The following proof of (2) is the work of Dr. Conrad Longmire.

We note that $w=\sinh\alpha r$ satisfies the equation

$$d^2w/dr^2-\alpha^2w=0, \tag{3}$$

and that the wave equation for the ground state is

$$d^2u/dr^2-\alpha^2u=(M/\hbar^2)Vu. \tag{4}$$

Multiplying (3) by u and (4) by w, subtracting, integrating by parts from 0 to R, we have

$$w(r)\frac{du(r)}{dr}\Big|_0^R-u(r)\frac{dw(r)}{dr}\Big|_0^R=\frac{M}{\hbar^2}\int_0^R V(r)u(r)w(r)dr.$$

The lower limit does not contribute since $u(0)=w(0)=0$; the upper limit gives, for R sufficiently large,

$$-\alpha\sinh\alpha Re^{-\alpha R}-\alpha\cosh\alpha Re^{-\alpha R}=-\alpha.$$

Hence $-\alpha\leqq(M/\hbar^2)\int_0^R Vuwdr$, the equality holding exactly in the limit $R\to\infty$.

On the Half-Life of Rb^{87}

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SEVERAL authors[1] have determined the half-life of Rb^{87} by measuring the rate of β-particle emission per mg RbCl. Their results vary between $T=4.5\cdot10^{10}$ yr. (Orban) and $12\cdot10^{10}$ yr. (Mühlhoff), the latter being the only value among the older papers obtained by modern counting technique. Hahn *et al.*[2] have calculated T by measuring the Sr/Rb ratio in a lepidolite of $2\cdot10^9$ yr. age, known from radioactive measurements of minerals from the same geological origin using the α-decay of U. Mattauch[2] had found by isotope analysis that the Sr contained in the lepidolite was exclusively of radioactive origin. They found $T=6.4\cdot10^{10}$ yr. The discrepancy between Mühlhoff's result and the value obtained by the geological method seemed rather embarrassing, not only because of the importance of T for the Rb/Sr-method of measuring geological ages, but also because it seemed to indicate a discrepancy between the time scale of α- and β-decay in a sense postulated by a cosmological theory of Jordan,[3] involving a variation of the rate of β-decay and other fundamental constants with the age of the universe.

We therefore measured very thin layers of RbCl produced by evaporation on a silver coated Zapon foil of about 0.1 mg/cm², suspended freely between a counter arrangement which allowed the measure of particles from both sides of the foil simultaneously, as well as the number of coincidences between counts on both sides.

With decreasing thickness of the RbCl layer from 2.0 to 0.05 mg RbCl/cm², the number of electrons per mg RbCl min. increases regularly for the back side of the foil, while the front side shows a considerably higher increase, the extrapolated activity for zero thickness being 13.6 and 19.6 counts/min. mg RbCl for the back and front side, respectively. This indicates a high percentage of very soft electrons from Rb, which are stopped by the supporting Zapon foil. Coincidence measurements (resolving time $3\cdot10^{-5}$ sec.) gave the surprising result that a considerable number of Rb counts on both sides coincided, up to 30 percent of the front side number for zero thickness, thus proving that more than one particle is emitted per decay process. All our results can be understood quantitatively with the assumption that for every decay of Rb^{87} one soft electron of energy up to 10 kev is emitted as well as one faster electron with the known energy limit of 135 kev. Since the electron spectrum[4] for Rb is not known well enough, it is not possible to identify either group as the decay electrons, while the other should be ascribed to a group of internal conversion electrons of 100 percent conversion rate. The presence of discrete lines shown by Ollano,[4] the difficulty of explaining a conversion electron of so low an energy emitted within $3\cdot10^{-5}$ sec., and a better fitting of Rb^{87} into a Sargent diagram by assuming a very low β-energy limit, seem even to favor the assumption that the slow electrons are the decay electrons.

By the independence of the coincidences from the argon pressure in the counters, we could prove that they were not due to back scattering from the gas. The efficiency of the counters was tested to be 100 percent by coincidence experiments, and the solid angle extended by the counters to be 2π within an error limit of 5 percent by using them as proportional counters and testing them with α-rays from a uranium deposit. Whatever the nature of the coincidences, the number of decays under the above assumptions is given by the sum of the kicks on both sides minus the number of coincidences. We thus found $n=27.2$ decays/mg RbCl min., and $T=(6.5\pm0.6)\cdot10^{10}$ yr.

The experiments with freely suspended Zapon foils, however, involve a comparatively large error in measuring the exact amount of Rb deposited. To check our results in another series of experiments, areas of 60 cm² were covered with RbCl by evaporation on Al foils and placed on the inside wall of a G-M counter of known efficiency. The weight of RbCl could be measured to about 3 percent, and the number of electrons leaving the front face of the layer could be followed down to a layer thickness of 0.025 mg/cm² RbCl. This brought after slight corrections for back-scattering and the influence of counter ends, a further increase to 23 electrons/min. mg RbCl and $n=30.7$ decays/min. mg RbCl, with $T=(5.8\pm0.5)\cdot10^{10}$ yr. As a weighed average of both series of experiments we consider $6.0\pm0.6\cdot10^{10}$ as a result of our measurements, in fair agreement within error limits with the geological value.

While our work was still in progress, a paper by Eklund[5] came to our knowledge. He measured T with a counter calibrated by mixed α- and β-particles from a uranium deposit. Eklund also found the beginning of the increase of the number of particles for thin layers down to 0.1 mg RbCl/cm², but he did not discern particles coinciding with those emitted to the back side. He found $T=5.8\cdot10^{10}$ yr., in excellent agreement with our value, but this seems to be due to the fact that by using insufficiently thin layers and neglecting coincidences, two considerable error sources compensated each other to a high extent.

The agreement of the present rate of decay of Rb^{87} with the average rate for the last $2\cdot10^9$ years within the mutual error limits leaves no reason to doubt the agreement of age determinations from α- and β-decay of Rb^{87} and UI. A further narrowing of both errors seems nevertheless desirable because of the principal importance of this question. A full account of our experiments will be published shortly.[7]

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Radiative X-Ray Transition within the *L* Shell of Sulfur

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WHEN the L levels of an atom in the crystal lattice are ionized by electron impact, transitions of electrons from the conduction band into the vacant x-ray level give rise to emission bands characteristic of the solid. Though such transitions into the L_{II} and L_{III} levels are observed in the case of the light elements,[1,2] emission spectra corresponding to valence electron transitions into the L_I level have not been detected. The absence of the L_I emission band may be ascribed to other competing processes such as radiative transitions $L_I \rightarrow L_{III}$ within the shell and radiationless transitions $L_I \rightarrow L_{III}$ with a transfer of energy to a valence electron.

In a previous paper[3] the $L_I \rightarrow L_{III,II}$ radiative transitions were tentatively identified in the case of Na, Mg, and Al with the aid of the screening doublet law. Since the wave-length predictions were based on an extrapolation, the proposed assignments were regarded as provisional. Recently, in connection with further studies of L-emission spectra, a relatively narrow line appeared on several spectrograms when sulfur was present on the target. The width of the line is 1.5 ev at half-maximum. The peak of this isolated line occurs at 203A. This is in excellent agreement with the previous prediction[3] of the wave-length of the $L_I \rightarrow L_{II,III}$ radiative transition of sulfur. With this additional identification it may be concluded that the absence of the L_I emission band is in part due to a radiative process within the L shell of the light elements. The peak wave-lengths of the $L_I \rightarrow L_{III,II}$ transitions observed to date lie at 375, 317, 290, and 203 angstroms for Na, Mg, Al, and S, respectively. Radiationless transitions $L_I \rightarrow L_{III}$ which are energetically possible must play a prominent role in further weakening of the soft x-ray emission bands involving L_I as the initial state.

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On the Reflection-Transmission Effect in Experiments on Polarization of Electrons

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IT is contended by Shull, Chase, and Myers[1] that the difference between their measurements on the polarization of electron beams and the earlier attempts[2] to find this effect can be attributed to the so-called reflection-transmission effect of Chase and Cox.[3] We have made a more detailed examination of the connection between these two effects, the results of which we will communicate here.

When an electron beam is scattered over an angle θ, the intensity ratio of both states of polarization normal to the incident and scattered beams is given by[4]

$$\frac{I_+}{I_-}=\frac{1+\epsilon\sin\theta}{1-\epsilon\sin\theta}. \tag{1}$$

When the electrons are scattered twice over a right angle, the ratio of the total intensities of the beams antiparallel and parallel to the incident beam is therefore

$$\eta=\frac{I_a}{I_p}=\frac{(1+\epsilon)^2+(1-\epsilon)^2}{2(1-\epsilon^2)}=\frac{1+\epsilon^2}{1-\epsilon^2}. \tag{2}$$

In the experiments of Shull *et al.* 360-kev electrons were scattered by gold foils. They found $\eta_t=1.11$, $\epsilon=0.23$, in agreement with theory, when the beam passed through both foils (transmission position). When the foils were placed in reflection position, as had been done in the earlier experiments, the intensity ratio was only $\eta_r=1.02$.

The reflection-transmission effect consists in a difference in intensity between the 90° scattering as both sides of a foil orientated at 45° with the incident beam. The intensity ratio between the reflected and transmitted beams will be denoted by α. Now Shull *et al.* suggest that the difference between η_t and η_r can be understood by supposing the excess electrons in the case of reflection to be unpolarized. Under this assumption, which will be discussed later on, a relation between η_r, η_t, and α can be derived. Analogous to (2) we will have

$$\eta_r=\frac{(\alpha+\epsilon)^2+(\alpha-\epsilon)^2}{2(\alpha^2-\epsilon^2)}=\frac{\alpha^2+\epsilon^2}{\alpha^2-\epsilon^2}. \tag{3}$$

The experimental value of ϵ from the transmission experiment is 0.23. For α a value of 1.6 can be deduced from the data given by Shull *et al.* This would give $\eta_r=1.04$ as compared to the experimental value 1.02. As the accuracy of η is stated by the authors to be 2 percent, the calculated and observed values might be reconcilable. But, as the