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

MANUEL S. VALLARTA
Instituto de Física, Universidad de México, México
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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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[2] M. S. Vallarta and R. P. Feynman, Phys. Rev. **55**, 506 (1939).
[3] M. S. Vallarta and O. Godart, Rev. Mod. Phys. **11**, 180 (1939); B. Rossi, Cosmic Ray Conference, New York, April 1947.

Calculation of the Interaction between Two Particles from the Asymptotic Phase

CARL-ERIK FRÖBERG
Institute for Mechanics and Mathematical Physics, University of Lund, Lund, Sweden
July 30, 1947

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

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

Now u can be expanded in a series the first term of which is u_0, as follows

$$u = u_0 + \sum_{n=1}^{\infty} k^{-n} \cdot \int_0^r dr_n \cdot \int_0^{r_n} dr_{n-1} \cdots \int_0^{r_2} dr_1 \cdot V(r_1)\cdot V(r_2)\cdots V(r_n) \cdot K(r_n, r)K(r_{n-1}, r_n)\cdots K(r_1, r_2)u_0(kr_1), \quad (4)$$

where $K(r, s) = u_0(kr)\cdot v_0(ks) - u_0(ks)\cdot v_0(kr)$ and v_0 is defined by

$$v_0(z) = (-)^l \cdot (\tfrac{1}{2}\pi z)^{\frac{1}{2}} J_{-l-\frac{1}{2}}(z). \quad (5)$$

If all terms but u_0 are omitted in the first approximation and we put $f_0(k) = (d/dk)[k \sin\delta(k)]$, we obtain

$$f_0(k) = 2\int_0^{\infty} u_0 u_0' \cdot r \cdot V(r)\cdot dr. \quad (6)$$

The solution of this equation can be written in the form

$$V(r) = (8/\pi \cdot l!)\int_0^{\infty} k\cdot f_0(k)dk \cdot \int_0^1 (ktr)^l \cdot (1-t^2)^l \cdot v_l(2ktr)\cdot dt. \quad (7)$$

Here v_l is identical with v_0 defined in (5).

In the case $l=0$ we have $v_l(z) = \cos z$ and thus

$$V(r) = 8/\pi\int_0^{\infty} kf_0(k)dk \cdot \int_0^1 \cos 2ktrdt = 4/\pi \cdot \int_0^{\infty} f_0(k)(\sin 2kr/r)dk, \quad (8)$$

as can be obtained directly from the theory of Fourier integrals.

Formally it will be possible to continue to higher approximations. In doing so we do not change the form of the integral equation, only the function $f_0(k)$ will be modified.

A fuller account of the investigation will be presented in the Arkiv f. Mat., Astr. o. Fys., Stockholm.

I wish to express my gratitude to Professor W. Pauli, Zürich, for suggesting this investigation and for valuable discussions.

A Coincidence Study of Ga^{72}*

C. E. MANDEVILLE AND MORRIS SCHERB
Bartol Research Foundation of the Franklin Institute, Swarthmore, Pennsylvania
July 31, 1947

BETA-GAMMA and gamma-gamma coincidences in the disintegration of radioactive Ga^{72} prepared in the Clinton pile have been reinvestigated[1] with the aid of two thin-walled Geiger counters, a coincidence circuit, and a scale of sixty-four. The details of the technique have been described in several publications.[2]

In the case of beta-gamma coincidences, measurements were extended to a beta-ray energy of 1.93 Mev, and all data were corrected for gamma-gamma coincidences, gamma-ray singles in the beta-ray counter, and accidental coincidences. The accidentals were determined by the expression

$$A = N_1 N_2 (K\tau),$$

where $K\tau$ was four microseconds. The coincidence arrangement was investigated with a strong beta-ray source to

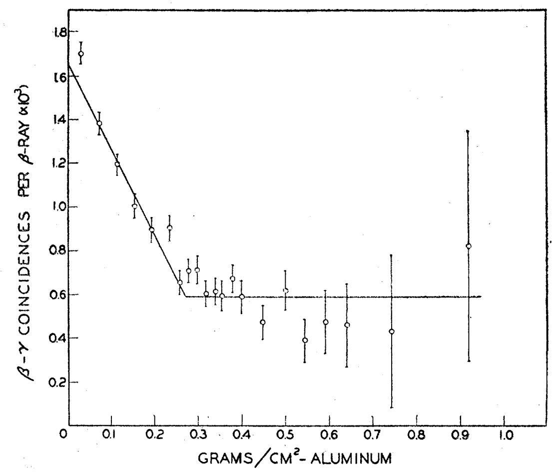

FIG. 1. Beta-gamma coincidences in the disintegration of radioactive gallium.

ascertain that no genuine coincidences were lost at the resolving time employed. The beta-gamma coincidences per beta-particle recorded in the beta-ray counter are plotted in Fig. 1 as a function of the thickness of aluminum absorber (wall thickness of the beta-ray counter included) between the thin source and the beta-ray counter. The genuine beta-gamma coincidences per beta-particle were observed to decrease from an extrapolated value of 1.63×10^{-3} at zero absorber thickness to 0.58×10^{-3} at a beta-ray energy of 0.72 Mev as determined by Sargent's equation.[3] The soft beta-ray spectrum of Ga^{72}, therefore, has a maximum energy of 0.72 Mev.

Gamma-gamma coincidences were observed to be $(0.84 \pm 0.10)\times10^{-3}$ per quantum recorded in the gamma-ray counter.

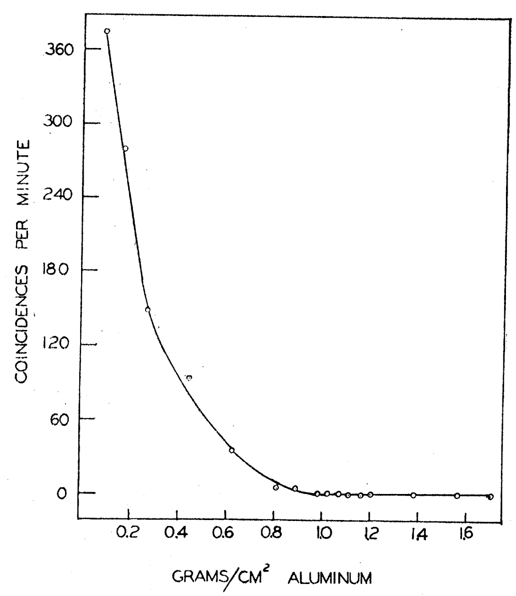

FIG. 2. Coincidence absorption of the Compton recoils of the gamma-rays from Ga^{72}.