Angular Distribution of Cosmic-Ray Particles

The recent cosmic ray[1] survey indicates that at least a part of the cosmic radiation comes to the earth in the form of charged particles, whose paths are influenced by the earth's magnetic field. This suggests an experiment to determine the predominating direction of these particles at several altitudes. To do this the directional intensity of these rays at different angles of elevation was measured in two planes perpendicular to each other. It was hoped to detect any possible shift of the maximum from the vertical which would indicate a predominance of charged particles of one sign. Such a survey was begun at Denver last October.

The apparatus, which was the familiar double Geiger counter arrangement,[2] had been developed for another purpose, but was readily adapted to this work. The counters were 1.5 cm inside diameter, 9 cm in length, and spaced 17 cm between centers. The experiment was performed in a thin roofed frame building whose absorption was negligible. The horizon was clear except for a brick building on the east, whose top subtended an angle of elevation of 40°. The results indicate that the shielding or scattering effect of this building was not significant.

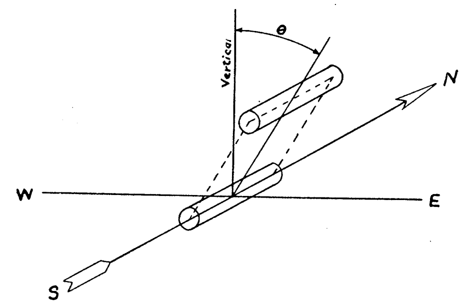

FIG. 1.

The counters were arranged as in Fig. 1 to obtain the data of Fig. 2a, while the data in 2b were determined by rotating the whole structure through 90° about the vertical axis. The points were taken alternately on opposite sides of the vertical, starting with the vertical, to reduce any effects due to slow changes in the sensitivity of the apparatus. Each point represents a run of 24 hours. The constancy of the apparatus was checked each ten days by determining the number of coincidences for a 24 hour period with the counters in a vertical direction. A record of the barometric pressure was kept, but its small variation was not considered significant on the final result.

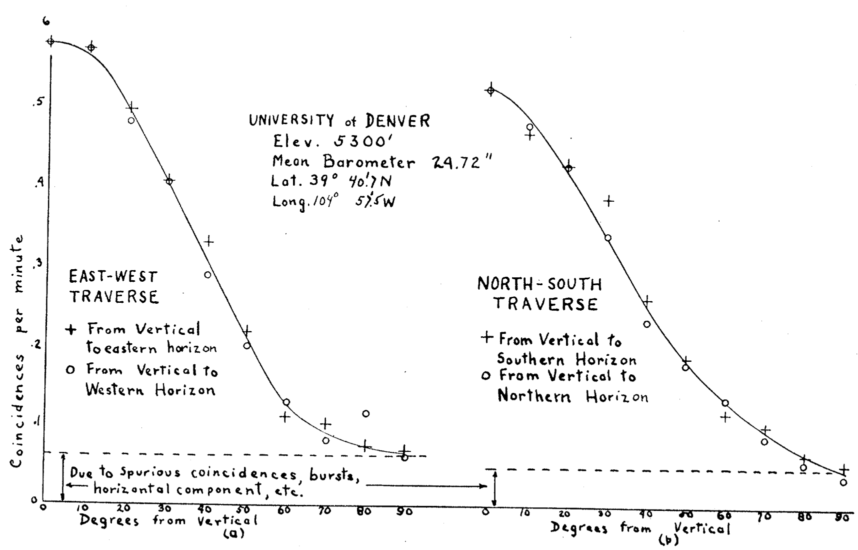

FIG. 2.

During the progress of the experiment the Vallarta-Lemaitre[3] theory of paths of charged particles in the earth's magnetic field appeared. This theory predicts no appreciable asymmetry of the radiation at the latitude of Denver.

The deviations of the points of Fig. 2 from the smooth symmetrical curve are within the range to be expected from a statistical study of the data. This would indicate a maximum intensity in the vertical direction. After the two curves in Fig. 2 had been obtained, it was decided to investigate the intensity in the region of the vertical more

[1] A. H. Compton, Phys. Rev. **43**, 387 (1933).

[2] Bennett, Stearns and Overbeck (in publication).

[3] Lemaitre and Vallarta, Phys. Rev. **43**, 87 (1933).

carefully. Alternate readings of 24 hours' duration were taken 2.5° north and south of the vertical, respectively. Because of an accident, these readings extended over only an eight day period. The results of these observations were 0.540 ± 0.020 and 0.587 ± 0.040 for directions 2.5° north and south of the vertical, respectively. This work is being repeated at the present time.

This result, like the preliminary results recently reported by Johnson[4] is in accord with the theory of Vallarta and Lemaitre.

The equipment was purchased with funds provided by the Rumford Committee.

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[4] T. H. Johnson, Phys. Rev. **43**, 1059(A) (1933).

Hyperfine Structure and Isotopic Constitution of Tungsten

The arc spectrum of tungsten was excited in a Schüler tube cooled in liquid air, the tungsten lines being very much stronger than those due to the inert gas (argon) used as an activator. Lines in the visible were photographed with a three prism glass spectroscope using silvered Fabry Perot etalons placed in the parallel beam behind the collimator.

Aston[1] reports four isotopes of tungsten of mass and abundance 182, 22.6 percent; 183, 17.2 percent; 184, 30.1 percent and 186, 30.0 percent. Our patterns show but three components which, since they have nearly equal separations, are attributed to the three isotopes of even atomic weight. Microphotometer traces taken on a number of lines show that the intensity relations between the three components differ materially from line to line. This indicates that a fourth isotope is present and shows that the component (or components) due to the odd isotope is differently placed with respect to the three even isotopic components in various lines. This is just what one would expect if the fourth isotope has both a magnetic and a mechanical nuclear moment.

Several lines, arising from transitions into levels involving a single $6s$ electron, are not split even with the largest separators employed, i.e., the isotope shift is practically zero. A preliminary investigation of such lines with small and large separators, having revealed no h.f.s. for isotope 183, indicates that the g-factor is quite small. Although the electron configurations for most of the levels in tungsten have not yet been published, the ground state[2] is reported to be $5d^4 6s^2$, ^5D and the first excited state to be $5d^5 6s$, ^7S. The theory of isotope shift in spectrum lines, as developed by Breit[3] indicates, in general, that the greatest isotope shift is to be expected in levels involving two tightly bound s electrons like $5d^4 6s^2$. Assuming the resolved lines are due to transitions into the ground states, and that the ground states are the levels widely split, the isotope intensities indicate that the levels of the heavy isotope lie deepest. This is in contradiction to the isotope shifts in Pb, Tl and Hg, treated by Breit but in agreement with the shifts in Zn observed by Schüler and Westmeyer.[4]

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June 7, 1933.

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[1] Aston, Nature **126**, 913 (1930).

[2] Bacher and Goudsmit, *Atomic Energy States*, p. 500.

[3] Breit, Phys. Rev. **42**, 384 (1932).

[4] Schüler and Westmeyer, Zeits. f. Physik **81**, 565 (1933).