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2.15 Study of ^{12}B Polarization in ^{14}N-induced Reactions

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Systematic study of ejectile spin polarization in (^{14}N,^{12}B) reactions was continued and a part of recent results has already been published[1]. Here we would like to describe the recent progress in data analysis.

We paid an attention on the shift of zero crossover of the polarization as a function of target mass number A. In most cases experimental polarization as a function of reaction Q-value had two zero-crossovers. A zero crossover appeared in larger kinetic energy loss was referred to as the second zero crossing (SZC). The ^{12}B polarization around SZC for several targets are summarized in Fig.1. The SZC shifted towards large energy loss with increasing A. The reaction Q-values for SZC plotted against A are shown in Fig.2, which can be fitted with a straight line. This linear relation could be understood in the framework of classical friction model[2].

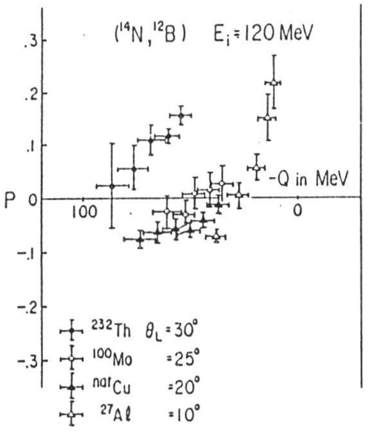


Fig.1 Superposed illustration of the experimental polarization for various target around SZC.

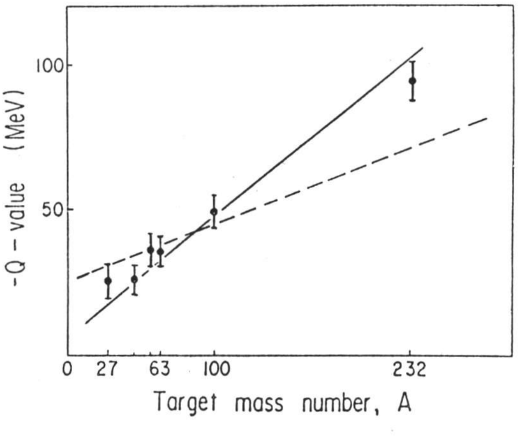


Fig.2 Experimental Q-values of SZC plotted against target mass number A. Dashed line is calculated by QLRT.

Provide that the frictional force f is proportional to the relative velocity v between the colliding nuclei as $f = k \cdot v$ with the averaged friction constant k[3], the kinetic energy loss E_{Loss} of the projectile-like fragment with negative angle deflection are written as a function of the interaction time τ as

$$E_{Loss} = E_{eff}[1 - \exp(2k\tau/\mu)], \qquad (1)$$

where μ is the reduced mass and E_{eff} is effective incident energy[3] which is the center-of mass incident energy E_{cm} measured from the top of the Coulomb barrier V_{ci} in the incoming channel. The interaction time τ can be extracted from rotation angle θ of double nuclear system DNS and its angular velocity ω. Since the ^{12}B ejected near the grazing angle was measured, the rotation angle θ can be taken to be roughly twice the grazing angle. The angular velocity ω is the total angular momentum J of DNS divided by its moment of inertia I. Then the interaction time is written as

$$\tau = \theta/\omega = V_{ci}R(2\mu/E_{cm})^{1/2}/(E_{cm} - V_{ci}). \qquad (2)$$

Taking the leading term of Eq. (1) and approximating the atomic number Z as Z = A/2, the energy loss resulting from the frictional force is expressed by,

$$E_{Loss} = k(A_1 + A_2)(A_1/E_i)^{1/2} \times 10^{22} \text{ (MeV)}. \qquad (3)$$

Here the subscripts 1 and 2 indicate the projectile and the target, respectively. The solid line drawn in Fig.2 is given from Eq.(3) applied on (^{14}N,^{12}B) reaction with $k = 1 \times 10^{-22}$ MeV·s/fm^2, and well reproduces the energy loss for SZC, −Q(SZC), plotted against the target mass number A. This fact suggests that SZC reflects the energy loss in the negative angle deflection.

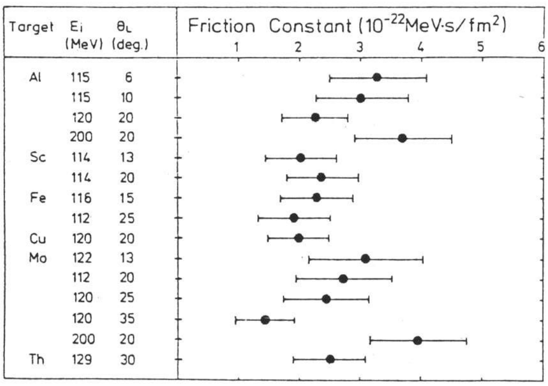
The constant k is calculated in the following expression derived from Eq. (1),

$$k = -(\mu/2\tau)\log[(E_{cm} - V_{cf} - E_{Loss})/(E_{cm} - V_{ci})]. \qquad (4)$$

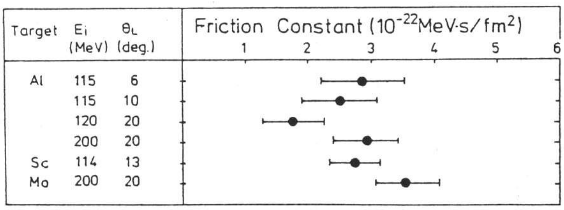
Here V_{cf} is Coulomb energy for the outgoing channel. To include the information of reaction angle explicitly, the expression for the rotation angle θ was modified as $\theta = (\theta_{gri}/2) + (\theta_{grf}/2) + \theta_{cm}$, where θ_{gri} and θ_{grf} are grazing angles for the incoming and the outgoing channels and θ_{cm} is the reaction angle in the center-of-mass frame.

Since the SZC is the kinetic energy where the production yield from the far side of the target nucleus and that from the near side are of the same strength, E_{Loss} is chosen to be the mean values of −Q(SZC) and −Q(V_{cf}) which is the Q-value corresponding to V_{cf}. Errors in E_{Loss} are set to be one energy window of −Q(SZC) in the measurement. The results are in good agreement with each other as shown in Fig.3(a) and the averaged friction constant is $(2.4\pm0.5)\times10^{-22}$ MeV·s/fm^2. The −Q-value for the largest negative polarization was supposed to be that for ^{12}B in most probable trajectory and was usually between −Q(SZC) and −Q(V_{cf}). The friction constant deduced using this Q-value as E_{Loss} was very close to the previous values as shown in Fig.3(b).

It should be noticed that k value thus derived by us agreed in the order of magnitude with that introduced by Schroeder et al.[3] in Xe+Bi reaction. Their value was 3×10^{-22} MeV·s/fm^2 and was extracted by applying a transport model on the atomic number distribution of projectile-like products. Note that quasi-linear response theory QLRT developed by Takigawa et al.[4] well reproduces the Q(SZC) as a function of A.



(a)



(b)

Fig.3 Experimental results of the friction constant. The values used for E_{Loss} are $-[Q(V_{cf}) + Q(SZC)]/2$ (left) and −Q for the largest negative polarization (up).

Reference

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