We find that if the probability of producing neutrons is proportional to the energy of the primary, the −1.8 spectrum predicts more neutrons than are observed. Even if we assume that the probability increases more slowly than a first power of the energy, there are still too few neutrons. It appears that the primary spectrum is probably not properly represented by the −1.8 power in the energy interval between 2 Bev and 300 Mev, but the exponent is likely a number closer to unity.

The experiments will be reported in fuller detail at a later date.

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Multiple Scattering of Fast Particles in Photographic Emulsions

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In recent experiments[1, 2] the small angle scattering of fast particles in photographic emulsions has been measured fairly accurately. The main purpose of this note is to point out that the detailed multiple scattering theory of Williams[3] gives results in approximate agreement with experiment. The formulation of Williams' theory given by Rossi and Greisen,[4] which was used for comparison in the above work, predicts greater mean scattering angles than those measured, and is not applicable under the conditions of these experiments. Corson also compares his results with the theoretical calculations of Snyder and Scott,[5] with which they are in closer agreement.

In both experiments[1, 2] $\langle\alpha(q)\rangle_{\mathrm{Av}}$, the projected mean angle between successive chords, was measured at intervals, q, along a track, following the method of Fowler.[6] Assuming that $\langle\alpha(q)\rangle_{\mathrm{Av}}\propto(q)^{\frac{1}{2}}$, and cutting off all angles $>4\langle\alpha(q)\rangle_{\mathrm{Av}}$ our results[1] from Li(p, γ) γ-ray electron pairs give $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}=21.3\pm1°/p\beta$, where p is in units Mev/c and β in units of c. Similarly, the results of Corson[2] on 115-Mev electrons yield $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}=19.6\pm2.5°/p\beta$. From Williams' theory[3] we calculate for photographic emulsions that $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}=22.8°/p\beta$ for $Z/137\beta\ll1$ (corresponding approximately in emulsions to the case when $\beta\sim1$),[7] and $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}=25.8/p\beta$ for $Z/137\beta\gg1$. Thus, Williams' relativistic relation is in approximate agreement with the fast electron calibrations. According to Corson[2] the scattering theory of Snyder and Scott gives $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}=23.0/p\beta$ which is nearly the same as the value given by Williams' relation. Also, it may be noted that, according to Williams,[8] the scattering theory of Goudsmit and Saunderson[9] gives results which agree with his own within a few percent.

The use of Williams' relation applies if α_{ms}, an angle which defines the change-over from multiple to single scattering conditions, is $<\bar{\lambda}/b$, an upper limit to the scattering angle given by the finite size of the nucleus ($2\pi\bar{\lambda}=$ de Broglie wavelength of the particle and $b=$ nuclear radius). For the photographic emulsion method this should hold in all practical cases. Actually, in the detailed statistical treatment,[3] the variation of $\langle\alpha(q)\rangle_{\mathrm{Av}}$ with q is more rapid than $(q)^{\frac{1}{2}}$, and the cutoff for the scattering distribution is not exactly $4\langle\alpha(q)\rangle_{\mathrm{Av}}$ but depends slightly on q, so that, in practice, the results should be analyzed explicitly for each q used in the experiments. In our experiment,[1] where $q<100\mu$, the value of $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}$, as deduced by assuming $\langle\alpha(q)\rangle_{\mathrm{Av}}\propto(q)^{\frac{1}{2}}$, should be increased by a few percent, bringing the results into closer agreement with Williams' relation. On the other hand, when $q>100\mu$, i.e., measuring particles with $p\beta>100$ Mev, $\langle\alpha(100\mu)\rangle_{\mathrm{Av}}$ will be less than that deduced by assuming $\langle\alpha(q)\rangle_{\mathrm{Av}}\propto(q)^{\frac{1}{2}}$. A more detailed analysis of our scattering results will be published when they are completed.

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The Strength of Interstellar Magnetic Fields

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This note outlines an argument that indicates that magnetic fields as strong as 10^{-4} gauss may extend through interstellar regions several hundred parsecs across. If established, this should be significant both in astrophysics and in the study of cosmic rays.

The experimental basis for the argument is the discovery by Hiltner[1] and by Hall[2] that if the light of a star is greatly weakened by its passage through interstellar dust, it is usually partially plane polarized to a small extent. The spatial anisotropy responsible must be fairly uniform, in at least one region, over a distance of some 200 parsecs, since the planes of polarization for different stars are found to be nearly parallel[3] for low galactic latitude and galactic longitudes between 80° and 120° (or perhaps even 170°) and since the mean distance to the obscuring matter, where the polarization presumably occurs, is at least 300 parsecs. The key assumption of the argument is that this anisotropy is due to an interstellar magnetic field. A survey of other possible anisotropies seems to reveal no plausible basis for the observed polarization, while a magnetic field is required both by Spitzer and Tukey[4] and by Davis and Greenstein[5] for their theories of the origin of the polarization. In the theory of Spitzer and Tukey the field in this region is mainly normal to the plane of the galaxy; in that of Davis and Greenstein it is mainly parallel to the plane of the galaxy, perhaps along the spiral arms or perhaps making random whirls in this plane. Regardless of the exact mechanism, if a magnetic field is involved, it must have some uniformity corresponding to the observed nearly parallel alignment of the planes of polarization for different stars.

A lower limit to the strength of the field can be deduced from the requirement that the field be strong enough to maintain its large scale anisotropy in the presence of the motions of the interstellar material. This section of the argument is based on the concepts of magneto-hydrodynamics introduced by Alfvén[6] and used by Fermi[7] and Schlüter and Biermann.[8] Because of its high conductivity the interstellar medium is coupled to the magnetic field, no relative motion being permitted normal to the field. When the field is weak, the situation is dominated by the material which, as it moves, drags the lines of force with it, forming a very crooked pattern in which the directions of the field would change greatly in distances of the order of 10 parsecs. This is the situation contemplated by Fermi; but if the field is strong, it dominates the situation and any motion of the matter will be similar to that of a bead moving on a vibrating string, the lines of force not being sharply bent by the moving matter. The observed approximate