Refraction of Very High Frequency Radio Signals at Ionospheric Heights

PEOPLE engaged in radio tracking of space vehicles are well aware of the fact that the Earth's atmosphere may cause serious refractive errors in the elevation angle determination. It is also generally accepted that refractive errors rapidly decrease with an increase in the elevation angle, and become virtually negligible above 10 or 15 degrees. In the case of radio astronomy, this is quite true. However, in the case of space-vehicles, which travel in the immediate vicinity of the Earth, this is not the case. The refractive errors due to the troposphere rapidly decrease with the elevation angle, while those due to the ionosphere initially increase with the elevation angle, and then gradually fall off. This behaviour of ionospheric refraction is a necessary consequence of the spherical geometry. The value of the elevation angle at which the maximum ionospheric refractive error occurs lies typically between 100 and 200 milliradians. The exact expressions are rather involved, but it can be shown that the value of this angle is roughly proportional to the square root of the height of the layer. The maximum value of the ionospheric refractive error is about 10–15 per cent higher than its value for a tangentially departing ray.

Fig. 1 shows a plot of the elevation angle error δ for realistic models of the ionosphere and troposphere. The tropospheric calculations were based on radiosonde data. The ionospheric calculations were based on a model of electron density profile which was parabolic below the region of the maximum density

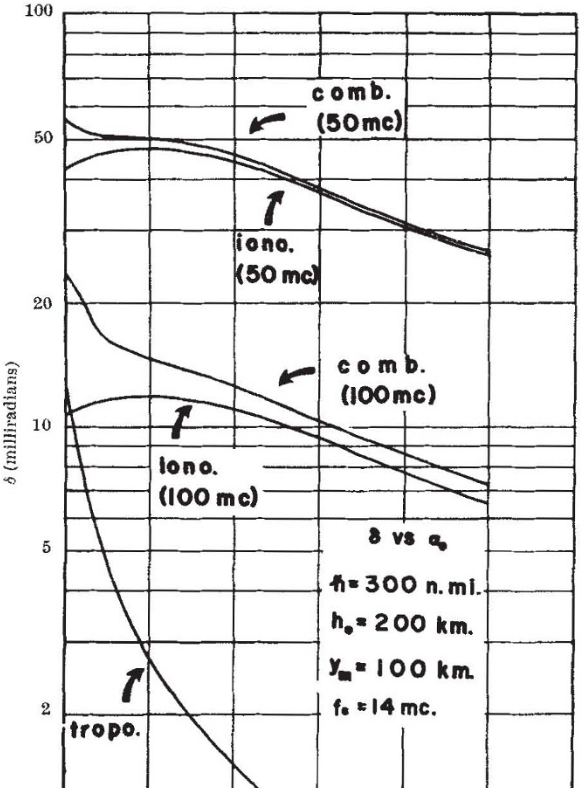

Fig. 1

and was represented by the hyperbolic secant above the maximum. The constants of the hyperbolic secant were adjusted so that the profile and its derivative were continuous everywhere, and the total electron content above the maximum was three times as large as below it. This is in accord with experimental data based on Faraday rotation measurements[1]. Details of the computational techniques are described elsewhere[2].

For the purpose of the accompanying illustration, the ionospheric constants were adjusted as follows: height of the base 200 km., half thickness 100 km., critical frequency 14 mc., signal frequencies 50 and 100 mc. The target height for which the refractive errors were computed was 300 nautical miles.

Examination of Fig. 1 shows that, at very low angles of elevation, α_0, the tropospheric refraction contributes appreciably to the refractive error while, at higher angles, the ionospheric factors predominate. The peculiar behaviour of the ionospheric refraction manifests itself by the presence of the shoulder which is especially prominent at 50 mc., and also by the fact that the refractive error decreases more slowly with the elevation angle than might have been expected from the study of the refraction of radio stars.

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[1] Evans, J. B., *Proc. Phys. Soc.*, B, **69**, 953 (1956).
[2] Weisbrod, S., and Anderson, L. J., *Proc. Inst. Rad. Eng.* (in the press).

Near Infra-Red System of Nitrogen

IN the course of studying the molecular spectrum of nitrogen under various excitation conditions, Carroll and Sayers[1] discovered a new triplet transition in the near infra-red. Only one band was observed as the spectral region of interest was dominated by bands of the first positive system. A spectrogram of the new band was given together with measurements of the four strongest heads at 8265·5, 8283·8, 8293·3 and 8310·6 A. The structure of the band was obviously complex, and it was suggested by Carroll and Sayers that the transition might be $^3\Pi - {}^3\Sigma$.

More recently Kistiakowsky and Warneck[2] have reported bands of nitrogen in the infra-red, and these observations have been extended by LeBlanc, Tanaka and Jursa[3], who studied the emission from afterglows in argon–nitrogen mixtures at low temperature. They also made a preliminary vibrational analysis and showed that the lower state was most probably $B\ ^3\Pi_g$.

There is no doubt that the new system is the same transition as that reported by Carroll and Sayers. This is proved by (*a*) the close similarity in structure between the 8265·5 A. band on Carroll and Sayers's spectrogram and the bands in the spectrogram given by LeBlanc, Tanaka and Jursa; and (*b*) the agreement between the measurements of corresponding heads in the 8265·5 A. band and the $(n + 1) - 1$ band of LeBlanc, Tanaka and Jursa.

As the new system is of both theoretical[4] and astrophysical[5] interest the 8265·5 A. band has recently been investigated under large dispersion. It was