ROTATIONAL STATES IN Ne^{20} EXCITED BY THE REACTION $O^{16}(Li^7, t)$†

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The reaction $O^{16}(Li^7,t)Ne^{20}$ has been studied at 16-MeV incident energy. The reaction is found to proceed essentially by a direct mechanism, exciting only those rotational bands in Ne^{20} which are allowed by the selection rules in the SU(3) scheme.

The (Li^7, t) reaction at intermediate energies is expected to proceed essentially via a stripping mechanism, in which a two-neutron, two-proton system is transferred to the target nucleus. The direct nature of this reaction was first suggested by Morrison[1] and further evidence supporting this view has recently been obtained by Bethge et al.[2] In the present communication, we wish to report on the first of a series of (Li^7, t) reactions leading to nuclei in the s-d shell, which are currently being studied in this laboratory. The reaction $O^{16}(Li^7, t)Ne^{20}$ was first chosen because of the expected simplicity in the interpretation of the experimental results, since O^{16} has principally a double closed-shell configuration and the nuclear structure of Ne^{20} is rather well understood.[3,4]

The reaction was studied using a 16-MeV $Li^{7(3+)}$ beam from the University of Pennsylvania tandem accelerator and a SiO_2 target, approximately 100 $\mu g/cm^2$ thick. The outgoing tritons were detected in nuclear emulsions at 47 angles ranging from $3\frac{3}{4}°$ to $172\frac{1}{2}°$, using the recently installed multiangle magnetic spectrograph. This instrument permits charged-particle spectra to be recorded simultaneously at 23 angles at $7\frac{1}{2}°$ intervals. By rotating the spectrograph through $3\frac{3}{4}°$ about target position, an additional 24 spectra may be measured at the intermediate angles.

A triton spectrum measured at $11\frac{1}{4}°$ is shown in Fig. 1. The energy resolution of the groups (70-keV full width at half-maximum) primarily reflects target thickness. Triton groups from the oxygen target component could be readily distinguished from those originating from silicon in view of their greater kinematic shifts with angle. Angular distributions for the six most intense triton groups are presented in Fig. 2. Since the triton groups corresponding to the higher excited states moved outside the range of detection of the nuclear plates at large angles, only partial distributions could be measured for these. The experimental results are summarized in Table I.

The ground and first two excited states at 1.63 and 4.25 MeV are members of the ground-state rotational band with $J^{\Pi} = 0^+$, 2^+, and 4^+, respectively. These states are therefore expected to be excited in the reaction $O^{16}(Li^7, t)$ by transferring alpha particles with orbital angular momenta of $L = 0$, 2, and 4 units, respectively. The measured distributions for these transitions are indeed seen to be strongly forward peaked and characteristic of stripping reactions. Furthermore, the different shapes of the primary peaks are consistent with the trends observed in other "stripping-type" reactions. The higher excited 6^+ and 8^+ members of this band were not observed since they fall outside the excitation energy range covered in this study. No other strong transitions leading to positive-parity states of Ne^{20} were seen. This is in agreement with the predictions of SU(3) theory, according to which the members of the $K = 0$, $(\lambda\mu) = (80)$ ground-

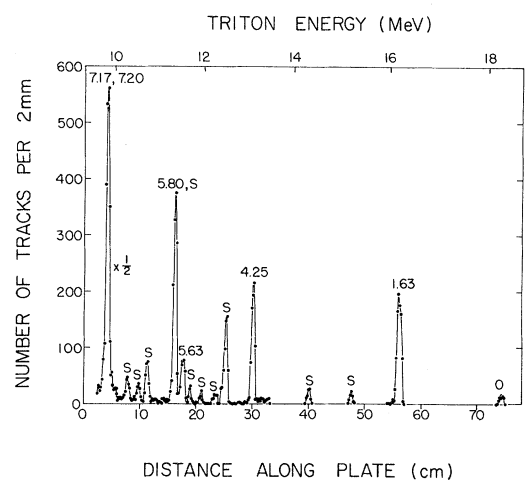

FIG. 1. Triton spectrum obtained from the reaction $O^{16}(Li^7, t)Ne^{20}$, measured at a laboratory angle of $11\frac{1}{4}°$ using a thin SiO_2 target. Groups corresponding to states in Ne^{20} are labeled according to the level excitation energies, and those labeled S correspond to levels in sulfur which arise from the silicon contaminant.

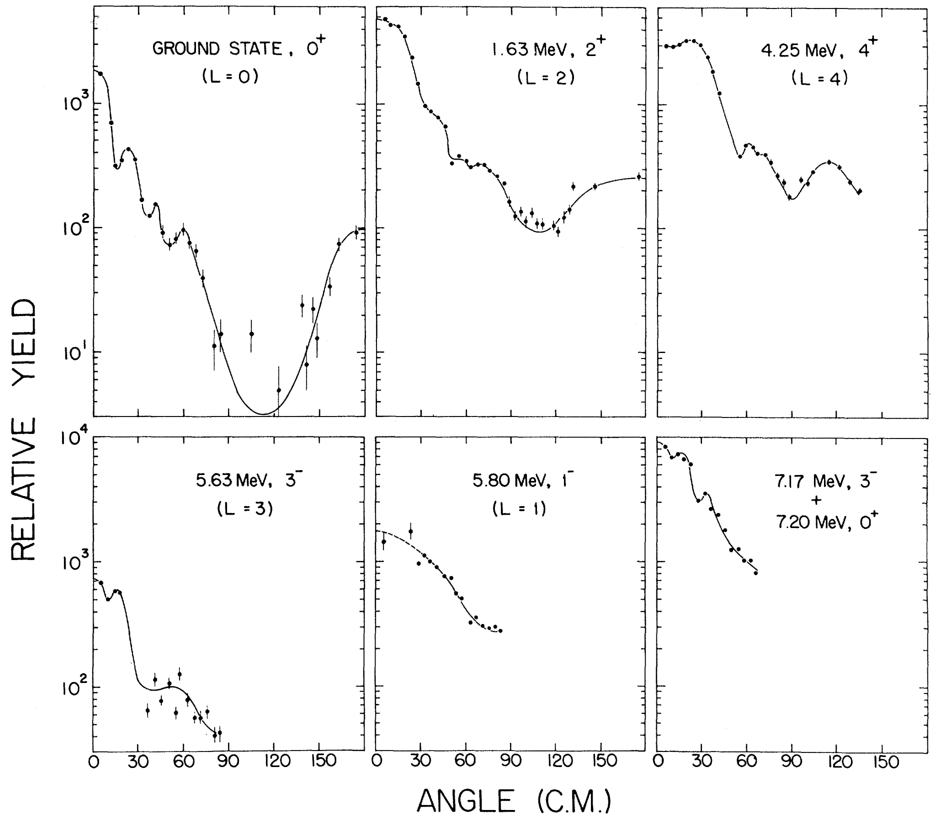

FIG. 2. Triton angular distributions measured from the reaction $O^{16}(Li^7,t)Ne^{20}$. The curves shown are intended to serve only as a guide to the eye.

state band are the only positive-parity states which can be excited by direct alpha-particle capture.

The low-lying negative-parity states in Ne^{20} are expected to arise from configurations in which an s-d nucleon is excited into the $1f$-$2p$ shell, or a $1p$ nucleon is excited into the s-d shell [the five-particle, one-hole (5p-1h) states]. The 1^- state at 5.80 MeV, which forms the head of the negative-parity $K=0$ band with $(\lambda\mu) = (90)$,[5] belongs to the first classification. This level is seen to be fed by a relatively strong transition. Unfortunately, the angular distribution at extreme forward angles could not be readily extracted owing to the close proximity of a contaminant triton group from silicon.

Of particular interest is the very intense transition leading to the levels at 7.17 MeV (3^-) and 7.20 MeV (0^+), which were not resolved in this experiment. It is not possible to obtain an accurate estimate of the relative contributions of these two states to the total transition strength. However, a rather crude estimate may be made if it is assumed that the $L=0$ component of the angular distribution resembles the ground-state distribution, and the $L=3$ component resembles the distribution for the 4.25-MeV level. On this basis, then, at least 80% of the total strength should be due

Table I. Results for reaction $O^{16}(Li^7,t)Ne^{20}$.

Excitation energy (MeV)	J^{Π} [a]	Required L	Relative $(d\sigma/d\Omega)_{max}$
0.00	0^+	0	100
1.63	2^+	2	272
4.25	4^+	4	171
4.97	2^-	...	...
5.63	3^-	3	39
5.80	1^-	1	82
6.72	0^+	...	...
7.03	4^-	...	...
7.17	3^-	$0+3$ [b]	486
7.20	0^+		
7.43	2^+	...	...

[a] Reference 3.
[b] See text.

to the $L=3$ transition to the 7.17-MeV state. This result is again in agreement with the predictions of SU(3) theory, according to which the 0^+ state should not be strongly populated.[6] The 3^- level, on the other hand, is the second member of the $K=0$, $(\lambda\mu)=(90)$ band based on the $(s\text{-}d)^3(1f)^1$ configuration, whose excitation by direct alpha-particle capture is not prohibited. It is interesting to note that the 3^- level is also very strongly excited as a resonance in the reaction $O^{16}(\alpha,\alpha')$.[7]

The negative-parity $K=2$ band, based on the $(\lambda\mu)=(82)$, 5p-1h configuration in Ne^{20}, is not expected to be excited since the ground state of O^{16} contains no $(1p)^{-1}(s\text{-}d)^1$ configuration. Indeed, the 2^- band head at 4.97 MeV and the 4^- member at 7.02 MeV are not observed at all in this study. However, the 3^- member at 5.63 MeV is observed to be weakly excited by this reaction, and its corresponding distribution suggests a significant direct component in the transition. This may be a consequence of configuration mixing, the level thus drawing its strength from the upper 3^- state at 7.17 MeV. The effect of such mixing on the excitation energy of this level has been previously discussed by Kuehner.[8] The similarity between the angular distributions for the 5.63 MeV state and the 7.17-7.20-MeV doublet also adds further support to the predominantly $L=3$ character for the latter transition.

We conclude that the reaction $O^{16}(Li^7,t)$ proceeds mainly by a direct stripping mechanism and that the present results lend strong support to the SU(3) classification of the rotational bands in Ne^{20}.

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SOLAR MODULATION AND THE GALACTIC INTENSITY OF COSMIC-RAY POSITRONS AND NEGATRONS

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It was first suggested by Hayakawa[1] that, because of their low relative intensity, cosmic-ray electrons (positrons and negatrons) may be entirely of secondary origin, resulting from the decay of charged pions produced in cosmic-ray interactions in the galaxy. Recent measurements[2,3] of the positron-to-electron ratio, however, have shown quite conclusively that for energies above a few hundred MeV, the majority of the electrons are negatively charged and therefore probably of primary origin, directly accelerated in the cosmic-ray sources. Nevertheless, these measurements also indicate that a measurable flux of positrons does exist and that it is of the same order as the flux expected[4-6] from the decay of charged pions produced in cosmic-ray interactions in the galaxy.

In the present Letter we shall show, on the basis of a more accurate secondary electron calculation, that the observed positron flux is entirely consistent with such a secondary