Deformation of ^{28}Si* produced via p on ^{27}Al

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Introduction

Deformation of an excited nucleus may be caused by different reasons. One of the reasons of excited state deformation is nuclear clustering. Angular momentum is another reason for deformation of nuclei in its excited state. Recently we have reported large deformation of ^{28}Si* produced through alpha-cluster entrance channel ^{16}O + ^{12}C [1]. There we showed that the deformation predicted by rotating liquid drop model [2] is not sufficient to reproduce the α-particle energy spectra predicted by statistical model calculation. We had to introduce extra deformation which may have its origin in multi-nucleon clustering. In the present work we have chosen a non-α cluster entrance channel p + ^{27}Al so that deformation due to clustering should not be present. At the same time the populated angular momentum shall also be very low. Therefore, the observation of any deformation in the present case would have a different origin. Here, we shall report preliminary result of the experiment.

Experiment

The experiment was performed at Variable Energy Cyclotron Centre (VECC), Kolkata, using proton beams at energies of 14 and 18 MeV, respectively. Self-supporting ^{27}Al of thickness ~0.267 mg/cm^2 was used as target. ~1mg/cm^2 ^{28}Si target is also used as target for the purpose of comparison. The α-particles were detected using two Si(SB) telescope (ΔE 10μm-E 500μm). Inclusive energy distributions for the alpha-particles have been measured at different laboratory angles. Typical centre of mass (c.m.) energy spectrum of α-particles obtained at $\theta_{lab} = 11^0$ is shown in Fig. 1 by solid lines. Laboratory spectra ($d^2\sigma/dEd\Omega_{lab}$) were converted to c.m. spectra by multiplying it with the ratio of velocity of the fragment in c.m to laboratory (v_{cm}/v_{lab}).

Results and discussion

There are many sharp peaks in the energy spectrum shown in Fig.1. A few of the these peaks at higher energy side have originated due to transfer reaction ^{27}Al (p,α) ^{24}Mg. As our main purpose is to study the deformation of the produced composite by light charged particle spectroscopy, we are interested in the alpha-particles emitted from an energy equilibrated composite. So in the present analysis we have excluded the transfer channel contributions (discrete peaks) as shown by solid circles

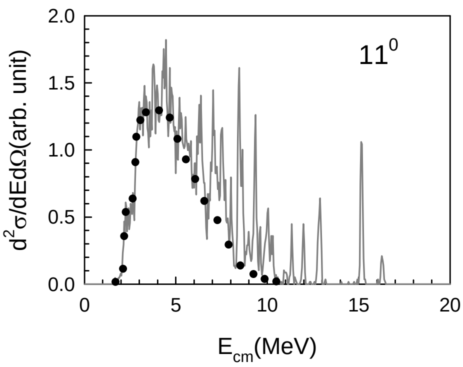

Fig. 1 Typical alpha-energy spectra obtained in the reaction p+^{27}Al at angle 11^0.

in Fig. 1. The differential cross section was extracted by just taking the area under the curve represented by the solid circles. To transform the scattering angle from laboratory to c.m. we assume two body kinematics averaged over total kinetic energy distribution excluding discrete peaks. Angular distribution of the differential cross section (c.m.) was plotted in Fig.2. Solid circles represent the experimental data. The systematic errors in the data, arising from the uncertainties in the measurements of solid angle, target thickness, and the calibration of current digitizer, have been estimated to be ~15%. Part of these uncertainties is due to procedure by which we exclude the peaks coming from transfer channel. These data was fitted with C/sin$\theta_{c.m.}$ where C is a constant. This fitted curve is represented by solid line in Fig. 2.

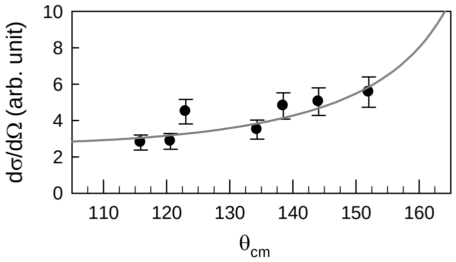

Fig.2 Angular distribution of α particles as a function of c.m. angles, θ_{cm}. See the text for details.

The agreement of the data with C/sin$\theta_{c.m.}$ corroborates the conjecture that the α-particles are emitted from a fully equilibrated composite.

Comparison with statistical model calculation

The c.m. energy spectra were compared with CASCADE [3] calculations and a typical comparison is shown in Fig. 3. For these calculations, critical angular momenta were taken as $1\hbar$ (Bass model) for 18 MeV proton on ^{27}Al. All the other parameters were taken from [3, 4] with RFACT=1. The solid line represents the results from CASCADE calculation with default radius parameter $r_0 = 1.29$, δ_1 and $\delta_2 = 0$. It is clear that slope of the calculated spectrum is higher than that of the experimental one. The low energy part of the experimental spectra has an abrupt falloff due the finite thickness of the ΔE detector. That may be the reason for mismatch of the lower energy data with the respective CASCADE prediction. The mismatch of the higher energy part may be due to the extra deformation of the composite from which alpha are emitted. The deformation affects the particle spectra in two ways. First, it lowers the effective emission barrier, and second, it increases the moment of inertia. The first effect modifies the transmission coefficients for the evaporated particles which may be taken care of by increasing the radius parameter of optical model potential. However, the change in moment of inertia affects the level density and the slope of the particle spectrum. This can be taken care of by incorporating the spin-dependent deformability parameters (δ_1 and δ_2).

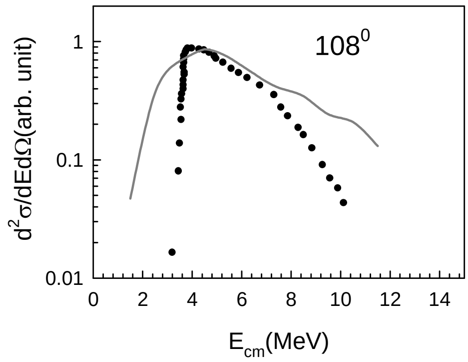

Fig. 3 Comparison of experimental spectra (solid circle) with the same obtained by statistical model calculation with RLDM deformation (solid line).

Conclusion

Angular distribution of the alpha-particle spectra shows that particles are emitted from an equilibrated source. CASCADE calculation is not able to reproduce the actual slope of the experimental spectra, which may be reproduced by introducing extra deformation as in case of ^{16}O + ^{12}C [1]. So it may be concluded that though the present system is not alpha-clustered and is also having very low angular momentum, still there is some deformation in the produced composite. Detailed analysis is in progress.

References

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