A Note on the Variation of Cosmic Ray Intensity Produced by an Electric Field

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The variation of the cosmic ray intensity during a magnetic storm has been ascribed to the electrically polarized beam of particles from the sun.[1] The loss of particles due to the total reflection in the electric field has been calculated.[2] For comparison with observations, however, the change of the intensity I per surface element dS, solid angle $d\Omega$, and energy interval dW should be considered.

For the motion of particles in electromagnetic fields there exists a Hamiltonian. In a slowly varying field the density of particles in ordinary momentum space (x, p), $D = dN/dV_x dV_p$, is constant along a trajectory.[3] Putting $dV_x = dSpdt/m$ (m = mass), $dV_p = p^2 d\Omega dp$ and $dN = I(W) dW dS d\Omega dt$ one finds

$$I = Dp^3 dp/mdW$$

or since $c^2p^2 = W(W + 2\,W_0)$, $mc^2 = W + W_0$

$$I = W(W + 2\,W_0) D$$

For particles reaching the earth with the energy W and the intensity $I'(W)$ and having far away the energy $W + \Delta W$ and the intensity $I(W + \Delta W)$

$$I'(W)/I(W + \Delta W) = W(W + 2\,W_0)/ (W + \Delta W)(W + \Delta W + 2\,W_0)$$

or for ΔW small

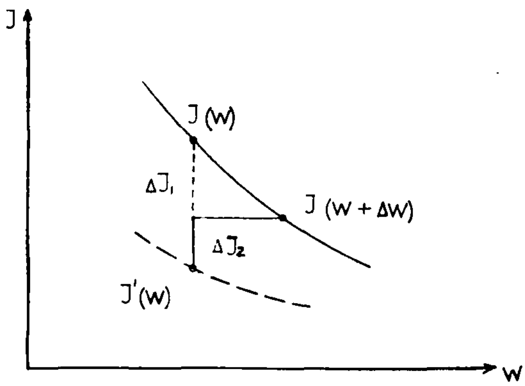
$$\Delta I/I = [I'(W) - I(W)]/I(W) = = [WdI/IdW - 2(W + W_0)/(W + 2W_0)]\Delta W/W$$

[1] H. Alfvén, *Cosmical Electrodynamics*, Oxford, 1950.
[2] B. Trumpy, *Physica* XIX, 645, 1953.
[3] L. Jánossy, *Cosmic Rays*, Oxford 1948, p. 266.

Assuming an undisturbed spectrum $I(W) = = AW^{-k}$

$$\Delta/I = I - (k + k_1)\Delta W/W$$

with $1 \leq k_1 \leq 2$ and $k \approx 2.5$. ΔW is the decrease of energy of the particle due to its motion in the electric (not necessarily electrostatic) field. The two terms of ΔI are shown in fig. 1.



Decrease of cosmic ray intensity I due to a change in the earth's electric potential corresponding to a change of particle energy $= \Delta W$. I = undisturbed spectrum, I' = observed spectrum. $I_1 = WdI/IdW \cdot \Delta W/W$, $I_2 = 2(W + W_0)/(W + 2W_0) \cdot \Delta W/W$.

The result is valid for any direction in which particles can reach the earth. If the electromagnetic field of the beam introduces forbidden cones, these should be considered. The change of intensity here is considerably lower than that given in (2).