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LF-MF Radioemission from EIS

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ABSTRACT

Emission of LF-MF radiopulses by Transition Radiation associated with negative charge excess of neutrino-induced Extensive Ice Showers (EIS) is investigated theoretically. Possible implications of simultaneous detection of LF-MF Radioemission and HF Radioemission for such showers are also discussed.

1 Introduction

High energy neutrinos passing through the earth generate electron-positron showers in the Antarctic ice. These showers are christened as Extensive ice showers (EIS) by Prof. J.V.Jelley (1965). These showers emit radio frequency Cherenkov radiation (RCR) which are detectable in VHF-UHF antenna (100 MHz to 1000 MHz) burried in ice (Allen et al., 1997) . Detailed theoretical models are developed (Zas et al., 1992) for the RCR from EIS which shows fieldstrength to be maximum around 1 GHz.

Radioemission (RE) from EAS first detected by Jelley et al. (1965) have been extensively studied by different groups and arrived at the conclusion that observed higher fieldstrengths from EAS in the L[1]F-MF band may be due to Transition Radiation (TR) mechanism which is different from RCR (Baishya R, 1997). Observation of higher fieldstrengths in the LF-MF band compared to VHF band in case of EAS encourages us to predict a similar trend for EIS also. It is to be mentioned here that high fieldstrengths are practically convenient for detection in the background of noise pulses.

In this paper, a model for TR for LF-MF RE from EIS is developed and possible implications of simultaneous detection of LF-MF and VHF-UHF RE from such showers are discussed.

2 Method

When a charged particle moving uniformly in a medium enters another medium, radiation is emitted in the forward as well as backward direction. This radiation is called transition radiation. When charged particles of the EIS cross the surface of ice and air, the phenomenon of TR must occur. For the LF-MF band all the charged particle of the shower may be assumed for mathematical convenience, be concentrated at a point instead of distribution over a region and only the negative charge, in effect, will contribute to the TR.

For a particle of charge e moving with relativistic velocity **v** along the z

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axis and crossing the boundary plane at z = 0, t =0, the radiation field in the second medium is given by,

$$\vec{E}'_{\omega 2} = \vec{e}'_{\omega 2}\, e^{i\lambda_2 z} \qquad (1)$$

For a vertical ice shower, the magnitude of the horizontal component of the field is

$$\vec{E}_{\omega H} = \frac{\in Ne\lambda_2\eta_2 \vec{k}}{2\pi^2 v\zeta}\cos\theta \qquad (2)$$

And the magnitude of the vertical component of the field is

$$\vec{E}_{\omega V} = \frac{\in Ne\eta_2 k^2}{2\pi^2 v\zeta}\cos^2\theta \qquad (3)$$

Where N = Size of the EIS at the boundary surface

$\in Ne$ = Excess negative charge
k = $\omega/c = 2\pi v/c$ = wave number,

$$\lambda_1^2 = \frac{\omega^2}{c^2}\chi_1 - k^2 \quad ; \quad \chi_1 = \in_1 \mu_1$$

$$\lambda_2^2 = \frac{\omega^2}{c^2}\chi_2 - k^2 \quad ; \quad \chi_2 = \in_2 \mu_2$$

$$\eta_2 = \frac{\in_1/\in_2 + (v/\omega)\lambda_1}{k^2 - \chi_2\omega^2/c^2} - \frac{(v/\omega)\lambda_1 + 1}{k^2 - \chi_1\omega^2/c^2}$$

$$\zeta = \lambda_2 \in_1 + \lambda_1 \in_2$$

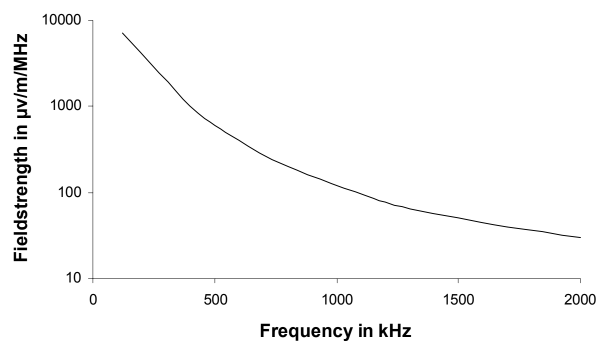
$$\tan\theta = Z/R$$

Z = height of the antenna above the ice surface
R = distance of the antenna from the shower axis

3 Result

Frequency spectrum for vertical component obtained from eqn (3) is given in fig.1. Frequency spectrum for

Fig.1. Frequency Spectrum of Vertical component



horizontal component as well as lateral distribution of fieldstrength for both horizontal and vertical component can also be obtained from eqns (1), (2) & (3) and these findings will be presented at the conference.

4 Discussion & Conclusion

From the model developed and preliminary calculation done, it is seen that LF- MF fieldstrengths from EIS is a function charge excess, neutrino energy and core position and high fieldstrengths may be observed at this band of frequencies. On the basis of this, a new method is proposed for neutrino detection and is detailed below.

(i) An array of LF-MF antenna is to be installed on Antarctic ice surface above the VHF-UHF antenna of RICE (Allen et al., 1997) project.

(ii) Coincidences are to be taken between the LF-MF & VHF-UHF antenna and the fieldstrengths of both are to be determined.

(iii) With the observed fieldstrengths for LF-MF RE, $\in$, N and core coordinates X_0, Y_0 are to be determined in the same way as age parameter, N, X_0, Y_0 are estimated in EAS from density data.

(iv) Knowing $\in$ & N, depth of first interaction can be estimated from the model for development of EIS.

(v) Step (iii) & (iv) are to be followed for fieldstrengths for VHF-UHF antenna buried in ice.

(vi) Parameters $\in$, N, X_0, Y_0 and first interaction depth obtained from LF-MF measurements are to be compared with those obtained from VHF-UHF measurements to arrive at some concrete conclusions.

Following points are worth mentioning in the implementation of the proposed method

(i) Communication signals in the Antarctic is known to be in the HF-VHF band. AS such, there will not be any possibility of interference with the proposed LF-MF antenna placed on ice surface.

(ii) LF-MF antenna will register pulses due to TR mechanism only because RCR for this band will be negligible (Zas et al.,). Hence question of absorption of radiation in ice does not arise.

(iii) By simultaneous observation of LF-MF and VHF-UHF radiation associated with the same events, it will be possible to estimate different parameters of the events from two independent observations, importance lying on the fact that production mechanism of pulses for the two bands are different.

(iv) RE from EAS may appear as a significant background for EIS observation. However, since coincidences will be taken between LF-MF and VHF radiation and also different parameters of the EIS obtained from these two independent observations will be compared, it would be possible to reject noise pulses.

Hence, it is concluded that simultaneous detection of LF-MF & VHF-UHF radiation from EIS will give more concrete information of neutrinos coming from CR sources. However, preliminary calculations are only presented in the paper and details will be discussed in the conference.

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