and further emphasized by the extremly large variations in the amount over Columbus as reported by Migeotte. There is a temptation to regard the presence of carbon monoxide in the air as a consequence of its nature as a product of incomplete combustion. It would be most instructive to follow the course of carbon monoxide above Columbus as a function of fuel consumption and local weather.

Amongst the minor constituents of the atmosphere, carbon monoxide must be regarded as a local manifestation, unlike nitrous oxide, for example, which was recently shown to be world wide in an essentially constant amount.[3]

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On the Excited States of Li^7

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THE ground state of Li^7 has nuclear spin $I=3/2$, and the possibility[1] that the 480-kev excited state is the other state of the doublet, $^2P_{\frac{1}{2}}$, is favored[2] by the existence of a transition[3] to this state by K-capture in Be^7. However, when thermal neutrons impinge on B^{10}, which[4] has $I=3$, the transition by alpha-emission leads[5] almost entirely (93 percent) to the excited state of Li^7, and this strong preference seems to demand[6] a selection rule based on a large angular momentum associated with the excited level, considerably larger than the value $I=1/2$. In keeping with the assumption of spherically symmetric exchange interactions, which have been used[7] fairly successfully to correlate nuclear stability properties, it was suggested[6] that the excited level of Li^7 might be the two states of an unresolved ^2F, having $I=7/2$ and $5/2$. In the light of recent observations[8] which display the energy groups as sharp peaks and agree quite closely on the excitation energy (and barring a pervasive selection rule), this would require very small spin-orbit coupling (<10 kev).

The objection to this latter scheme[9] is that it leaves the total orbital angular momentum L too nearly a good quantum number, and the Be^7 K-capture to the excited level would be forbidden with $\Delta L=2$. Retention of L as a quantum number is perhaps an oversimplification. It is noteworthy that agreement could be obtained both with the Be^7 K-capture and the $B^{10}(n,\alpha)Li^7$ transitions to the excited state by the assumption that this excited state is single and simply has $I=5/2$. This assumption is also compatible with the observed lifetime[10] of the excited state, which may be attributed to a magnetic dipole transition moment of plausible magnitude,[10] but requires an electric quadrupole transition moment considerably larger than estimated from nuclear dimensions. It agrees as well with the observed angular distribution[11] of the reaction $Li^6(d,p)Li^7$ at low energies, wherein the spherical symmetry of the long-range protons and a term as high as $\cos^4\theta$ in the short-range protons may be explained, only if the excited state has $I\geq 5/2$, in which case the explanation involves compound states 0^+, 2^+ (both competing with alphas[12]) and 5^-. Since $I=5/2$ seems to be the only single value compatible with all the observations, the problem is to make this assumption theoretically plausible.

The shell structure apparent as "magic numbers" in nuclear stability has been correlated by Mayer[13] with the trend of nuclear spins and magnetic moments by postulating $j-j$ coupling for the individual nucleons, which requires strong spin-orbit coupling in most nuclei. There are sufficiently few exceptions to the general experimental agreement[13,14] that the scheme has a strong empirical appeal in spite of its sharp divergence from previous concepts.[7] Perhaps the most serious discrepancy is found in Li^6, where two nucleons each with $j=3/2$ would be expected[14] to combine to make $I=3$, rather than 1 as observed, but there might be exceptionally small spin-orbit coupling in this nucleus because of the exceptionally weak binding of these nucleons. Then Li^7 might also be expected to have somewhat weaker spin-orbit coupling than normal for p orbits, and a 480-kev doublet splitting would seem ample to be compatible with a splitting of 2 Mev or more in heavier nuclei as might be required to have an influence on shell structure. This would leave the excited state a $^2P_{\frac{1}{2}}$. Because this is incompatible with the $B^{10}(n,\alpha)Li^7$ and the $Li^6(d,p)Li^7$ data, we wish also to consider the possibility of stronger spin-orbit coupling in Li^7.

In extreme $j-j$ coupling, one obtains the low states by coupling three vectors $j=3/2$. Because of the exclusion principle, the two neutron vectors make $J_\nu=0$ in the ground state, and $J_\nu=2$ combining with j_π to make $I=7/2$, $5/2$, $3/2$, $1/2$ in the simplest description of the next higher states, and we may expect that some acceptable choice of nucleon interactions would make their energies ascend in this order. Enumeration of the higher states with various nucleons having $j=1/2$ rather than $3/2$ shows that there are in all two states with $7/2$, five states with $5/2$, eight with $3/2$, and six with $1/2$. In a second-order calculation departing from extreme $j-j$ coupling, one might expect very roughly that the extent of depression of the lowest state with a given I, due to the familiar second-order "repulsion" in energy, would be greatest for the value of I which characterizes the greatest number of states. By this criterion, the first-order ground state would be depressed most and remain the ground state, and $I=5/2$ would be depressed more than $I=7/2$, which does indeed make it a fairly plausible first excited state. Unfortunately, in an approach to the intermediate coupling situation from the opposite extreme of $L-S$ coupling with the ^2P assumed lowest in first order as in earlier calculations,[7] the same plausibility argument favors $I=1/2$ as the first excited state. This suggests that the interactions which one assumes to provide the $j-j$ coupling scheme may have to deviate from previous concepts so severely as to alter the order of the multiplets calculated by neglecting spin-orbit coupling. Another difficulty is that recent observations[15] fail to detect further excited states in Li^7 up to about 1.6 Mev, and this qualitative discussion unfortunately does not suffice to explain this gap.

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Meson Exchange and Spin-Orbit Coupling in Nuclei

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THE single-nucleon spin-orbit coupling required by recent conjectures[1-3] concerning the prevalence of a $j-j$ coupling scheme in most nuclei is too strong a coupling to be entirely accounted for by the simple theory based on a Thomas precession

$$\omega_T = a \times v / 2c^2, \qquad (1)$$

proportional to the acceleration a and velocity v of a nucleon endowed with an intrinsic spin.[4-6] The analysis of the magnetic moments of the three-nucleon nuclei involves the graphic concept of exchange currents[7] representing the transport of charged mesons responsible for some of the inter-nucleon interactions. Certain types of mesons which may be responsible for nuclear forces (π-mesons with spin 1) are carriers of spin as well as of charge, and one may anticipate on the basis of similar graphic concepts that the process of meson exchange which binds a circulating nucleon to the rest of the nucleus involves a predominantly centripetal acceleration of the meson momentarily associated with the circulating nucleon. This meson acceleration is expected to be much greater than the centripetal acceleration of the nucleon, since the exchange process may be expected in effect to take place many times per revolution. Although one does not have at hand a sufficiently complete analysis of the energetics of meson fields, it seems plausible to suppose that this large acceleration a of the meson, together with the tangential component of v which the meson would have in common with the circulating nucleon, should give rise to a Thomas precession of the meson spin much more rapid than that of the intrinsic nucleon spin previously derived from (1). Even if somewhat suppressed by a weighting factor representing the ephemeral association of the meson and nucleon (as enters, for example, in the interpretation of anomalous nucleon magnetic moments),[8] this might still give a spin-orbit coupling $\sigma \cdot \omega_T$ much larger than that arising from precession of the nucleon spin alone. (A factor of ten or more seems to be needed by the empirical conjectures.) During the meson's fleeting association as part of the circulating nucleon, the meson spin has the direction of the nucleon spin of which it is a part (that is, a nucleon with spin up is part of the time a nucleon with spin down and a meson with spin up), and the directions of a and v are the same as before, so the sign of the coupling is the same as that arising from a Thomas precession of an intrinsic nucleon spin, which is satisfactory. From these graphic considerations, it seems more likely that a spin-orbit coupling belonging to each individual nucleon would arise from this second-order relativistic effect than from the second-order perturbation theory with a tensor interaction, as treated by Dancoff[6] in the simple case of He^5 with only one circulating nucleon.

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The Interpretation of the K^{42} Radioactivity*

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A NUMBER of recent studies have been concerned with the occurrence of a characteristic forbidden type of energy distribution in several well-known beta-radioactive transitions. The necessary theoretical conditions[1] are

(1) Gamow-Teller selection rules govern the beta-process,
(2) the transition is first-forbidden, with $\Delta I = \pm 2$ and a change in parity.

For this situation the beta-spectrum differs from the allowed shape by a factor G, which, if Z is small, has the approximate form $G \sim (W_0 - W)^2 + W^2 - 1$. Here W is the electron energy

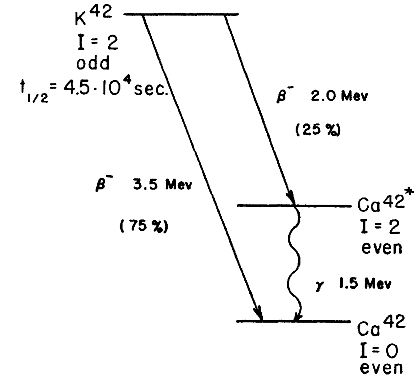

FIG. 1. Decay scheme of K^{42}.

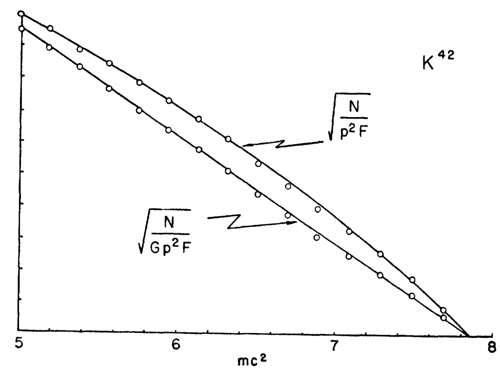

FIG. 2. FK plots for K^{42}, using data due to Siegbahn. Upper curve "allowed" plot, lower is "forbidden" plot.

and W_0 is the total energy release, both in units mc^2. The factor G emphasizes the relative number of high-energy particles and may also emphasize low-energy particles if $W_0 \geqq 2$. The FK (Fermi-Kurie) plot (computed as though the transition were allowed) tends to bulge upward at high energy, and may also curve upward at low energy, thus producing an S-shaped plot.

Beta-distributions of the type described above have been measured for Y^{91} by Langer and Price[2] and by Osobà,[3] for Cs^{137} by Mitchell and Peacock[4] and by Osoba,[3] for Y^{90} and Sr^{90} by Braden, Slack, and Shull,[5] and for Rb^{86} by Mitchell.[6]

The product ft provides a means of classifying transitions as allowed or forbidden to various degrees.[7] Here t is the half-life and f is the integral of the allowed probability function $P(W)$ over the available energy range. For the first-forbidden transitions discussed above $P(W)$ is modified by the factor G; consequently in this case the product $(W_0^2-1)ft$ should be more nearly constant than ft.

Using the shell model[8] as a guide, it is possible to select a group of beta-transitions between ground states wherein a change of parity is likely and for which the ft product is characteristic of first- or second-forbiddenness according to the empirical scheme of Konopinski. When these are reclassified according to the magnitude of $(W_0^2-1)ft$, it is found that the isotopes Y^{91}, Cs^{137}, Y^{90}, Sr^{90}, and Rb^{86}, for which the forbidden shape has already been observed, fall into a select category. For these isotopes, the product $(W_0^2-1)ft$ has values close to 10^{10}, whereas it is smaller by a factor of 10 or more for other transitions marked by a change in parity (according to the shell model). This suggests that $(W_0^2-1)ft \sim 10^{10}$ provides a rough criterion whereby one can pre-select the first-forbidden transitions for which $\Delta I = \pm 2$.

Nucleus	Cl^{38}	A^{41}	K^{42}	Br^{84}	Rb^{86}	Sr^{89}
$(W_0^2-1)ft \times 10^{10}$	0.5	1.4	0.7	0.8	0.8	0.7