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1.26 The First Three 2^+ States of ^{34}S by the Inelastic Scattering of Polarized Protons at 65 MeV

N. Sakamoto, S. Matsuki*, T. Ohsawa*, H. Okamura* and T. Komatuzaki†

Department of Physics, Nara Women's University, Nara 630, Japan
* Institute for Chemical Research, Kyoto University, Kyoto 606, Japan
† Department of Education, Kyoto Pharmaceutical University, Kyoto 607, Japan

The sensitivity of inelastic hadron scattering to determine relative signs of neutron and proton transition multipole matrix elements, Mn and Mp, has been discussed by Bernstein et al.[1]. In particular, when its results are combined with those from electromagnetic (EM) measurements of mirror nuclei, we can determine the relative signs between Mn and Mp without ambiguity. Shell model calculations for s-d shell nuclei with the new empirical s-d shell effective interaction of Wildenthal[2] predicted positive relative signs for all quadrupole transitions calculated except in one case. This was $0_g^+ \to 2_2^+$ transition in ^{34}S for which negative sign was predicted. Proton inelastic scattering data from ^{34}S at 650 MeV[1] indicate negative relative sign for this transition, whereas alpha inelastic scattering data at 120 MeV[3] show positive relative sign.

The elastic and inelastic scattering experiment of 65 MeV polarized protons on ^{34}S was performed at RCNP in order to investigate the relative sign for the 2_2^+ transition in ^{34}S and to determine the ratio α of proton-neutron (b_n^p) to proton-proton (b_p^p) interaction strengths, $\alpha = b_n^p/b_p^p$. A high-resolution magnetic spectrograph RAIDEN was used to analyze emitted protons.

Angular distributions of cross sections $\sigma(\theta)$ and analyzing powers $A(\theta)$ for the 2.127 MeV 2_1^+, 3.304 MeV 2_2^+ and 4.115 MeV 2_3^+ states are shown in Fig. 1 together with the results of coupled channel (CC) calculations. The CC analysis was performed with a code ECIS79 within a framework of collective models, a harmonic vibrator and an asymmetric rotor.

The B(E2) value of 5.92 in single particle units was obtained for the 2_1^+ transition. Combining this value with Mp deduced from EM measurement and assuming $\alpha = 3$, we obtained the value of 1.00±0.15 for Mn/Mp, which is consistent with the experimental result of Alarcon et al.[4] and shell model calculation.

Supposing that the reaction mechanism is one step, we can write the cross section ratio $R = d\sigma(2_2^+)/d\sigma(2_1^+)$ as

$$R = \left| \frac{b_p^p \cdot Mp(2_2^+) \pm b_n^p \cdot Mn(2_2^+)}{b_p^p \cdot Mp(2_1^+) + b_n^p \cdot Mn(2_1^+)} \right|^2 . \qquad (1)$$

The experimental values of the ratio R are displayed in Fig. 2 along with those calculated from Mp and Mn obtained from EM transition rates under the assumption of α=3. As clearly seen in Fig. 2, the present experiment indicates that the excitation of the $^{34}S(2_2^+)$ state requires that Mn and Mp have the same sign. This result supports the conclusion of Saha et al.[3], Keinonen et al.[5] and Alarcon et al.[4] but is inconsistent with that of Bernstein et al.[1].

It is interesting to note that the $A(\theta)$ for three 2^+ states have different angular distributions, while those of $\sigma(\theta)$ are similar to one another. The CC analysis predicted similar angular distributions of $\sigma(\theta)$ and $A(\theta)$ for these three 2^+ states and failed to reproduce the angular distributions of $A(\theta)$ for the 2_2^+ and 2_3^+ states. This fact is considered to imply that these 2^+ states have a different property from the 2_1^+ state, which may be related to the theoretical finding of Castel et al.[6] that the 2_1^+ state is fundamentally a one-phonon state but other 2^+ states have large amplitude of a single-particle state.

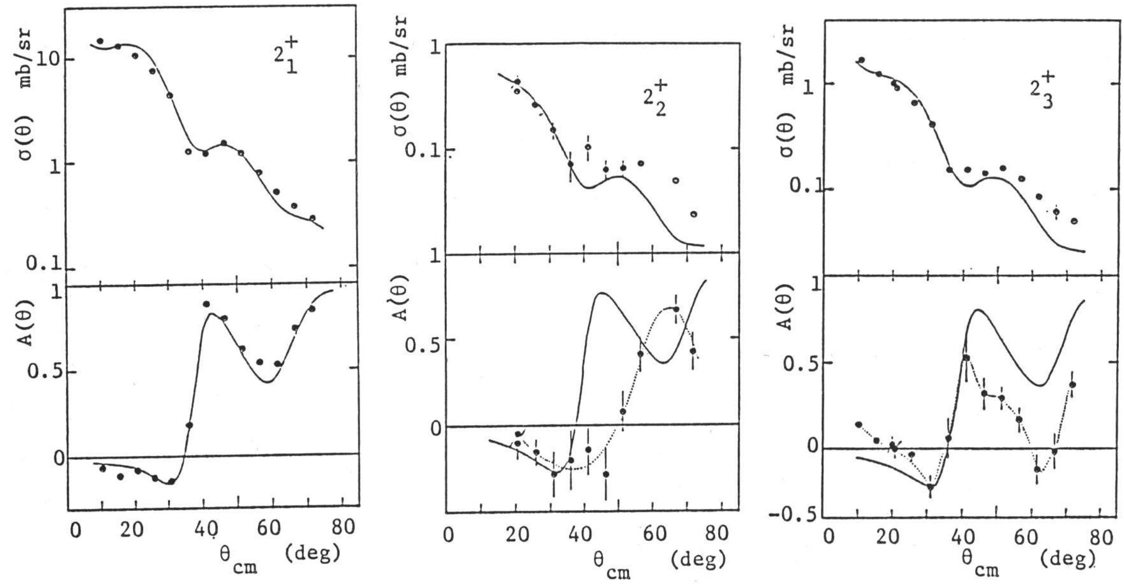

Fig. 1. The angular distributions of cross sections and analyzing powers for the 2_1^+, 2_2^+ and 2_3^+ states of ^{34}S. Solid curves are the predictions of CC calculations and dotted curves are only to guide the eye.

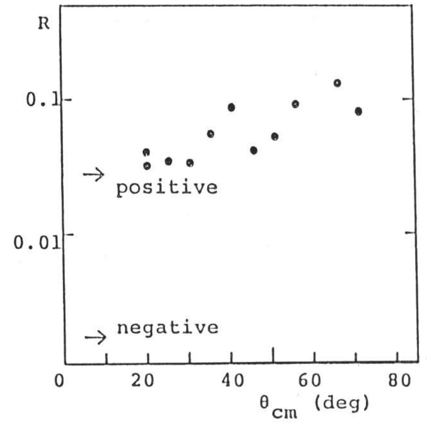

Fig. 2. Cross section ratio R as a function of θ_{cm}. The values of R obtained from Eq.(1) are indicated with arrows.

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