ON THE PRODUCTION MECHANISM OF RADIO_PULSES FROM LARGE EXTENSIVE AIR SHOWERS

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1. Introduction : None of the theories (1,2,3 & 4) put forward so far to explain the radio-emission from EAS, has been successful to give satisfactory explanation of all the experimental data obtained from various laboratories over the globe. It is apprehended that emission mechanism at low and high frequencies may be quite different (5). This calls for new theoretical look into the phenomenon.

Using basic equations of Kahn & Lerche (1) and a much sophisticated model for shower structure, Castagnoli et al. (2) calculated the radiation field at a point outside the disc of charges. They, however, calculated the radiation field due to current and excess charge only. In this paper, the resultant field inside the disc of charges, due to current and dipole moment have been calculated afresh using the technique adopted by Castagnoli et al. (2), from very low to very high frequencies.

2. Methods : The radiation field at a distance R from the axis of the shower disc can be obtained by phase mixing the contributions from the various rings of charges. For a point lying inside the disc of charges of radius Ro at a distance R from the axis, the point will be an outer one w.r.t. the disc of radius R and an inner one w.r.t. the annular ring of inner radius R and an outer radius Ro. Accordingly, effects of the disc of radius R and the annular ring are to be taken into account.

The current field at a distance R from the axis ($R < Ro$) :

(A) Current field due to the disc of radius R :

$$E_c'(R) = -\frac{ke\times 10^5}{2C(29\cdot 4)^2}\times 2\pi\times 0\cdot 4N\times H_0^{(1)}(K\alpha R)\int_0^R J_0(K\alpha r)r^2\left(\frac{r}{29\cdot 4}\right)^{-0\cdot 75}\left(\frac{r}{29\cdot 4}+1\right)^{-3\cdot 25}\left(1+\frac{r/29\cdot 4}{11\cdot 4}\right)dr \cdots (1)$$

(B) Current field due to the annular ring of inner radius R and outer radius Ro :

$$E_c''(R) = \frac{-ke}{2C}\,\frac{J_0(K\alpha R)}{(29\cdot 4)^2}\times 10^5\times 2\pi\times 0\cdot 4N\int_R^{R_0} H_0^{(1)}(K\alpha r)r^2\left(\frac{r}{29\cdot 4}\right)^{-0\cdot 75}\left(\frac{r}{29\cdot 4}+1\right)^{-3\cdot 25}\left(1+\frac{r/29\cdot 4}{11\cdot 4}\right)dr \cdots\cdots (2)$$

The dipole field at a distance R from the axis (R < Ro) :

(C) Dipole field due to the disc of radius R :

$$E_p'(R) = i K\alpha e r\pi\frac{0\cdot 4N 10^5}{40(29\cdot 4)^2}\,H_0^{(1)'}(K\alpha R)\int_0^R J_0(K\alpha r)r^2\left(\frac{r}{29\cdot 4}\right)^{-0\cdot 75}\left(\frac{r}{29\cdot 4}+1\right)^{-3\cdot 25}\left(1+\frac{r/29\cdot 4}{11\cdot 4}\right)dr \cdots\cdots (3)$$

(D) Dipole field due to the annular ring of inner radius R and outer radius Ro :

$$E_p''(R) = i K\alpha e r\pi\frac{0\cdot 4N}{40(29\cdot 4)^2}\times 10^5 J_0'(K\alpha R)\int_R^{R_0} H_0^{(1)}(K\alpha r)r^2\left(\frac{r}{29\cdot 4}\right)^{-0\cdot 75}\left(\frac{r}{29\cdot 4}+1\right)^{-3\cdot 25}\left(1+\frac{r/29\cdot 4}{11\cdot 4}\right)dr \cdots\cdots (4)$$

The vector sum of E_c', E_c'', E_p' & E_p'' will give the resultant field.

3. <u>Results</u> : Equations (1) to (4) have been integrated numerically at various frequencies for R=40 m, Ro=100 m and $E = 10^{16}$ eV. Theoretical frequency spectra of (i) the present work, (ii) Hough, as well as the experimental data of different workers normalised at 80 MHz with the theoretical curve of Hough (4), are shown in Fig.1.

4. <u>Discussion</u> : Experimental results of different workers (6,7, 8) support the presence of a plateau region in the frequency range (40-60)MHz. For frequencies above 80 MHz, experimental data of the present group, within experimental error, agree with the present calculation. But in the low frequency region (< 10 MHz), none ofthe experimental results support any of the theoretical predictions. It seems to indicate that below 80 MHz besides geomagnetic machanism,

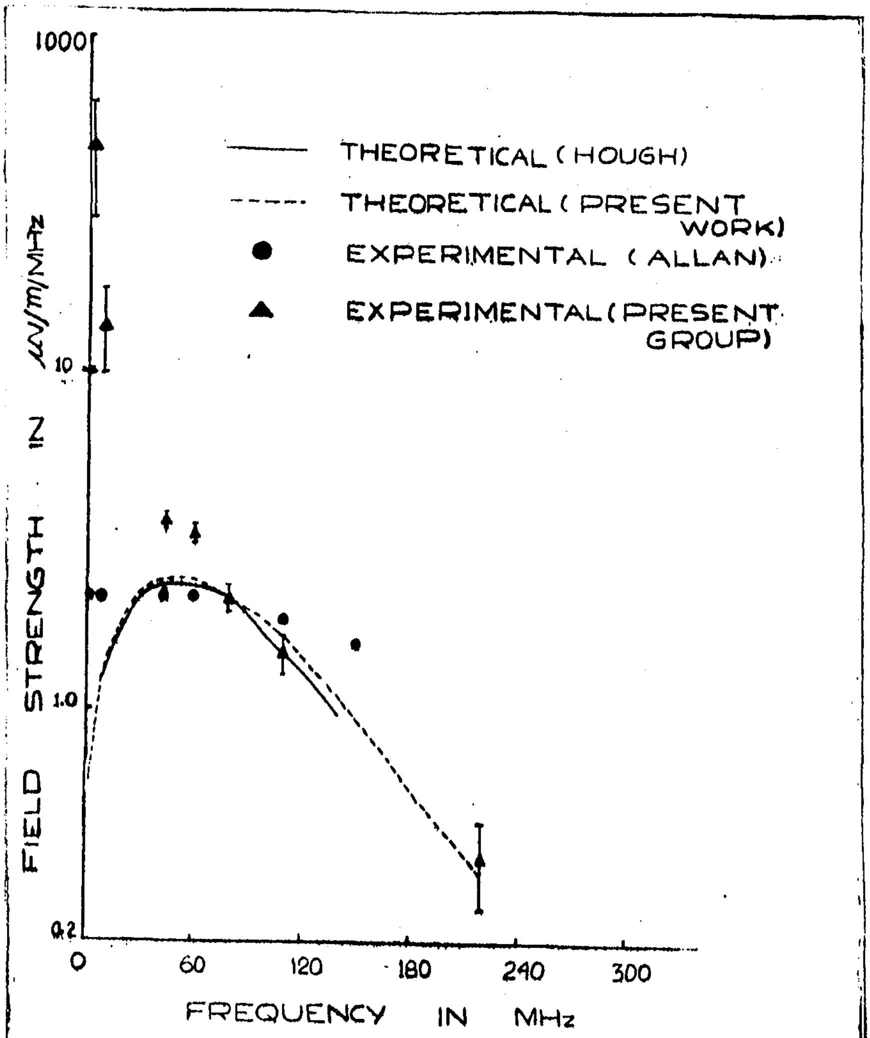

FIG.-1. VARIATION OF RADIO FIELD STRENGTHS WITH FREQUENCIES

some other mechanism/s are also involved. Nature of variation of experimental data with frequency shows gradual decrease of the effect of theabove unknown mechanism/s towards 80 MHz.

5. <u>Conclusions</u> : Theoretical as well as the experimental results of the present authors and also of other workers indicate that the frequency spectrum is rather flat in the frequency range (40-60)MHz. Above 80 MHz, the radio-emission can be explained with the help of geomagnetic mechanism. But at very low frequency ($<$ 10 MHz), mechanisms other than geomagnetic are involved.

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