TABLE I. Flow rates of He^3 and He^4 components in a 3.9 percent He^3 solution relative to rate of pure He^4 at 1.96°K.

Temp. °K	He^3	He^4
2.02	0.022	0.11
1.94	0.024	0.44
1.92	0.025	0.50
1.86	0.029	0.84
1.75	0.032	0.91 ±0.1
1.57	0.031	0.93 ±0.3
1.40	0.027	···
1.20	0.023	···

Above 2.2°K, the gas flow of pure He^4, pure He^3, and the 3.9 percent mixture through these leaks (gap width approximately 1×10^{-5} cm) has been investigated for various mean pressures and pressure drops. We have ascertained (a) that this type of flow is clearly dependent upon the driving pressure and (b) that gas flow accounts for less than 8 percent of the observed He^3 transport in the experiments described above.

He^3 in dilute solution below the λ-point thus exhibits the following transfer properties through fine capillaries: (a) constant velocity of transfer independent of driving pressure, (b) independence of length of path, and (c) incapability of flowing into an evacuated space at an appreciable rate until its relative partial pressure is almost unity. In contrast to pure He^4, the He^3 flow rate shows little tendency to diminish as the λ-temperature of the solution[6] is reached. Further studies are under way to ascertain whether these phenomena are consequences of the presence of superfluid atoms of He^4 [7] or are intrinsic properties of He^3.

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[7] When the transfer of He^4 from chamber 1 into 2 into 3 stops, and the partial pressures of He^4 become equal in all three chambers, e.g., point C, Fig. 2(b), there is no discontinuity of the flow rate of He^3 from 1 into 2 (BD). Hence the He^3 flow seems to be independent of whether or not He^4 is flowing through the same channel.

Nucleon-Lepton Interaction in β-Decay

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ACCORDING to theory, the interaction of β-decay is a linear combination of five possible forms S, V, T, A, and P. However, experimental results show that, on one hand, T or A should be taken in the combination and that, on the other hand, combinations of S and V, or T and A, are in first approximation[1] excluded by the shape of the allowed β-spectra. Until now the study of the shapes of forbidden spectra has not permitted the complete specification of the interaction. For example, the shape of Cl^{36} could be explained in terms of the two quantities $\beta\boldsymbol{\sigma}$ and $\beta\boldsymbol{\alpha}$ of T only, as well as with a combination (T, V) or (T, S), or (A, V).[2]

The analysis of the nuclear matrix element for allowed transitions with light nuclei permits some indications regarding the interaction.[3–5] Since the interaction is of the type, $H_\beta \equiv C_t H_t + C_f H_f$, where H_t is either T or A, and H_f either S or V, the nuclear matrix element is M, where $|M|^2 \equiv |C_f|^2|M_f|^2 + |C_t|^2|M_t|^2$. This study gives $|C_f|^2 \simeq 0.20$ and $|C_t|^2 \simeq 0.80$.

$$M_S \simeq M_V = \int \Psi_f^* \Psi_i dt \equiv M_f; \qquad M_T \simeq M_A = \int \Psi_f^* (\boldsymbol{\sigma}/\sqrt{3}) \Psi_i dt \equiv M_t.$$

TABLE I. Summary of data for mirror nuclei. For the first two transitions listed the initial and final states have the configuration $P_{1/2}$. For the remaining four transitions they have the configuration $D_{3/2}$.

Transition $i \to f$	W_0 kev	t sec	$f_0 t$	$H_\beta \equiv H_t$ (Gamow-Teller) $\lvert a\rvert^2$	$H_\beta \equiv H_t$ (Gamow-Teller) $T_0/\lvert M_\rho\rvert^2$	$H_\beta \equiv H_f$ (Fermi) $\lvert a\rvert^2$	$H_\beta \equiv H_f$ (Fermi) $T_0/\lvert M_\rho\rvert^2$	$H_\beta \equiv C_t H_t + C_f H_f$ $\lvert a\rvert^2$	$H_\beta \equiv C_t H_t + C_f H_f$ $T_0/\lvert M_\rho\rvert^2$
N^{13} C^{13}	1200	608	4900±300	1/9	545±30	1	4900±300	0.29	1370±80
O^{15} N^{15}	1683	118	3500±300	1/9	390±30	1	3500±400	0.29	1010±80
Cl^{33} S^{33}	4130	2.8	4000±400	1/5	800±80	1	4000±400	0.36	1440±150
A^{35} Cl^{35}	4400	1.84	3400±400	1/5	680±80	1	3400±400	0.36	1220±150
K^{37} A^{37}	4700	1.3	3240	1/5	650	1	3240	0.36	1150
Ca^{39} K^{39}	4900	1.06	3100	1/5	620	1	3100	0.36	1110

The β-disintegration interaction would therefore be (T, V), the only one consistent with the symmetry principle of de Groot and Tolhoek, or (T, S), or (A, V).

The principle of this analysis, similar to that used by Wigner,[5] is to compare, for the different allowed β-transitions, the quantities $T_0/|M|^2 = ft$. Practically, we take for odd A nuclei the one-particle shell model,[6] where the orbital momentum L is nearly a good quantum number. Then we set $|M|^2 = |a|^2|M_\rho|^2$, with $|M_\rho| \equiv \int G_f^* G_i r^2 dr$, where G_i, G_f are the radial wave functions of the initial and final nuclei, $|a|^2$ depends on the angular wave functions, and in the interaction: $|a|^2 = |C_t|^2|a_t|^2 + |C_f|^2|a_f|^2$.

$|a_f|^2 = 1$ for $\Delta J = 0$, and $|a_f|^2 = 0$ for $\Delta J = 1$. $|a_t|^2$ is given by relations similar to those obtained in atomic spectroscopy by Hönl-Kronig. The only condition to satisfy is then $|M_\rho| \leqslant 1$. We have given in Table I a summary of information furnished by mirror nuclei, mainly of the type $J = L - \frac{1}{2}$, for which the magnetic moment values are in best agreement with the Schmidt line; so these nuclei can fairly be taken with only one LS configuration: $P_{1/2}$ for C^{13}, N^{15}; $D_{3/2}$ for Cl^{33}, ···, Ca^{39}. These transitions lead to values $|M_\rho| > 1$ with a pure H_t interaction. Thus, taking $T_0 \simeq 1100$ as reference, from the decay of the neutron, tritium, and He^6, we must take $|C_f|^2 \gtrsim 0.20$ (strictly $\geqslant 0.21$ for $T_0 = 1100$) to have $|M_\rho| \leqslant 1$.

Nuclei of type $J = L + \frac{1}{2}$ lead to smaller values of $|M_\rho|$, $|M_\rho| < 1$, even with H_t only (these seem generally composed of several LS configurations so that the apparent $|M_\rho|$ value is here lowered).

The value $|C_f|^2 \simeq 0.20$ (about ±10 percent); $|C_t|^2 \simeq 0.80$ was also obtained[4] by comparison with superallowed transitions of even A nuclei; our hypothesis of Russel-Saunders coupling and definite supermultiplet is rather good, because for any other case (e.g., extreme $j-j$ coupling), the value of the matrix element $|a|^2$ is too small and gives $|M_\rho| > 1$.

It would also be possible to use a pure H_t interaction if we admitted different values of J for initial and final mirror nuclei, but it would then be necessary to change slightly the order of the shells. On the other hand, the fact that the difference of masses corresponds to the difference of the Coulomb energies is such nuclei strongly suggests the identity of their structure and the equality of the J values.

The same argument lead to $J = 0$ for N^{14*} (2, 3 Mev), so that the allowed $O^{14} \to N^{14*}$ transition would be a $0 \to 0$ transition, which could not be explained by H_t alone.

After we had completed this work, we received a note from O. Kofoed-Hansen and Aage Winther (Institute for Theoretical Physics, Copenhagen) on the same subject, "β-Decay of Mirror Nuclei and the Shell Model." We are very grateful for this communication. Their results give in our notation $|C_f|^2 = 0.25 \pm 0.04$, in good agreement with our values.

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