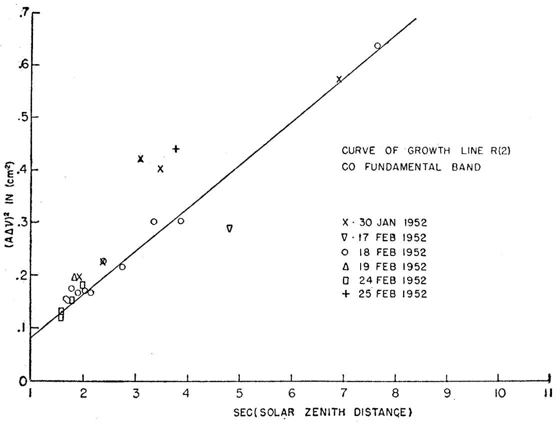

FIG. 2. Curve of growth of line $R(2)$ of the CO fundamental band.

The scatter of the points is due in part to experimental error, but it may also be due to variations in the amount of CO.

If laboratory data are available it is possible to calculate the amount of atmospheric CO from the curve shown in Fig. 2, assuming that the CO is uniformly distributed in a suitable model atmosphere. Goldberg[7] has described in detail how such a calculation can be performed, and we have made the necessary laboratory studies. Our measurements indicate that the average amount of telluric CO above Columbus, Ohio on the days when spectra were obtained was 0.09 atmos-cm per air mass. This is somewhat less than the amount suggested by Goldberg *et al.*[6] from an inspection of our published tracings.[2]

The solar spectrum from 4.5 to 5μ is being remapped using considerably higher resolution than previously reported, and a large number of new lines have been observed. Many of these lines are weak and do not vary in intensity with solar altitude, a result which indicates that they are of solar origin. The frequencies of most of these solar lines agree well with the calculated frequencies of lines of CO bands near 5μ due to solar CO recently predicted by Goldberg *et al.*[5] These calculated frequencies were obtained from the improved constants of the CO molecule published by Plyler, Benedict, and Silverman.[8]

It should be noted here that, if one assumes the amount of solar CO estimated by Goldberg *et al.*, it can be shown that the solar contribution to the observed absorption of the line $R(2)$ is negligible compared with the telluric absorption.

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Second Sound in He^3-He^4 Mixtures*

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THE hydrodynamics of superfluid mixtures of He^3 and He^4 has been worked out on the assumptions: (a) that the two-fluid dynamics still applies; and (b) that the He^3 atoms have the average velocity $\mathbf{v}_n$, i.e., move entirely with the normal fluid. The acceleration of the superfluid is then given by the gradient, not of the Gibbs function, but of the chemical potential of the He^4 component. For large concentrations of He^3, an appreciable coupling of the temperature and pressure waves is predicted. If we make use of Henry's law[1] for the partial vapor pressures p_3 and p_4, then for small concentrations X the general formula for the velocity u_2 of second sound reduces to

$$u_2^2=\left(\frac{\rho_s}{\rho_n}\right)\left\{\frac{T}{C}\left[S(0)+\frac{kX}{m_4}\frac{d}{dT}(a_4T)\right]^2+\frac{kTX}{m_4}\right\}, \quad (1)$$

where $C=C(X)$, $\rho_n=\rho_n(X)$, etc., and $a_4=(p_4^0-p_4)/p_4^0X$. This result reduces to Pomeranchuk's[2] if we set $a_4=1$, that is, assume perfect ideality of the solution. However, analysis of the experimental values[1] of vapor pressures shows this assumption to be far from the truth. Using these data, and those of Lynton and Fairbank[3] for $u_2(X)$, we find that for $X=5.8\times10^{-3}$ the effect of the He^3 on ρ_n may be represented, from 1.3^0 to 1.6^0, by the formula

$$\frac{\rho_n(X)}{\rho(X)}=\frac{\rho_n(0)}{\rho(0)}+\frac{\rho_s(0)}{\rho(0)}\left(\frac{\mu}{m_4}\right)X, \quad (2)$$

where $\mu=5.7m_4$. The mixture evidently behaves in this temperature range as though five He^4 atoms were "condensed" on each He^3 atom, and the rest of the liquid were unaffected. A detailed account of the theory will be published in due course.

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Interpretation of the Long-Range Protons from the Deuteron Bombardment of Be^9

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THE experimental curves of the angular distribution of the long-range protons resulting from the deuteron bombardment of Be^9 at energies from 1.00 Mev to 2.20 Mev have been obtained by Canavan.[1] Analysis of the curves into a cosine power series or a series of Legendre polynomials shows that they can be fitted within experimental error only by employing both even and odd power terms and by including the sixth power.

The assumption of deuteron penetration and compound nucleus formation results in four spin states with negative parity and five spin states with positive parity which are possible for the compound nucleus, if no values of orbital angular momentum quantum number higher than 4 are included for the initial and final systems and the following properties are assumed:

$${}_4Be^9:\quad I=3/2,\quad \text{odd parity}$$
$${}_4Be^{10}:\quad I=0,\quad \text{even parity.}$$

At least two states of the compound nucleus must be considered and the number of combinations which give the necessary complexity of the angular distribution curves is severely limited by the requirement that the quantum numbers of the orbital angular momenta of the initial state, the spins of the compound state, and the orbital angular momenta of the final state each add at least to six.[2]

Calculation of the barrier penetration factors for the orbital angular momenta involved shows that the ratio of the factors for the terms giving the higher complexity to those giving the lower complexity is of the order 10^{-3} or 10^{-4} in the lower energy region. In order to obtain the necessary complexity in the final angular distribution it is, therefore, necessary to assume that the other factors of the term, which essentially involve the matrix elements of the interaction of the incoming and outgoing nucleons with the nucleus, differ in an inverse ratio. The assumption that there

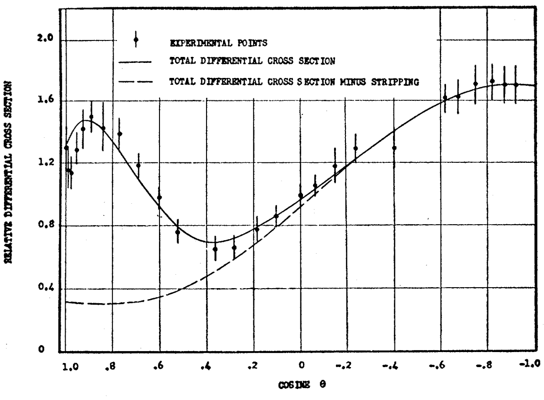

FIG. 1. Comparison of long range proton differential cross section from $Be^9(d, p)Be^{10}$ with calculated stripping curve for $l_n = 1$.

are such unusually large ratios of the matrix elements to compensate for the decreased penetrability of the necessary higher orbital angular momenta can be avoided by considering the possibility of a stripping process for the deuteron. In a stripping process neither the incoming deuteron nor the outgoing proton need penetrate as far into the potential barrier, and higher orbital angular momenta can participate.

The angular distribution of the protons from a deuteron stripping process has been calculated by Butler[3] neglecting the effects of the Coulomb potential. The distribution obtained depends, in addition to the energies involved, on the angular momentum l_n which the absorbed neutron adds to the initial nucleus. The alpha-particle model for the Be nuclei under consideration has recently been discussed by Haefner,[4] and provides the assumption that the angular momentum quantum number of the additional neutron which is added to Be^9 to give Be^{10} in this reaction must be 1, since this, together with the neutron spin, provides for the change from spin 3/2 to 0 and for the parity change. Calculation of the proton angular distribution curves by Butler's methods for the values of the energy and Q involved, and for $l_n = 1$, gives curves which have a characteristic maximum at a small forward angle and agree well with the initial peak observed in the curves obtained by Canavan. Using an arbitrary constant multiplicative factor the calculated stripping curve can be subtracted from the experimental points and the resulting smooth remainder curve shows a marked decrease in complexity from the sixth to the fourth power of the cosine. Figure 1 shows a comparison between the curve obtained by adding the calculated stripping curve to the smoothed-out remainder curve, designated as Total Differential Cross Section, and the experimental points. The agreement is good and it may be noted that the maximum of the experimental curve is shifted towards larger angles by a few degrees.

A recent investigation of the same reaction by Black[5] at much higher energies confirms the result that the angular momentum quantum number of the added neutron is 1 and also shows a shift between the calculated and observed maxima which may be interpreted as the effect of the Coulomb repulsion neglected in the calculations. It may, therefore, be concluded that the forward peak observed in the angular distributions even at low energies is due to the stripping reaction and that the remaining curve, which represents a sum of a term referring only to compound nucleus formation and one due to interference between compound nucleus formation and stripping, is lowered in complexity and therefore not as severely affected by penetrability difficulties.

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Neutrons from Deuteron Bombardment of N^{14}†

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THE neutron spectrum from the reaction $N^{14}(d, n)O^{15}$ has been recently studied by Gibson and Livesey,[1] who found only one group of neutrons from this reaction at a bombarding energy of 930 kev. Earlier work[2,3] had led to the conclusion that two groups of neutrons were emitted in this reaction, corresponding to Q-values of 5.1 and 1.1 Mev. Subsequently, it was concluded by Hudspeth and Swann[4] that the low energy group reported by them was actually produced by deuteron bombardment of aluminum, and the neutrons from $N^{14}(d, n)O^{15}$ were found to be associated with only one Q-value for Q greater than a few tenths of a Mev. The value of this reaction as a source of neutrons intermediate in energy to those produced in the $d-d$ and $d-t$ reactions has been emphasized.[5]

We have now made a more complete study of this reaction, utilizing the statitron at the Carnegie Institution of Washington. Targets of NH_4NO_3 of thickness about 300 kev were bombarded with deuterons for approximately 15,000 microcoulombs at 1.7 Mev. The neutrons produced in the reaction were recorded in Ilford C-2 photographic emulsions, which were placed at 0° and at 90° to the bombarding beam. The plates were developed and analyzed with a microscope in the conventional manner; all recoil proton tracks within 12° of the direction of the neutrons emitted by the target were counted. Corrections were applied for the variation of the $n-p$ cross section with energy, for the probability that tracks remain in the emulsion over their entire lengths, and for inverse square decrease of track density with distance from target. The resulting data are shown in Fig. 1. The errors indicated are probable errors based on number of tracks observed in the corresponding energy interval.

It is believed that two groups of neutrons were observed at our bombarding energy which may be ascribed to $N^{14}(d, n)$. These correspond to Q-values of approximately 5.1 and 0.2 Mev, indicating an excited state in O^{15} at approximately 4.9 Mev. (The lowest excited level in the mirror nucleus N^{15} is at 5.5 Mev.) The low energy group which we found would not have been observed by Gibson and Livesey[1] at their bombarding voltage.

The lowest energy group found at both 0° and 90° is thought to come from the reaction $C^{12}(d, n)$, since this is the expected energy of the neutrons from this reaction and since carbon is apparently a universal contaminant in such systems. In a separate experiment, we checked this point by bombarding a pure carbon target of known thickness and observing the density of recoil proton

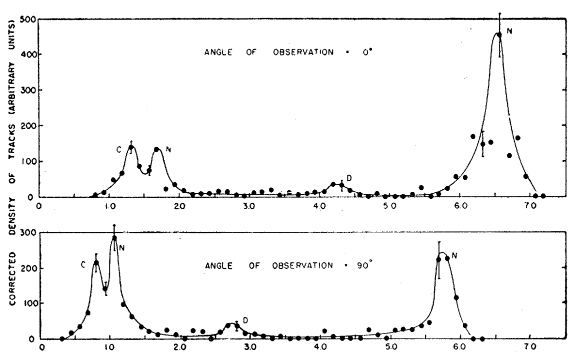

FIG. 1. Neutron groups observed from bombardment of NH_4NO_3. The groups marked C, N, and D are thought to arise from $d-n$ reactions in carbon, nitrogen, and deuterium, respectively.