

**Figure 4.** Measurements of  $X_2$  and calculations of  $X_2$  and  $A_{xz}$  using a microscopic model of Ref. 7 (solid curve) and an optical model with and without (dashed and dotted) the real  $T_R$  potential of Ref. 3.

MEASUREMENT OF THE RELATIVE SIGN OF NEUTRON ( $M_n$ ) AND PROTON ( $M_p$ ) TRANSITION MATRIX ELEMENTS FOR THE  $2^+_2$  STATE IN  $^{30}\text{Si}$  BY INELASTIC ALPHA-PARTICLE SCATTERING.

A. Saha, K.K. Seth and D. Barlow  
Northwestern University, Evanston, Illinois 60201

H. Nann and W.W. Jacobs  
Indiana University Cyclotron Facility, Bloomington, Indiana 47405

One of the most exciting recent developments in the study of nuclear structure has been the appreciation of the isovector characteristics of nuclear excitation. A number of different experimental techniques have been developed to examine the separate roles played by neutrons and protons in the nuclear

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excitations. In inelastic scattering, the cross section for the transition to an excited state can be described in terms of separate matrix elements for proton and neutron excitations,  $M_p$  and  $M_n$ , respectively, or in terms of isoscalar and isovector matrix elements,  $M_0 = M_n + M_p$  and  $M_1 = M_n - M_p$ . The cross

section can generally be written as

$$\sigma_{\text{exp}}(\theta) = \sigma_{\text{theory}}(\theta) [b_n M_n + b_p M_p]^2$$

where the reaction mechanism and kinematical information is contained in  $\sigma_{\text{theory}}(\theta)$ .  $b_n$  and  $b_p$  are measures of the interaction of the probing particle

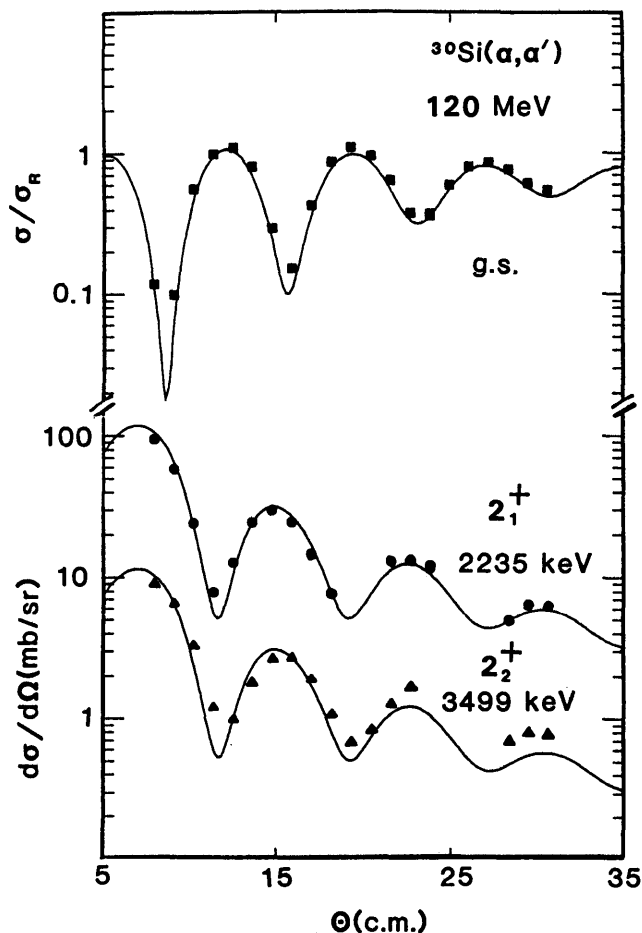


Figure 1. Angular distributions of the ground state and the first two  $2^+$  states in  $^{30}\text{Si}$ .

with the neutrons and protons involved in the excitations. For alpha particles as the probe,  $b_n/b_p=1$  can be safely assumed. Thus, inelastic alpha scattering can be combined with electromagnetic transition probabilities in mirror nuclei to obtain the relative sign between  $M_n$  and  $M_p$ .

We have measured inelastic alpha-particle scattering to the ground and first two excited  $2^+$  states in  $^{30}\text{Si}$  using a 120 MeV alpha-particle beam at IUCF. The reaction products were detected with the QDDM magnetic spectrometer. Angular distributions were obtained for angles from  $6^\circ$  to  $30^\circ$ . The differential cross sections for these transitions are shown in Fig. 1.

A standard DWBA analysis was performed and deformation parameters,  $\beta_R$ , of 1.09(3) fm and 0.35(1) fm for the  $2^+_1$ , 2235 keV and the  $2^+_2$ , 3499 keV states were obtained. Combining these results with lifetime measurements of the  $2^+$  levels in  $^{30}\text{S}$  and  $^{30}\text{Si}$ ,<sup>1</sup> we conclude unambiguously that the signs of  $M_n$  and  $M_p$  of the  $2^+_2$  state are the same as for the collective  $2^+_1$  state; i.e., they are both isoscalar in character. This is consistent with recent lifetime measurements of  $^{30}\text{P}$  by Antilla and Keinonen,<sup>2</sup> but is in contradiction with the predictions of recent shell-model calculations by Brown and Wildenthal.<sup>3</sup>

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