difference; however, in that case the shift difference was found to be practically zero. Also, if our measured difference had been zero, the corresponding results for ^{44}Ca would have been for the c_n/z_n pair 3.68/0.60, 3.76/0.567; and if it had been +0.34, keV 3.68/0.47, 3.37/0.567.

We may also mention that this result of the neutrons extending beyond the protons for ^{44}Ca has been obtained with calculations where the nuclear distributions are built up from single-particle wave functions in shell-model potentials[11] and with Coulomb energy calculations.[12] Furthermore, an experimental work on K^--meson absorption[13] also showed, for a number of medium and heavy elements, that the neutrons probably extend beyond the protons, even if a large absorption parameter is considered for the optical model.

In regard to the width which was also found smaller for ^{44}Ca, any calculation is practically out of the question now, mostly because of a lack of theoretical as well as experimental data on the absorption part of the optical-model description of the π-nucleus interaction.

In summary, with the above mentioned reservations, we conclude from our experiments that the neutrons (rms radius 3.9 ± 0.15 F) seem to extend appreciably outside the protons (rms radius 3.55 F) at the nuclear surface of ^{44}Ca, if one admits that for ^{40}Ca both proton and neutron distributions are identical (rms radius 3.52 F).

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CONSTANCY OF INERTIAL MASS IN A CENTRIFUGAL FIELD*

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A search was made for a possible variation in the inertial mass of platinum with respect to that of magnesium produced by the application of a centrifugal field. No variation was found within an experimental uncertainty of 4 parts in 10^5 due to the application of a centrifugal field of $1.5\times10^5 g$ or within 3 parts in 10^{10} per g.

The mass of a light element such as magnesium or aluminum and the mass of a heavy element such as platinum or gold differ significantly in their mass composition. For example, the neutron-to-proton ratio is 1.026 in magnesium and 1.5 in platinum; the masses of the electrons in magnesium are nonrelativistic while the k-shell electrons in platinum have about 15% increase in their masses due to relativity; and the electromagnetic binding energy of the nucleus is very small in magnesium but is roughly 0.5% in the case of platinum. von Eötvös, Pekar, and Fekete[1] and more recently Dicke[2] and his associates concluded that the gravitational mass and the inertial mass of a body are equal within the limits of their experimental error. Dicke and his associates mounted aluminum and gold weights on a torsion balance and compared their accelerations with respect to the sun. They found that the accelerations of the two masses were equal with an accuracy of one part in 10^{11}. This Eötvös-Dicke experiment constitutes one of the most basic and important terms of reference for gravitational and cosmological theory. The effective gravitational and centrifugal fields in the above experiment are considerably smaller than the gravitational field of the earth g. This results from the fact that gravitational fields much in excess of g have not been produced on the earth. On the other hand, steady centrifugal fields up to $10^9 g$ have been generated in the laboratory and large centrifugal and gravitational fields are believed to exist in certain regions of the universe. Consequently it may be of interest to describe some experiments in which the force on a mass of platinum and on a mass of magnesium in a centrifugal field were found to be the same within an experimental uncertainty of about 3 parts in 10^{10} per g. It, of course, may be argued that the above results were to be expected because any relative variation in the inertial masses of heavy and light ions when they traverse a magnetic field and where the centrifugal field is very large would have been observed. On the other hand, the present results were obtained with macroscopic uncharged matter in the absence of magnetic and electrical fields. Also, they are free of complicating relativistic corrections since both masses move with essentially the same comparatively low speed.

Figure 1(a) shows a schematic diagram of the apparatus. The rotor R was spun inside the evacuated chamber V by an air-supported, air-driven turbine T situated below V. The flexible metal shaft S which connects the air turbine to the rotor passes through vacuum-tight oil glands G_1 and G_2. This method for supporting and spinning high-speed rotors in a vacuum has been previously described.[3] The rotor R, made of Duraluminum, is hollowed out as shown in cross section [Fig. 1(a)] and carries a liquid in which the Dow-metal cylinder C barely floats. The Dow metal is composed mostly of magnesium. The Dow-metal cylinder is shown in Fig. 1(b). It is approximately 1.50 cm in diam, 1.65-cm long, and very carefully machined. It contains three cylindrical channels parallel to the axis which do not quite extend to one end. On the other end, the holes are covered with an end cap so that

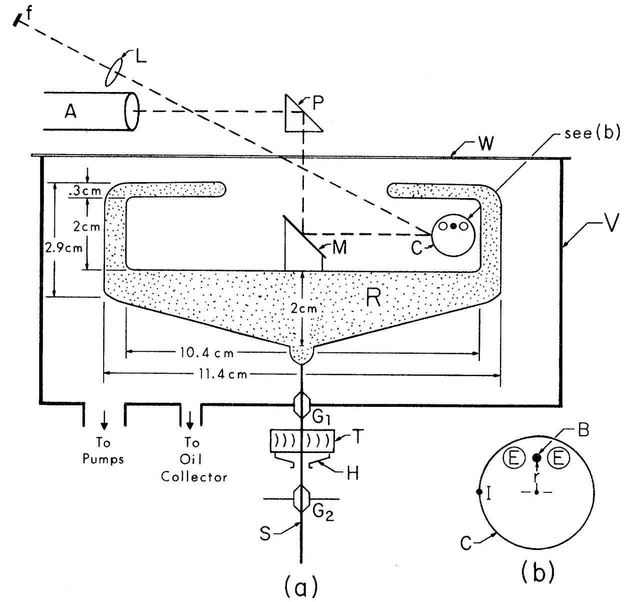

FIG. 1. (a) Schematic diagram of the apparatus. (b) Schematic cross section diagram perpendicular to the axis of the cylinder C showing location of platinum rod B.

they contain no liquid. The holes E contain only air while B contains a tightly fitting platinum rod. C and its end cap were weighed before and after the cylindrical holes B and E were bored. The platinum rod was then placed in B. C was floated first on an air cushion and then in the fluorocarbon liquid and carefully balanced until the metacenter and the center of mass were made to approach each other as close as possible. The dimensions of C were such that it floated stably with its axis parallel to the liquid surface.[4] In some cases, the cylinder C was placed in the rotor R with its axis in a plane perpendicular and in others parallel to the spin axis. Most of the observations were taken with the axis of C parallel to the axis of R. The rotor contains equally spaced radial vanes not shown in Fig. 1 to accelerate and decelerate the liquid. The liquids used to float C were fluorocarbons[5] with the numbers 43 and 101, whose densities at room temperature were greater than that of the Dow metal. The temperature of the rotor R which spun in a vacuum could be accurately controlled and thus easily adjusted so that C just floated, as shown in Fig. 1(a). The surface of the fluorocarbon liquid was covered with a layer of low vapor-pressure silicone diffusion-pump oil in order to prevent evaporation of the fluorocarbon. The chamber V was evacuated only when the rotor was spinning. A small scratch I

on C parallel to the axis and the tangent to the liquid surface was illuminated by a narrow vertical image of a fine filament lamp and viewed by the mirror M with a telescope A so that one set of the adjustable cross hairs coincided with the scratch and the other with the image of the edge (periphery) of C. W is a plate-glass top to the vacuum chamber. The image of C remained stationary regardless of the rotor speed.[6,7] The cylinder C also was observed with a stroboscope. By a tedious process of trial and error, with the help of surface tension and of small vibrations at certain rotor speeds, the cylinder C could be made to float free of the rotor surfaces. Small drifts which were usually present could be followed by the adjustable telescope. The experiment consisted in viewing the scratch I as a function of rotor speed both as the rotor was slowly accelerated and when it was decelerated. Three different cylinders C, each of which was subjected to the centrifugal fields many times, were used in the experiments. In one case a small rotation of C was observed but this was found to be due to an imbalance induced by the centrifugal field. In the other experiments no rotation of C around its own axis was observed when the centrifugal field was increased to approximately $1.5\times 10^5 g$ and then decreased. Rotation would have occurred if the centrifugal force on the platinum differed from that of the magnesium. The large number of experiments was necessary because of the considerable difficulty mentioned above in getting C sufficiently free of the rotor surfaces so that it could rotate about its axis.

If the inertial mass m of the platinum changes with respect to that of the magnesium by an amount Δm in the presence of the centrifugal field of $1.5\times 10^5 g$, then a torque equal to $\Delta m r \omega^2 a$ will act to rotate the cylinder C around its own axis, where r is the effective distance of the platinum from the axis of C, ω is the angular velocity of the centrifuge, and a is the effective distance from the axis of the centrifuge rotor R to C. The restoring couple[4,8] is given by $M(Ak^2/V-h)\varphi\omega^2 a$, where A is the area of the plane of flotation, k is its radius of gyration about the axis of rotation which is a principal axis, V is the volume of C immersed, h is the distance from the center of buoyancy to the center of mass of C, φ is the small angle of rotation of C, and M is the mass of C. Equating the two torques, $\Delta m/M = (Ak^2/V-h)\varphi/r$. An upper limit to $(Ak^2/V-h)$ of 7×10^{-4} cm was estimated by determining the period of the almost critically damped oscillation of C when disturbed while floating in the fluorocarbon 101 outside the centrifuge. It also could be very roughly determined from the amount of mass required to slightly unbalance C. The measurements were made both before and after subjecting C to the high centrifugal field. The value of $(Ak^2/V-h)$ in the presence of the centrifugal field may have been larger or smaller than the measured value because of the gradient of the centrifugal field, compression of the fluorocarbon, air-density gradients in EE, and the small elastic distortion of C. However, all of these factors could hardly have changed it more than a factor of 2, so that a value of 1.5×10^{-3} cm is believed to be a safe value for the experiment. A change in φ of 10^{-3} rad could have been detected. A somewhat smaller angle could have been detected had it not been for the small drifts or free floating of C. The mass of the platinum $m = 0.7$ g, the mass M was approximately $7.5m$, and $r = 0.4$ cm. Consequently $\Delta m/m$ was less than 4.0×10^{-5} in a centrifugal field of $1.5\times 10^5 g$. As stated in another way the change in the inertial mass of platinum with respect to that of magnesium in a centrifugal field is less than 3 parts in 10^{10} per g.

It might be noted that the above observations were taken with an experimental arrangement originally designed to determine the variation in the density of metals.[9] With a different design and stronger rotor materials the centrifugal field could easily be increased by a factor of 10 and the precision of the angular change φ probably could be increased by one or two orders of magnitude.

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ASYMMETRY PARAMETER FOR $\Lambda^0 \to n\pi^0$ †*

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The asymmetry parameter α_0 for $\Lambda^0 \to n\pi^0$ has been measured relative to α_- by comparing the neutron distribution with the proton distribution from the decay $\Lambda^0 \to p\pi^-$ for polarized Λ^0 hyperons. A sample of 4760 neutron decay events and 8500 proton decay events gave $\alpha_0/\alpha_- = 1.000 \pm 0.068$ in good agreement with the $|\Delta\vec{I}| = \frac{1}{2}$ rule.

This Letter reports the result of a second experiment designed to test the validity of the $|\Delta\vec{I}| = \frac{1}{2}$ rule in the hadronic decays of hyperons. The first experiment was a measurement of proton polarization in $\Sigma^+ \to p\pi^0$.[1] Because the Λ^0 hyperon is an isospin singlet, the $|\Delta\vec{I}| = \frac{1}{2}$ rule leads to a very simple relation between the amplitudes for $\Lambda^0 \to p\pi^-$ and $\Lambda^0 \to n\pi^0$, namely, $S_- = -\sqrt{2}S_0$, $P_- = -\sqrt{2}P_0$; here S and P represent the amplitudes for orbital angular momentum 0 and 1, respectively. In terms of these amplitudes the decay rate is given by $\Gamma = |S|^2 + |P|^2$ and the asymmetry parameter by $\alpha = 2\,\mathrm{Re}S^*P/(|S|^2 + |P|^2)$. The spatial distribution of nucleons is of the form $N(\omega) = (1/4\pi)(1 + \alpha P_\Lambda \cos\omega)$, where ω is the angle between the Λ^0 spin and the proton momentum in the hyperon rest frame, and P_Λ is the average Λ^0 polarization. In the absence of radiative corrections the $|\Delta\vec{I}| = \frac{1}{2}$ rule predicts the branching ratio to be $\Gamma_0/\Gamma_- = 0.5$, and the asymmetry parameter ratio to be $\alpha_0/\alpha_- = 1$. The best experimental value for the branching ratio is $\Gamma_0/\Gamma_- = 0.550 \pm 0.019$.[2] An earlier measurement of the asymmetry parameter ratio yielded $\alpha_0/\alpha_- = 1.10 \pm 0.27$.[3] The branching ratio is sensitive primarily to $|\Delta\vec{I}| = \frac{3}{2}$ S-wave amplitudes because $|S|/|P| \approx 3$, while the asymmetry parameter ratio is equally sensitive to S- and P-wave $|\Delta\vec{I}| = \frac{3}{2}$ terms. [See Eq. (5) below]. Within experimental errors these data allow P-wave $|\Delta\vec{I}| = \frac{3}{2}$ amplitudes of ~20%.[4] Radiative corrections are somewhat uncertain, but should be at the 3% level.[5] The ratio α_0/α_- was measured directly in this experiment by comparing the spatial distributions $N(\omega) = (1/4\pi)(1 + \alpha P_\Lambda \times \cos\omega)$ for neutrons and protons following the decay of polarized Λ^0 hyperons.

The Princeton-Pennsylvania Accelerator furnished a secondary positive beam at 1.0 GeV/c. The π^+ intensity in the beam was 10^5/sec with a ±1% momentum spread; the spot size at the final focus was 3.5 cm × 4.5 cm. The polarized Λ^0 hyperons were produced in liquid deuterium by the reaction $\pi^+ n(p) \to K^+\Lambda^0(p)$, where (p) represents the spectator proton. The K^+ mesons were detected electronically to select associated production events. The nucleons from Λ^0 decay were detected in a spark chamber array with 11 scintillators and 33 polyethylene plates each 60 cm square. Each scintillator was 0.3 g/cm^2 thick, and each polyethylene plate was 0.9 g/cm^2 thick. Neutrons were detected by observing recoil proton tracks in the spark-chamber volume. A floor plan of the apparatus is shown in Fig. 1. The K^+ mesons satisfied $\beta < 0.75$, stopped in the large water tank, and decayed into μ^+ each of which registered in one of 12 wrap counters surrounding the water tank. To study $\Lambda^0 \to n\pi^0$, a K^+ in coincidence with $\bar{P}N_I$ was required, where P was a veto counter to suppress charged particles, and N_I was a count in any one of the eleven scintillators in the polyethylene array. This signature was designed to detect proton recoils from n-p collisions. To study $\Lambda^0 \to p\pi^-$ the P counter was placed in coincidence. The charged trigger rate was 1 picture/sec, about half caused by $\Lambda^0 \to p\pi^-$. The neutral trigger rate was $\frac{1}{4}$ picture/sec, about $\frac{1}{4}$ caused by $\Lambda^0 \to n\pi^0$. Most of the rejected neutron triggers had no visible recoil proton in the polyethylene chamber. The detection efficiency for the chamber was 12% for 50- to 250-MeV neutrons from Λ^0 decay.[6] For each event the K^+ direction was recorded in a foil spark chamber