## Cosmic Rays in the Bering Sea

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THE authors have previously reported[1] an investigation of the latitude effect between the magnetic latitudes of 53° 30′ N and 61° 36′ N with a precision type ionization chamber. The data there obtained showed the intensity, after reduction to a standard barometer and temperature, to be approximately independent of latitude. There were, however, some disturbing features ascribed to the "horizon effect," the principal one being a drop of 2 percent at the high latitude end of the curve. In order to check whether this was a purely local effect, and also in order to extend reliable measurements to as high a magnetic latitude as possible, measurements of cosmic-ray intensity were carried out along the northwest coast of North America from Seattle through the Gulf of Alaska and the Bering Sea and along the Alaskan Arctic coast as far as Point Barrow.

The apparatus used was a Millikan-Neher type of electroscope[2] shielded with 11 cm of lead. Unfortunately there were two factors which materially reduced the precision of the present measurements over those of the preceding investigation.[1] The first factor was the lower intrinsic sensitivity of this instrument as compared with the Carnegie Model C [3] meter used previously and the second factor was the inability to take repeated readings over the same course, as had been done previously. The meter was mounted aboard the Coast Guard Cutter *Itasca* during the period from July 26 to October 10, 1940 while it was on patrol duty in the Bering Sea.

The hourly values of the cosmic-ray intensity were averaged over six hourly periods and reduced to a standard barometer of 760 mm of mercury by using a barometric coefficient of 0.17 percent per mm of Hg as determined by Millikan and Neher.[2] The daily averages of these intensities were then taken and plotted against the daily mean geomagnetic latitude of the ship. These results are shown in Fig. 1 where the vertical scale is arbitrary but proportional to the intensity and the point 9.0 represents 1.90 ions/cc/sec./atmos. of air. From the figure it can be seen that the values of intensity at any given magnetic latitude, which in general were taken at very different geographic locations, agree as well as the intensities taken on different days at a definite geographic location such as Unalaska or Nome. This would indicate that there is no significant difference in intensity over the whole region investigated. The results were next averaged by degrees of magnetic latitude and all reduced to a standard atmospheric temperature of 50°F by the use of the temperature coefficient of −0.05 percent per degree previously found by the authors[1] and other investigators[4] for rays of the type measured by such a lead-shielded ionization chamber. The temperature correction made no significant difference in the intensities with the exception of the intensity measured at Point Barrow where the temperature was 36°F.

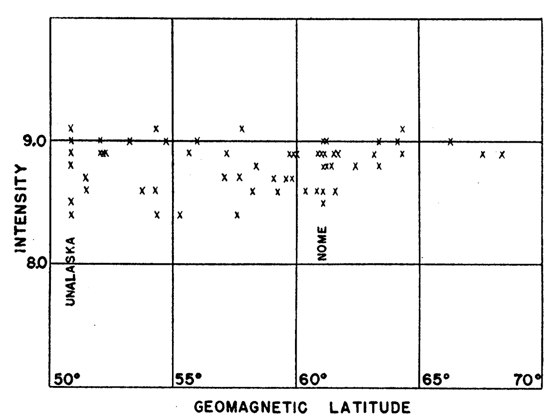


FIG. 1. Daily mean cosmic-ray intensities as a function of geomagnetic latitude.

The mean intensity *vs.* magnetic latitude curve after reduction to standard temperature is shown in Fig. 2

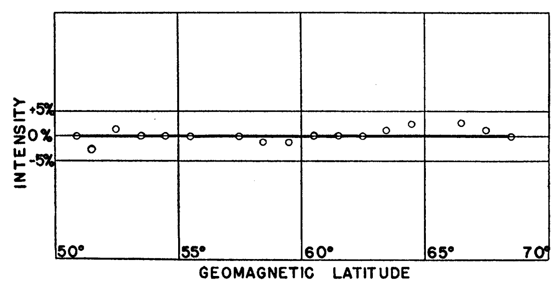


FIG. 2. Mean cosmic-ray intensities for each degree of latitude plotted against latitude.

where the vertical scale shows percent deviation from the mean. Since, under the conditions of measurement, the intensities are accurate to within 1 or 2 percent,[2] the intensity can be regarded as substantially independent of magnetic latitude over the region investigated.

The results of the present investigation are two. First, it is shown that the drop at the high latitude end of the intensity *vs.* latitude curve previously obtained by the authors is not the beginning of a downward trend but a purely local phenomenon due, evidently, to the "horizon effect." Secondly, the investigation of the latitude effect has been carried to higher magnetic latitudes (68° 22′ N) than have previously been reached and the intensity found to be independent of latitude up to this point. The accuracy of the measurements was not such as to afford any reliable information on the "atmospheric latitude effect" of Compton and Turner[5] nor of the allied "air mass effect"[6] in these regions.

The authors wish to express their sincere appreciation to Commander F. A. Zeusler, Commandant of the Juneau District, U. S. Coast Guard, and to Commander L. W. Perkins, commanding officer of the cutter *Itasca*, for making possible a trip into the Bering Sea and Arctic; to President L. P. Sieg of the University of Washington for making available the necessary funds; to Dr. J. A.

Fleming of the Department of Terrestrial Magnetism for supplying the apparatus, and to Dr. H. V. Neher for carefully rechecking the quartz electroscope.

[1] Paul F. Gast and D. H. Loughridge, Phys. Rev. **59**, 127 (1941).
[2] R. A. Millikan and H. V. Neher, Phys. Rev. **50**, 15 (1936).
[3] A. H. Compton, E. O. Woldan and R. D. Bennett, Rev. Sci. Inst. **5**, 415 (1934).
[4] V. F. Hess, Phys. Rev. **57**, 781 (1940).
[5] A. H. Compton and R. N. Turner, Phys. Rev. **52**, 799 (1937).
[6] D. H. Loughridge and Paul F. Gast, Phys. Rev. **58**, 583 (1940).

## The Magnetic Anisotropy of Gadolinium Sulphate Octahydrate

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In a previous publication[1] we reported preliminary measurements on the magnetic anisotropy of gadolinium sulphate octahydrate, $Gd_2(SO_4)_3 \cdot 8\,H_2O$, made with a moderately pure specimen. The difference between the two extreme principal susceptibilities of the crystal was found to be about 1.4 percent of its mean susceptibility. This value for the magnetic anisotropy, though small, is much larger than should be expected from the narrow separation of the $^8S$ levels of $Gd^{+++}$ that would occur under the crystalline electric fields in the neighborhood of the $Gd^{+++}$ ions in the crystal.

Recently we have made measurements with a specimen of known purity, kindly presented to us by Professor Trombe, of the Paris University. The specimen was quite free from both samarium and terbium, and its europium content was less than 0.1 percent. The main impurity present was the *diamagnetic* yttrium salt, about 1.4 percent, which will not affect the magnetic anisotropy appreciably. The results of the magnetic measurements are given below.

The crystal of $Gd_2(SO_4)_3 \cdot 8\,H_2O$ is monoclinic, and has the axial elements $a : b : c = 3.009 : 1 : 2.007$, $\beta = 118°.0$. Denoting the maximum and the minimum susceptibilities in the (010) plane, for the above formula weight (747 grams, containing 2 gram ions of $Gd^{+++}$), by $\chi_1$ and $\chi_2$, respectively, and the susceptibility along the $b$ axis by $\chi_3$, it is found that at room temperature (303°K): $\chi_1 - \chi_2 = 36 \times 10^{-6}$; $\chi_3 - \chi_1 = 16 \times 10^{-6}$; $\chi = (\chi_1 + \chi_2 + \chi_3)/3 = 52{,}000 \times 10^6$ e.m.u. The $\chi_1$ axis makes an angle of about 17° with $c$ and 45° with $a$. The difference between the extreme susceptibilities, namely $\chi_3 - \chi_2 = 52 \times 10^{-6}$, is only 0.1 percent of the mean susceptibility. This value of the anisotropy will correspond to a separation of the order of $\epsilon$ between the adjacent levels in the Stark pattern of the $^8S$ state of $Gd^{+++}$, where

$$\frac{\epsilon}{k \times 303°} \sim 10^{-3} \quad \text{or} \quad \epsilon \sim k \times 0.3°, \quad \text{or} \quad 0.2\ \text{cm}^{-1},$$

which is of the same order as should be expected from the demagnetization and the specific heat measurements on the salt at very low temperatures.[2]

[1] Krishnan, Mookherji and Bose, Phil. Trans. Roy. Soc. **A238**, 133 (1939).
[2] See M. H. Hebb and E. M. Purcell, Phys. Rev. **51**, 384A (1937).

## A Single Component for the Primary Cosmic Radiation

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With reference to the *Letter to the Editor* entitled "The nature of the primary cosmic radiation and the origin of the mesotron," by M. Schein, W. P. Jesse and E. O. Wollan,[1] I wish to point out that identical conclusions have been cited by the present writer from other considerations. These conclusions, which are covered in three published communications,[2] are as follows:

(1) There is *only one type of primary radiation*, a charged particle radiation—probably protons—comprising particles of heavy mass.

(2) By processes at present unknown, the *primary radiation gives birth, probably indirectly, in the upper atmosphere, to mesotrons.*

(3) Those mesotrons which are born approximately at rest will have such short lives that they will disintegrate before they have traveled more than 300 meters. *They will, in fact, disintegrate in the stratosphere, and in so disintegrating, will give rise to electrons which, on account of the disintegration occurring from mesotrons at rest, will emerge on the average equally in all directions.*

(4) The mesotrons formed with higher energy will disintegrate at lower altitudes, because of their longer lives, and *because they disintegrate at high energy, will give rise to electrons which possess on the average a forward component at these lower altitudes.*

(5) The assumptions (1) and (2) lead, through the logical consequences (3) and (4), to an explanation of the following facts: (a) As shown by the Bartol Foundation's observations in the two National Geographic—U. S. Army Air Corps Stratosphere Flights[3,4] and in the Jean Piccard Flight,[5] *the curve of intensity versus zenith angle flattens out with increasing altitude* to a condition in which, at a depth of 0.5 meter in the water equivalent atmosphere, there is only a 20 percent change from vertical intensity to horizontal intensity. (b) As shown by our stratophere observations in *Explorer II*[4] and independently by the observations of T. H. Johnson and J. G. Barry,[6] *there is no appreciable azimuthal asymmetry at high altitudes.* It was, of course, to provide for the experimental facts cited under (a) and (b), that the hypotheses (1) and (2), with the consequences (3) and (4), were formulated.

(6) Any incoming electrons of primary origin and of one sign would necessitate azimuthal asymmetry and primary electrons of one sign or of both signs would cause strong dependence of intensity upon zenith angle. The absence of such effects prohibits assumption of the existence of any primary electrons and *necessitates that all the cosmic-ray electrons be born from the mesotrons in accordance with (2).*[7] *In other words, there can be no primary electrons.*

That the primary cosmic rays are *in part protons* has been suggested by A. H. Compton and H. Bethe,[8] and also by T. H. Johnson.[9] A single primary radiation of protonic nature giving rise to mesotrons and through them to the