TABLE III. Isotopic composition of normal xenon.

Mass unit	Present data (180° M.S.) Abundance (percent)	Mean deviation	Nier's data*** abundance (percent)
124	0.095	±0.001	0.094
126	0.088	±0.001	0.088
128	1.917	±0.006	1.900
129	26.240	±0.080	26.230
130	4.053	±0.005	4.070
131	21.240	±0.030	21.170
132	26.930	±0.020	26.960
134	10.520	±0.020	10.540
136	8.930	±0.030	8.950

*** See reference 4.

The agreement between our results for xenon and those previously obtained by Nier is quite within the limits of accuracy claimed.

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Note on the Barometric Coefficient of Cosmic-Ray Intensity

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An analysis of the observations on cosmic-ray intensity was made by Duperier[1] in London to find the connection between surface pressure and cosmic-ray intensity. The high correlation coefficient of -0.87 was obtained between the hourly numbers of cosmic particles, averaged in groups of 24 hours, and the barograph readings at the station averaged over the same time intervals. It was also found that the barometric coefficient β, represented by the slope of the corresponding regression line, was 3.45 percent per cm mercury. The effects of absorption and decay have been separated by expressing the relation between the number of cosmic particles at ground level (N), the barograph reading at the station (B), and the height of the pressure level at which mesons are generated, (H), in the form

$$N-N_m=\mu(B-B_m)+\mu'(H-H_m),$$

where the subscript m refers to mean values μ represents the true absorption coefficient in air, and μ' the mean rate of decay of mesons. The true absorption coefficient in air was found to be 2.28 percent per cm mercury and the mean rate of decay of mesons 5.4 percent per km.

The purpose of the present note is to show that it is possible to find the value of the barometric coefficient by another method. We consider the effects of absorption and decay separately and shall first investigate the variation due to decay. Penner has analyzed the variations of pressure at different levels over Sault Ste. Marie, Michigan, and a diagram showing the variations is reproduced in Haurwitz's book.[2] The conditions over Europe and North America are similar, and Penner's diagram may be regarded as representative for the north temperature latitudes in general. We take the meson-producing layer to be at a height of 16 km corresponding to 75-mm pressure. It is seen from Penner's diagram that the pressure at 16 km rises by 1 mb when the pressure at the ground level rises by 4 mb. The isobar corresponding to 75-mm pressure rises through a height $\delta p/g\rho$, where δp is the rise in pressure at 16 km and ρ is the density of air at that height. Hence when the pressure at 16 km rises by 1 mb, the isobar corresponding to 75-mm pressure rises through 52 meters.

The mean free path (decay) of mesons (L) is related to the lifetime of mesons at rest, τ_0, by the well-known equation $L=E\tau_0/cM$, where M is the rest mass and E the energy of the mesons. If we assume that the mesons have a mean energy of 3×10^9 ev and take M equal to 200 times the mass of an electron and τ_0 equal to 2×10^{-6} sec. (Wilson),[3] we have $L=18$ km. If N_0 is the number of cosmic particles at 16 km, we see that $N_m=N_0e^{-16/18}$. When the pressure level at which mesons are produced rises through 52 meters, $N=N_0e^{-16.05/18}$, and the percentage variation is $(N-N_m)/N_m\times100$, or neglecting the negative sign, 0.28 percent. Hence, we infer that the percentage variation per cm of mercury is 0.92. The variation of cosmic-ray intensity due to true absorption can be deduced from the measurements by Ehmert[4] of the absorption curve in water, and is estimated by Duperier to be 1.65×10^{-3} cm²/g or 2.24 percent per cm of mercury. Therefore, the barometric coefficient is 3.16 percent per cm of mercury which is in good agreement with the value of 3.45 percent per cm of mercury obtained by Duperier.

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H^3 and the Mass of the Neutrino

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The maximum energy of the β-particles from H^3 has most recently[1] been reported as 11 ± 2 kev. The unusually low energy of this β-spectrum makes it extremely sensitive as an indicator of a non-vanishing rest mass for the neutrino. Coupled with measurements of the H^3 half-life, it shows that the neutrino cannot have a mass greater than 2 to 3 percent of the electron's rest mass. Moreover, the H^3 decay rate as presently known seems 6 to 10 times too rapid in comparison with that of heavier elements unless the neutrino is attributed a finite mass of the magnitude mentioned.

The relation[2] between the half-life t and the maximum energy E_0 (in units of mc²; here $E_0=0.021_5$) is such that the product $[|M|^2tf(E_0)]$ should be the same for all allowed β-transitions. $|M|^2$ is the so-called "nuclear matrix element" which measures the overlapping of the states connected by the transition. The function $f(E_0)$ is essentially the integral over the well-known statistical distribution of the energy between the electron and the neutrino:

$$f(E_0)=\int_0^{E_0} dE(1+E)(2E+E^2)^{\frac{1}{2}} \times(E_0+\mu-E)(E_0-E)^{\frac{1}{2}}(2\mu+E_0-E)^{\frac{1}{2}}.$$

Here μ is the ratio of the neutrino rest mass to that of the electron.

We compare H^3 with He^6, which may be regarded for our purposes as a fair representative of the allowed β-emitters. It has a half-life $t(He^6)=0.8$ sec. and an energy $E_0(He^6)=7.25$. The large energy makes μ negligible in the evaluation[2] of $f(He^6)=1200$. $|M|^2$ is expected[2] to have the value 6 for He^6, so that we have for the resulting product:

$$|M|^2ft=5760 \text{ sec.} \quad (He^6).$$

One gets[2] about this value for most of the allowed transitions.

The published[3] half-life of H^3 is about 30 years. Taking into account experimental uncertainties, it may easily be as low as 20 years. We calculate for both these values. $|M|^2=3$ is expected[2] for H^3. If the neutrino is assumed to have no rest mass, $f(H^3)\approx 0.216E_0^{7/2}=3.2\times 10^{-7}$. This yields:

$$|M|^2ft\approx 600 \text{ sec.} \quad (H^3;\ \mu=0;\ t=20 \text{ y.}),$$
$$|M|^2ft\approx 900 \text{ sec.} \quad (H^3;\ \mu=0;\ t=30 \text{ y.}).$$

Either result is far too small; with its low energy, H^3 should have a half-life of $\sim$200 y. on the basis of a neutrino without rest mass.

We now determine a neutrino rest mass μm so that H^3 will also yield $|M|^2ft\approx 5700$. If

$$E_0<\mu<1, \quad f\approx(\pi/4)\mu^{\frac{1}{2}}E_0^2[1+(5E_0/8\mu)+\cdots].$$

We obtain $\mu\approx 1/30$ for $t=20$ y. and $\mu\approx 1/45$ for $t=30$ y. Thus a neutrino mass can account for a discrepancy of a factor 10 in the H^3 half-life.

Attention should be directed to the simplicity of the theory on which this determination of the neutrino rest mass is based. Aside from the relatively unimportant factor of 2 arising from the comparison of $|M|^2$, the only theoretical assumption needed was that the electron and neutrino share their energy according to the simple statistical formula which yields the function f.

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On the Magnetic Field of the Milky Way and Its Effect on Cosmic Radiation

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IT was discovered by H. W. Babcock[1] that early-type stars possess very high magnetic fields, corresponding to magnetic moments of the order of 10^{37} gauss-cm^3, and that for stars of approximately the same mass the magnetic field is proportional to the angular momentum. On the assumption that this relation is applicable to a galaxy, he calculates a dipole moment of 10^{59} gauss-cm^3 for the Andromeda nebula (Messier 31) and concludes that "this should apply almost as readily to our galaxy as to the Andromeda nebula."

The purpose of this note is to point out that, so long as the condition of weak magnetic coupling among the stars of a galaxy still obtains, stellar dipole moments are still oriented at random and the resultant field of the galaxy almost vanishes. Under these conditions the considerations developed by Vallarta and Feynman[2] still hold and no effect on an isotropic distribution of charged cosmic rays entering the galaxy from the outside can be expected. Taking into account the order of magnitude of interstellar distances within the galaxy, it can be readily shown that even with stellar dipole moments as high as 10^{38} gauss-cm^3 the condition of weak coupling still prevails.

If high enough stellar magnetic fields are found within our galaxy to insure strong coupling among them, and a resultant galactic field, then observable effects on the intensity of cosmic radiation might well result. Some of the difficulties connected with the explanation of the diurnal and seasonal variations of intensity through the agency of the solar magnetic field alone might then disappear.[3] No galactic magnetic effect can be expected, however, as long as the condition of weak coupling among the stars of a galaxy still holds.

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Calculation of the Interaction between Two Particles from the Asymptotic Phase

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AS is well known, the asymptotic phase of a wave function can be calculated from the potential function. It seems to be of some interest to examine whether the reverse is also true, i.e., whether the potential can be calculated from the asymptotic phase. We shall show that this is possible, at least formally. Questions of convergence will not be taken into consideration.

In the case of elastic scattering the following reduced form of the Schrödinger equation is valid, ψ_r being the radial part of the eigenfunction and $u=r\cdot\psi_r$

$$\frac{d^2u}{dr^2}+k^2u-\frac{l(l+1)}{r^2}u=-V(r)u. \tag{1}$$

If $V(r)\rightarrow 0$ sufficiently rapidly, e.g., as r^{-2} or stronger, as $r\rightarrow\infty$, we have the asymptotic solution $u\sim\sin(kr-\frac{1}{2}l\pi+\delta)$, where δ is the phase. Then we get

$$k\sin\delta(k)=\int_0^\infty u_0V(r)udr, \tag{2}$$

where u_0 is the solution for $V=0$ which is regular in the origin, thus

$$u_0=(\tfrac{1}{2}\pi kr)^{\frac{1}{2}}J_{l+\frac{1}{2}}(kr). \tag{3}$$