marked asymmetry as is noted for the slow neutron fission of uranium may also be related to the supra-threshold energy at which the reaction occurs.

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[2] A 56-hr. $\beta^-$-emitter which proved to be the parent of 5-min. $Cu^{66}$.
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## Theoretical Evidence for the Existence of a Light-Charged Particle of Mass Greater than That of the Electron

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FROM theoretical considerations developed in a previous paper,[1] it can be deduced that particles with a charge equal to that of the electron and having a mass equal to 1.444 times that of the electron may be expected to exist.

It was shown that for an elementary charge the electrostatic potential

$$U=-(1/2K)\log[1-(2Ke/r)+(2K^2e^2/r^2)],$$

where $e$ is the charge and $K$ is a constant, satisfies the conditions that the integral of the charge density should be convergent and equal to $e$, and that the integral of the energy density should also be convergent. The value of the energy integral depends on that of $K$, and it also depends on the sign of $e$; the value is equal to

$$(e/4K)[(\pi/2)+1] \quad \text{or} \quad (e/4K)[(3\pi/2)-1],$$

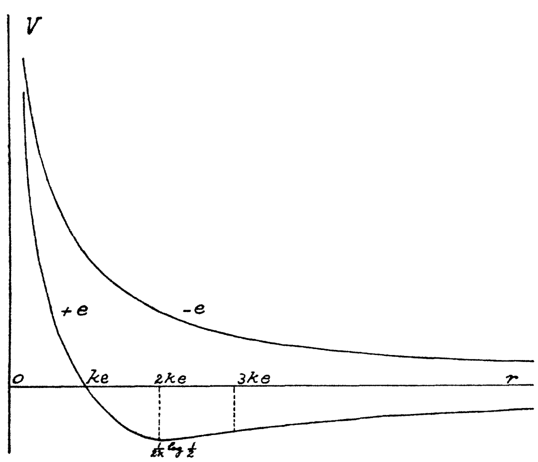


Fig. 1.

depending on whether $e$ is negative or positive. The ratio of these two values is 1.444. Setting the value of the energy integral equal to the mass of the electron gives us the value of $K$, which will thus depend on the sign chosen for the charge of the electron. If this is arbitrarily taken to be negative, then we obtain $K=3.8\times10^{4}$. There should then exist a positive particle of mass equal to 1.444 times that of the electron. A positive counterpart of the electron can also exist, but it should have a tendency to be annihilated by combining with an electron.

According to the sign of $e$, the potential curve takes one of the two forms shown in Fig. 1. For $e<0$, the curve has no minimum, and the force on a particle of the same sign is always repulsive. For $e>0$, there is a minimum at $r=2Ke$, and the field becomes attractive at distances smaller than $2Ke$. The force on a particle of opposite sign becomes repulsive at very small distances. With the value $K=3.8\times10^{-4}$ we find that the field changes sign for $r=3.7\times10^{-13}$.

Evidence for the existence of positive particles of mass greater than that of the electron occurring in the neighborhood of $\beta$-ray emitters has been found by Smith and Groetzinger.[2] A rough estimate of the mass, determined from the loss of momentum of the particle in a foil, has led the authors to a value approximately equal to 1.5 to 2 times the electron mass.[3]

It has also been recently reported in the press that charged particles of mass about three times that of the electron have been found by Auger in cosmic radiation.

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## Production of Cosmic-Ray Mesons

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IT is currently believed that cosmic-ray mesons are produced in nuclear events induced by primary protons near the top of the atmosphere. The well-known difficulty of the absence of nuclear interaction by sea level mesons and the recent experiments with photographic emulsions[1] have led to the idea[2] that $\pi$-mesons, of mass 180 Mev, are the ones produced initially and that each $\pi$-meson quickly decays ($10^{-7}$–$10^{-10}$ sec. lifetime) into an "ordinary" $\mu$-meson of mass 100 Mev and a neutral recoil. An investigation has been undertaken to see whether these ideas are in quantitative agreement with actual observations on meson spectra and intensities.

It is found that there is indeed agreement if the mean free path for absorption of the primary protons is taken to be $\sim$5 cm Hg and if about half the primary energy goes to charged $\pi$-mesons, the average multiplicity being around 5 at high latitudes and increasing roughly as the square root of the primary energy.

Our analysis is based on the following argument. No meson theory has as yet proved adequate, but if one uses the general picture that a field of virtual mesons surrounds