served pyroelectric coefficient was often as much as a factor of 2 less than this, the irreproducibility presumably related to the degree of alignment and memory state which exists in the individual sample.

An estimate of the theoretical value of dP/dT can be made in the following manner. Polarization P is defined as the macroscopic dipole moment per unit volume V:

$$P = N\bar{u}/V = \rho\bar{u}, \tag{2}$$

where N is the number of dipoles in the volume V, $\bar{u}$ is the dipole moment, and $\rho = N/V$. By differentiating Eq. (2) with respect to temperature T, one obtains

$$\frac{dP}{dT} = P\left(\frac{1}{\rho}\frac{d\rho}{dT} + \frac{1}{\bar{u}}\frac{d\bar{u}}{dT}\right). \tag{3}$$

The relative change in density $(1/\rho)d\rho/dT$ is approximately the volume expansion coefficient (negative sign) and should have the value of $\sim -1 \times 10^{-3}$ deg^{-1}.[6,7] The magnitude of the second term in Eq. (3) is -10^{-5} deg^{-1},[8] and can therefore be neglected.[9] P can be assumed[1] to have a value of ~ 125 esu cm^{-2} ($= 4.2 \times 10^{-8}$ C cm^{-2}). Therefore an estimate of dP/dT is $\sim -4 \times 10^{-11}$ C deg^{-1} cm^{-2}.

Thus the observed value of the pyroelectric coefficient [(2 to 3)$\times 10^{-11}$ C deg^{-1} cm^{-2}] is quite close to the theoretical value. Since neither perfect alignment of smectic-C and -H phases nor perfect untwisting of the chiral phases can be assured, the agreement is rather good. Further work on describing the properties of these interesting phases is underway.

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COMMENTS

Anomalous Angular Distribution in the Transition to the $2s_{1/2}$ State in ^{17}O

T. Motobayashi,* I. Kohno, K. Katori,† M. Yoshie,† T. Ohi,† and H. Kamitsubo
The Institute of Physical and Chemical Research, Wako-shi, Saitama 351, Japan

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The reaction ^{16}O(^{14}N, ^{13}N)^{17}O has been studied at a bombarding energy of 79 MeV. The angular distribution for the transition to the $2s_{1/2}$ state in ^{17}O showed an anomaly similar to that already reported in studies of ^{12}C(^{14}N, ^{13}N)^{13}C and ^{12}C(^{10}B, ^{9}Be)^{13}N.

Recently, an anomaly has been reported in the angular distributions for population of $2s_{1/2}$ states of ^{13}C ($E_x = 3.09$ MeV) and ^{13}N ($E_x = 2.37$ MeV) in studies of the reactions ^{12}C(^{14}N, ^{13}N)^{13}C [1] and ^{12}C(^{10}B, ^{9}Be)^{13}N,[2] respectively. In these studies it was found that exact finite-range distorted-wave Born-approximation (DWBA) calculations assuming a direct one-step transfer reaction mechanism gave theoretical angular distributions which oscillated completely out of phase with the experimental ones. To provide further information on this anomaly, we studied the transfer reaction ^{16}O(^{14}N, ^{13}N)^{17}O to the $2s_{1/2}$ state in ^{17}O ($E_x = 0.87$ MeV). A comparison between the reaction on the ^{16}O target and that on the ^{12}C target is of interest for the reason that the $2s_{1/2}$ state in ^{17}O seems to be a better example of a single-particle state than that in ^{13}C or ^{13}N. The angular distributions to the $1d_{5/2}$ states in ^{17}O and ^{17}F were also studied for comparison.

The experiment was performed with a ^{14}N beam from The Institute of Physical and Chemical Research cyclotron at a bombarding energy of 79 MeV. A Li_2CO_3 foil, 30 μg/cm^2 thick, evaporated on a thin carbon backing, was used for the ^{16}O target. The ^{13}N particles coming from ^{16}O were measured by means of a ΔE-E counter telescope in coincidence with the recoil nuclei (^{17}O) so as to distinguish them from those coming from ^{12}C contained in the target, since in the singles spectra of ^{13}N, peaks to the ground and $2s_{1/2}$ states in ^{17}O cannot be separated from that to the ground state in ^{13}C over the angular range of interest. The angular distributions of the elastic scattering and one-nucleon-transfer reactions are shown in Fig. 1. It can be clearly seen that the angular distribution to the $2s_{1/2}$ state shows an oscillation out of phase with that of the elastic scattering.

The same results were obtained by DeVries *et al.*[1] and Nair *et al.*[2] in their studies of the reactions ^{12}C(^{14}N, ^{13}N)^{13}C and ^{12}C(^{10}B, ^{9}Be)^{13}N, respectively, and their results together with ours contradict the prediction of the phase rule of the transfer reactions.[3]

Exact finite-range DWBA calculations of the angular distributions were performed using the computer code SATURN-MARS 1.[4] For both entrance and exit channels, we used two kinds of optical parameter sets,[5] a deep potential ($V = 65$ MeV, $W = 20$ MeV, $r_R = 1.21$ fm, $r_I = 1.35$ fm, $a_R = 0.48$ fm, $a_I = 0.25$ fm, and $r_c = 1.3$ fm) and a shallow one ($V = 22.4$ MeV, $W = 9.04$ MeV, $r_R = r_I = 1.3$ fm, $a_R = a_I = 0.5$ fm, and $r_c = 1.3$ fm). The solid and dashed lines for the elastic data in Fig. 1 show the results of the calculations using these parameter sets. The bound-state potentials were of Woods-Saxon form with $r_0 = 1.2$ fm and $a = 0.65$ fm and the potential depth was adjusted by the separation-energy method. The calculated results are shown by solid and dashed lines in Fig. 1.

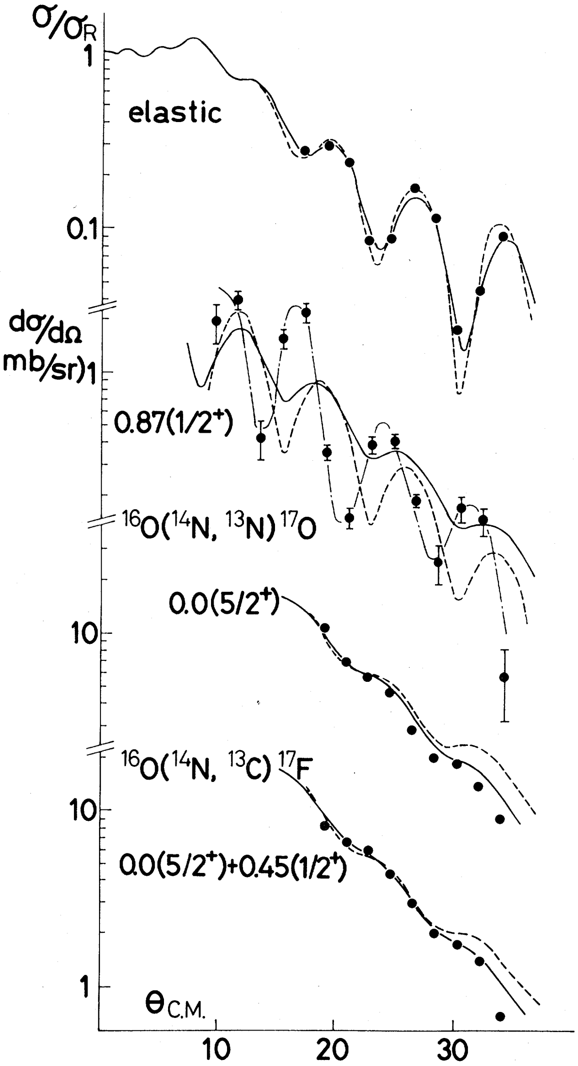

FIG. 1. Angular distributions obtained by bombarding ^{16}O with ^{14}N at 79 MeV. The solid and dashed lines for the elastic scattering correspond to the fit of the optical model using deep and shallow potentials, respectively (the parameters of which are in the text). The solid and dashed lines for the transfer reactions correspond to the exact finite-range DWBA calculation using the optical parameters of deep and shallow potentials, respectively. The dashed-dotted line connecting the experimental points is intended only to guide the eye.

The angular distributions for transitions to the $\frac{5}{2}^+$ ground states in both ^{17}O and ^{17}F are reasonably well fitted by the calculations which include an incoherent sum of the transition amplitudes for angular momentum transfer $L = 2$ and 3. The values obtained for the product of two spectroscopic factors, $C_1{}^2S_1C_2{}^2S_2$, are 0.71 and 0.49 for ^{16}O(^{14}N, ^{13}N)^{17}O and ^{16}O(^{14}N, ^{13}C)^{17}F, respectively. The spectroscopic factors $C_2{}^2S_2$ of $1d_{5/2}$ states of ^{17}O (1.03) and ^{17}F (0.71) are extracted by using the value $C_1{}^2S_1 = 0.69$ predicted for the ground state of ^{14}N by Cohen and Kurath[6] [the contribution from the $\frac{1}{2}^+$ state in ^{17}F ($E_x = 0.45$ MeV) was neglected]. These values of $C_2{}^2S_2$ are consistent with those expected in a simple shell model (1.0) or those predicted by Brown, Evance, and Thouless[7] (0.75).

On the other hand, the angular distributions calculated for the $\frac{1}{2}^+$ state in ^{17}O show a discrepancy in phase similar to the one reported in the reactions ^{12}C(^{14}N, ^{13}N)^{13}C($\frac{1}{2}^+$) and ^{12}C(^{10}B, ^{9}Be)^{13}N($\frac{1}{2}^+$). The phase of the calculated angular distribution does not agree with that of the experimental one. Another choice of the optical potential[8] affects only the amplitude of the oscillation in the calculated angular distributions, and produces no change in the phase itself. The value of $C_1{}^2S_1C_2{}^2S_2$ extracted by normalizing the calculated value to the experimental one is 0.38. From this the value 0.55 is obtained for $C_2{}^2S_2$ by using the value of $C_1{}^2S_1$ predicted by Cohen and Kurath.

A multistep reaction mechanism can make some contribution to the transition to the $\frac{1}{2}^+$ states as is suggested by DeVries *et al.*[1] For instance, if the $[^{12}\mathrm{C}(2^+)\otimes d_{5/2}]$ configuration is contained in the $\frac{1}{2}^+$ state in ^{13}C or ^{13}N, the process via the strong inelastic excitation of the first 2^+ state in ^{12}C is expected to be important in the reactions on ^{12}C. However, since the anomaly is also observed here in ^{17}O, any contribution of a multistep-process should be the same in all cases, ^{13}C, ^{13}N, and ^{17}O. Therefore, the process via inelastic scattering is not sufficient to explain these anomalies, since the $\frac{1}{2}^+$ state in ^{17}O is almost a pure single-particle state and seems to have a smaller $[2^+\otimes d_{5/2}]$ component than the $\frac{1}{2}^+$ state in ^{13}C or ^{13}N.

In summary, the same anomaly in the one-nucleon-transfer reactions to the $2s_{1/2}$ state as reported by DeVries *et al.* and Nair *et al.* for the mass-13 system is again observed here for the mass-17 system. This suggests that the multistep process via inelastic scattering is unlikely to occur in the excitation of the $2s_{1/2}$ states. Further measurements and calculations should be performed to understand this anomaly in connection with the reaction mechanism. The authors would like to thank Mr. S. Nakajima for his help in data taking, and Mr. H. Amakawa and Dr. T. Matsuura for their helpful discussion. They are also grateful to The Institute of Physical and Chemical Research cyclotron crew for excellent operation of the cyclotron.

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*On leave from the University of Tokyo, Tokyo, Japan.

†On leave from Tokyo University of Education, Tokyo, Japan.

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