at an incident energy of 200 MeV and an average current of ~ 400 nA. A $2\text{mg}/\text{cm}^2$ thick ^{24}Mg foil enriched to 99.92% was used as the target.

The momentum of scattered electrons was measured by the LDM magnetic spectrometer of a solid angle of 2.64 msr with a vertical drift chamber on the focal plane. Acceptance of 5% of the LDM allowed

to detect scattered electrons with 175-185 MeV, thus the energy transfer of 15-25 MeV. Three layers of plastic scintillators were placed after the VDC and used for the trigger. The position of the LDM was defined to be a scattering angle $\theta_e = 30^\circ$ corresponding to momentum transfer $q = 0.51 \text{ fm}^{-1}$.

Charged particles emitted by decay were detected with 9 particle telescopes in order to measure the angular correlation of α particles. Each of the telescopes consists of a $50 \mu\text{m}$ and a 1mm SSD such that ΔE - E can be measured. The telescopes were placed in a plane rotated by $\phi_\alpha = 90^\circ$ from the scattering plane. Angular distributions of emitted particles were measured at $\theta_\alpha = -18^\circ \sim 6^\circ$ and $54^\circ \sim 174^\circ$ in 12° step. The angle $(\theta_\alpha, \phi_\alpha)$ is defined with respect to the q axis. A typical ΔE - E spectrum is shown in Fig.1 for $\theta_\alpha = 6^\circ$. Calibration was done fitting the Bethe-Bloch curve to the data.

Since the energy loss of charged particles, especially alpha, through the target is not negligible, the target foil was tilted such that the effect on particles heading toward the telescopes is minimized. The energy loss in the target material ranged from ~ 300 to ~ 1000 keV by calculation. The energy loss was taken into account in analysis.

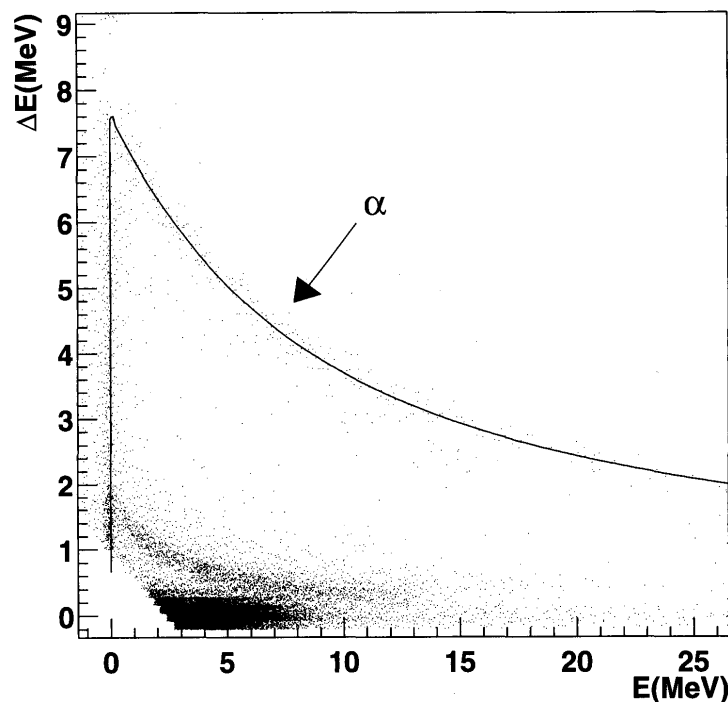


Fig.1. ΔE - E plot used for particle identification. The solid line shows theoretical values calculated by the Bethe-Bloch formula.

§ 3. Preliminary results

Since the data analysis is under way at the moment, brief results obtained so far, the excitation energy spectrum of the residual nucleus and the absolute cross section, are shown in this section.

The excitation energy of the residual nucleus is given by

$$E_x = \omega - E_\alpha - E_{\text{th}} - E_r$$

where ω is the energy transfer, E_α is the energy of the alpha particle detected coincidentally with scattered electrons, E_{th} is the threshold energy of ^{24}Mg nuclei for α emission, and E_r is the recoil energy

which is determined kinematically. Figure 2 shows the E_x spectrum for $\omega = 15-25$ MeV.

The energy resolution is enough to separate contributions from α_0 and α_1 , although that is worse than expected. Such worse resolution could be caused by energy straggling in the target, imprecise calibration of the SSD's, or noise from the SSD's or preamplifiers. Farther, a peak considered as of α_1 channel is located at ~ 1.2 MeV, despite the fact that the first level of ^{20}Ne is at 1.63 MeV. As for the discrepancy there are some possible sources in analysis procedure. However, it is still not clear at the present time.

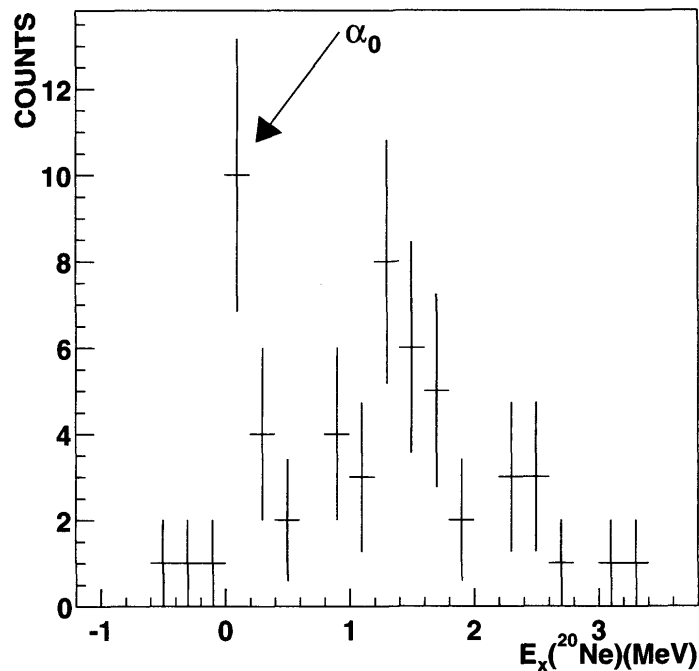


Fig.2. Excitation energy spectrum of the residual nucleus at $\theta_\alpha = 102^\circ$ and $\omega = 15-25$ MeV.

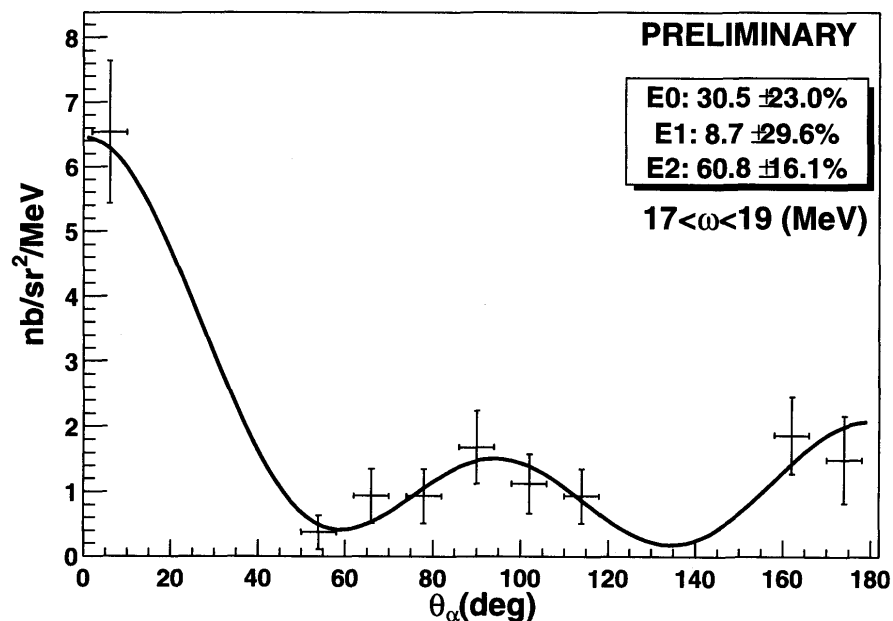


Fig.3. Angular distribution of the five fold differential cross section for α_0 , and $\omega = 17-19$ MeV. The solid line is the Eq.(2) fitted to the data.

Figure 3 displays angular distribution with statistical errors. The Legendre expansion of the five fold differential cross section can be simplified in our condition and consequently can be written as [9]

$$\frac{d^5\sigma}{d\omega d\Omega_e d\Omega_{\alpha'}} = \sigma_{\text{Mott}} \left| \sum_{L=0}^2 \sqrt{(2L+1)A_0(L)} C_L e^{i\delta_L} P_L(\cos\theta_{\alpha'}) \right|^2 \quad (2)$$

where σ_{Mott} is the Mott cross section, the L is the multipolarity, $A_0(L)$ are the decay coefficients, C_L are the longitudinal form factors, δ_L are the phase of the product between $A_0(L)$ and C_L . The equation (2) was fitted to the data leaving C_L and $A_0(0)$ as free parameters (solid line in Fig.3). As very preliminary result, E0, E1, and E2 components occupied 30.5%, 8.7%, and 60.8% of the cross section, but with large uncertainty.

§ 4. Plan

It is obvious that the statistics is quite poor for decomposition of the multipoles with satisfying precision; nevertheless approved machine time was not completed in the last period. Thus our group plans to collect more data with the left machine time, and hopefully with addition.

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