LETTERS TO THE EDITOR

A NOTE ON THE OCCURRENCE OF N ECHOES IN THE EQUATORIAL REGION

THE presence of sporadic E (Es) ionisation is well known to be a regular day-time feature of the equatorial ionosphere and it usually manifests on bottom-side ionograms in the two forms, equatorial sporadic-E (E_{sq}) and equatorial slant sporadic-E (E_{sl}). Substantial evidence exists in literature to show that the blanketing sporadic-E (E_{sb}), a characteristic feature of the temperate latitude ionosphere, also occurs during day-time at and in the vicinity of the geomagnetic dip equator[1-5]. The partial transparency of the sporadic-E layers causes ray paths of the multiples to be complicated, sometimes giving rise to reflections referred to as M and N echoes. Assuming the E_s layer thickness to be negligible, the virtual heights of the M and N echoes (h'M and h'N) are given as:

$$h'M = 2h'F - h'Es$$
$$h'N = h'F + h'Es.$$

It was reported earlier that, in the temperature latitude zone, M echoes occur for about 80 to 90% of all E_s occurrences and that they never occur with E_s configurations characteristic of the equatorial region[6]. Bhargava and Saha[7] were the first to show that M and N echoes do occur in the vicinity of the geomagnetic dip equator. A recent detailed investigation by us using Kodaikanal ionogram data confirmed this earlier observation. It was found that the occurrence of M and N echoes is characterised by the presence of either an isolated M echo or a combination of M and N echoes, but very rarely as an isolated N echo[8]. This rather abnormal property appears to be a unique feature of sporadic-E layers in the equatorial region as a similar pattern is also noticed on ionograms at Huancayo, an equatorial station at the 75° W meridian[9]. In this brief communication, we present observational evidence to show that an isolated N reflection sometimes occurs on equatorial ionograms in association with short lived secondary E_s layer at an altitude of 140 km, well above the height domain (95–100 km) of regular E_s layers.

Vertical ionospheric soundings at 1 min intervals were carried out during day-time at Kodaikanal (Geo. lat. 10° 14′ N, geo. long. 77° 28′ E, dip 3·5° N) on several selected days during the winter months of 1974–75, with a view to monitor the short period changes in the ionospheric F-region. Careful scrutiny of this high time resolution ionogram data showed the occurrence of N reflections around noon on 12 January 1975. The salient details of this event are as follows. On 12 January 1975, a geomagnetically quiet day ($Ap = 4$), a weak secondary E_s layer around an altitude of 140 km was first seen on ionograms at 1306 hrs I.S.T., in addition to the regular E_{sq} around 100 km. The secondary E_s layer grew in intensity and turned into a fairly extended trace thereafter, and gave rise to isolated N reflections over the short interval of time from 1309 to 1316 hrs I.S.T. This can clearly be seen from Fig. 1 wherein, the ionogram at 1312 hrs I.S.T. is presented. It is quite evident from Fig. 1 that the N-reflection corresponds to the secon-

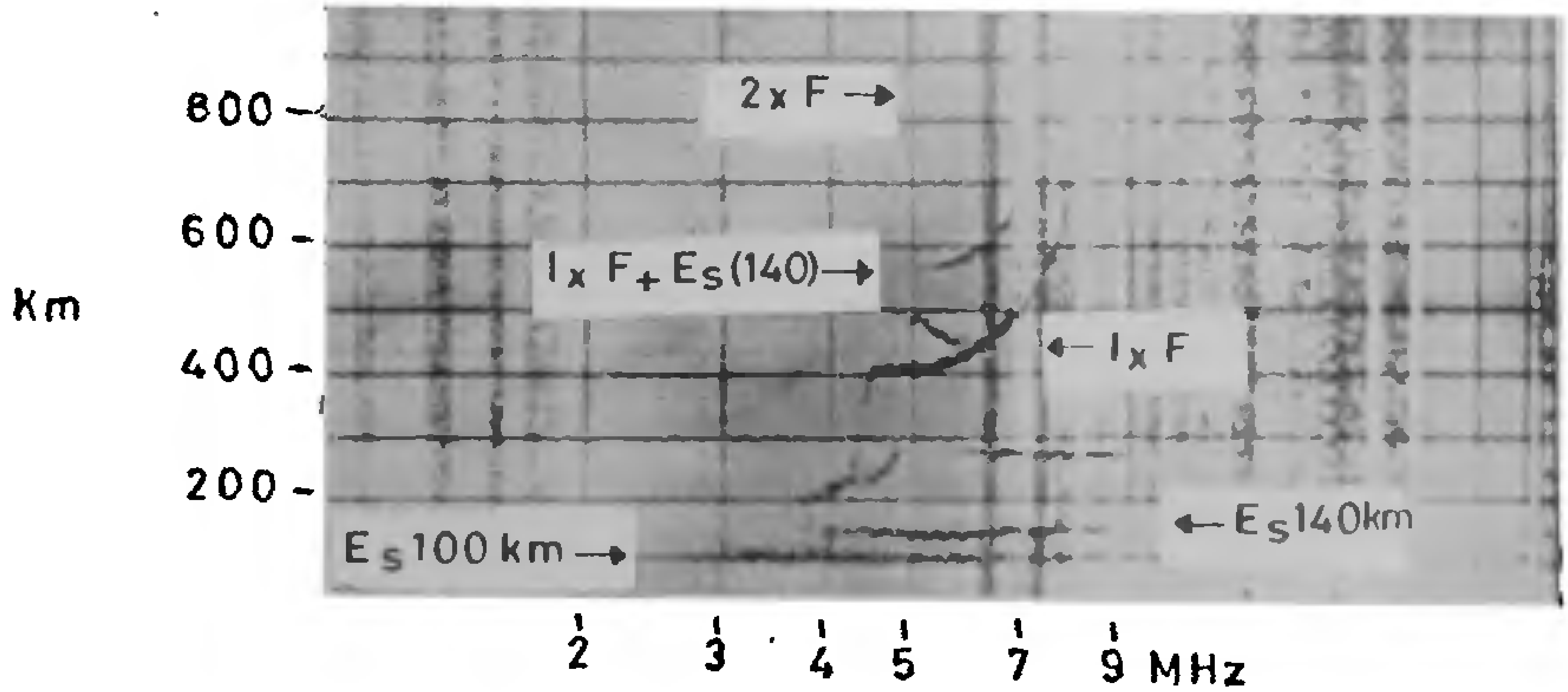

FIG. 1. Ionogram at Kodaikanal on 12 January 1975 at 1312 hrs I.S.T. showing the occurrence of N reflection in association with a secondary sporadic-E (E_s) layer around 140 km. The small high frequency ripple on the height markers is of instrumental origin.

dary E_s layer around 140 km and not to the regular E_{sq} around 100 km. The secondary E_s layer lost its identity by 1334 hrs I.S.T. During the entire period of its manifestation, the secondary E_s layer is essentially non-blanketing, although multiple reflections of this layer are clearly seen. The observation that the secondary E_s layer gave rise to N reflections alone (*i.e.*, without M reflections) suggests the presence of sharp electron density gradients at the bottom of this E_s layer and that the irregularities embedded in this layer are strong scatterers for radio waves propagating upward and weak scatterers for waves propagating downward. Further investigations are required to throw light on the origin of these transient secondary layers of *sporadic-E ionisation in the equatorial region.*

Indian Institute of Astrophysics, J. HANUMATH SASTRI.
Kodaikanal 624 103, *March* 24, 1980.

1. Bhargava, B. N. and Subrahmanyam, R. V., *Proc. Indian Acad. Sci.*, 1964, 60, 271.
2. Oyinloye, J. O., *Planet Space Sci.*, 1971, 19, 1131.
3. Reddy, C. A. and Devasia, C. V., *Ibid.*, 1973, **21**, 811.
4. Chandra, H. and Rastogi, R. G., *J. Geophys. Res.*, 1975, **80**, 149.
5. Devasia, C. V., *Indian J. Radio Space Phys.*, 1976, **5**, 217.
6. Thomas, J. A. and Smith, E. K., *J. Atmos. Terr. Phys.*, 1959, **12**, 295.
7. Bhargava, B. N. and Saha, A. K., *An Atlas of Equatorial Ionograms, Memoirs of the Kodaikanal Observatory*, 1967.
8. Sastri, J. H. and Murthy, B. S., *Indian J. Radio Space. Phys.*, 1975, **4**, 10.
9. Rastogi, R. G., *Ibid.*, 1977, **6**, 102.

HEAT TRANSFER IN A LATTICE HAVING CORE DISLOCATIONS AT LOW TEMPERATURES

FOR the first time, it has been found that at low temperatures, the Callaway expression of the lattice thermal conductivity of a sample having core dislocations reduces to a very simple expression which is similar to the expression obtained by the author based on the nonlinear heat transfer theory. A comparative study is also made between results obtained in the frame of the expression obtained and in the frame of the Callaway expression.

The lattice thermal conductivity of an insulator having isotopic impurities alone, was studied by Kazakov and Nagaev[1] (KN) and they reported a simple expression for it in the frame of the nonlinear heat transfer theory. The KN theory is very simple and it gives sufficiently good results at low temperatures. Due to its simplicity, it was applied by several workers[2-7] to calculate the lattice thermal conductivity of the various samples having different kinds of defects. Callaway[8] also gave a phenomenological expression to calculate the phonon conductivity of an insulator based on the relaxation time approach. The Callaway expression is very complicated and one has to perform the numerical integration of the conductivity integrals at each temperature which is not an easy task. The aim of the present note is to show that the complicated expression of Callaway of the lattice thermal conductivity of a sample having core dislocations, can be reduced to a simple expression which is similar to the expression obtained by the author[7] based on the nonlinear heat transfer theory. To have a comparative study between the results obtained in the frame of the expression reported and in the frame of the Callaway expression, the lattice thermal conductivity of a sample having core dislocations, has been calculated using both of the expressions in the temperature range 0·2–10° K and it has been found that both results are nearly the same.

According to Callaway[8], the lattice thermal conductivity of a sample having core dislocations together with isotopic impurities can be expressed as

$$K = (k_B/2\pi^2 v)(k_B T/\hbar)^3 \int_0^{\theta/T} (\tau_B^{-1} + \tau_{pt}^{-1} + \tau_{dc}^{-1} + \tau_{ph}^{-1})^{-1} x^4 e^x (e^x - 1)^{-2} dx \quad (1)$$

where k_B is the Boltzmann constant, $\hbar$ is the Planck constant divided by 2π, v is the average phonon velocity, θ is the Debye temperature, τ_B^{-1}, τ_{pt}^{-1}, τ_{dc}^{-1}, and τ_{ph}^{-1} are the scattering relaxation rates due to the crystal boundary[9], point-defects[10], core dislocations[10] and phonon-phonon scattering[11] processes, respectively, and these are given by $\tau_B^{-1} = v/L$, $\tau_{pt}^{-1} = Aw^4$, $\tau_{dc}^{-1} = cw^3$ and $\tau_{ph}^{-1} = Bw^2T^3$; where L is the Casimir length[9] of the crystal, A, c and B are the scattering strengths due to the respective processes. In writing eqn. (1), the contribution of the correction term[8] due to the three phonon normal processes has been ignored due to its negligibly small contribution[12-14].

At low temperatures, the upper limit of the integral stated in eqn. (1) can be taken as infinity due to large value of θ. At the same time, it has also been found that at such temperatures, the boundary scattering relaxation rate τ_B^{-1} dominates over other scattering relaxation rates. Neglecting τ_{ph}^{-1} due to its negligibly small contribution and incorporating the above stated approximations, the eqn. (1) can be approximated as

$$K = (k_B/2\pi^2 v)(k_B T/\hbar)^3 (L/v) \int_0^\infty [1 + (cL/v) \times (k_B T/\hbar)^3 x^3 + (AL/v)(k_B T/\hbar)^4 x^4]^{-1} \times \frac{x^4 e^x dx}{(e^x - 1)^2}. \quad (2)$$