STUDY OF PEAK FREQUENCY AND BANDWIDTH OF ATMOSPHERICS AS A FUNCTION OF AZIMUTH

S. GOPALAKRISHNA AND P. SITARAMASWAMY

Department of Applied Physics, Andhra University, Waltair 530 003

ABSTRACT

The frequency spectra of electromagnetic signals emitted from lightning discharges attain a peak value within the VLF region, *i.e.*, 3 to 30 KHz. Those signals, which will be referred to as 'atmospherics', provide a useful source for studies of the propagation of VLF radio waves. The source spectrum of an atmospheric in the VLF range is modified during its propagation to large distances due to varying attenuation rates. The attenuation rates depend upon the propagation conditions, namely the ground conductivity, the ionospheric parameter, earth's magnetic field, etc. The variation of attenuation rate with frequency causes the peak spectral component of the received atmospheric, to increase with the increase of the distance travel. The previous work on the spectral studies is given in the paper by Wadehra and Tantry[1]. It is also reported that the bandwidth of atmospherics decreases with the increase of propagation distance of the atmospherics. In this communication, the authors have studied experimentally, the variation of spectral peak frequency and the bandwidth of the received atmospherics as a function of azimuth.

INTRODUCTION

THE experimental technique and the method of calculation of the source distance of atmospherics were published[2] elsewhere by the authors. Nearly 800 waveforms of atmospherics are used for the present analysis during the period, March 1976 to March 1977. The received atmospherics are grouped into 8 sectors depending on the azimuth of arrival. Each sector corresponds to an angle of 45°. N–S means atmospherics received from North direction and those arriving making an angle of $\pm 22\frac{1}{2}°$ with the North direction. From the spectral analysis, the peak frequency corresponding to the peak amplitude, called peak frequency, is noted.

Curves of the variation of spectral peak frequency with the propagation distance of the received atmospherics in four sectors are shown in Figs. 1 and 2. It can be seen from the same figures that the peak frequency of the atmospherics increases with the distance. This increase of peak frequency is rapid at smaller distances. For larger distances, the rate of increase of peak frequency is very small. On close scrutiny of the figures, it can be observed that the rate of increase of the peak frequency between 1,000 to 2,000 Km in the smaller distances propagated along N–S and S–N is about 3·8 and 3·6 KHz and for E–W direction the value is 3·2 KHz whereas for W–E direction it is 2·8 KHz. For distances greater than 1,000 Km, the peak frequency varies from 5·4 to 11·2 KHz in the E–W direction and from 6·5 to 10·8 in the W–E direction. In the N–S and S–N directions the peak frequency variation is from 5·4 to 11 KHz and 5·5 to 11·6 KHz respectively. These results may be compared with those of the other workers particularly with those of Croom[3] who has presented the results in W–E nd E–W directions. Others have not taken the direction of propagation of atmospherics into consideration. The results obtained in the present work for the W–E direction and E–W direction agree with the observations of Croom, that the progressive increase of peak frequency with distance in the E–W direction should be more than that in W–E direction. But the magnitudes of the peak frequency limits for E–W and W–E direction are not in agreement with those of Croom. The values reported by him are 6 to 8 KHz from W–E path and 5·5 to 10 KHz for E–W path. This discrepancy might be due to the fact that W–E path is sea and E–W path is land for Croom, whereas, for Waltair Station, W–E is mostly land and E–W path is sea. This shows that the conductivity of earth plays an important role in controlling the peak frequency.

Taylor[4], Wadehra and Tantry[1] have reported that the bandwidth of the received atmospherics, computed from the spectra of atmospherics decreases with an increase of the source distance due attenuation to the versus frequency characteristics in the VLF band. The bandwidth of each atmospheric received in a particular sector is determined from the amplitude spectra and plotted against the distance of travel which is shown in Fig. 3. It is found that a mean straight line can be drawn passing through the points supporting the results of Taylor and Tantry. The slope, $\triangle f/d$, of the straight line determined in each of the eight sectors is plotted against the azimuth of reception which is shown in Fig. 4. It can be seen from Fig. 4 that $\triangle f/d$ of the atmospherics travelling from west to east has high value, whereas for atmospherics travelling from east to west, $\triangle f/d$ is minimum.

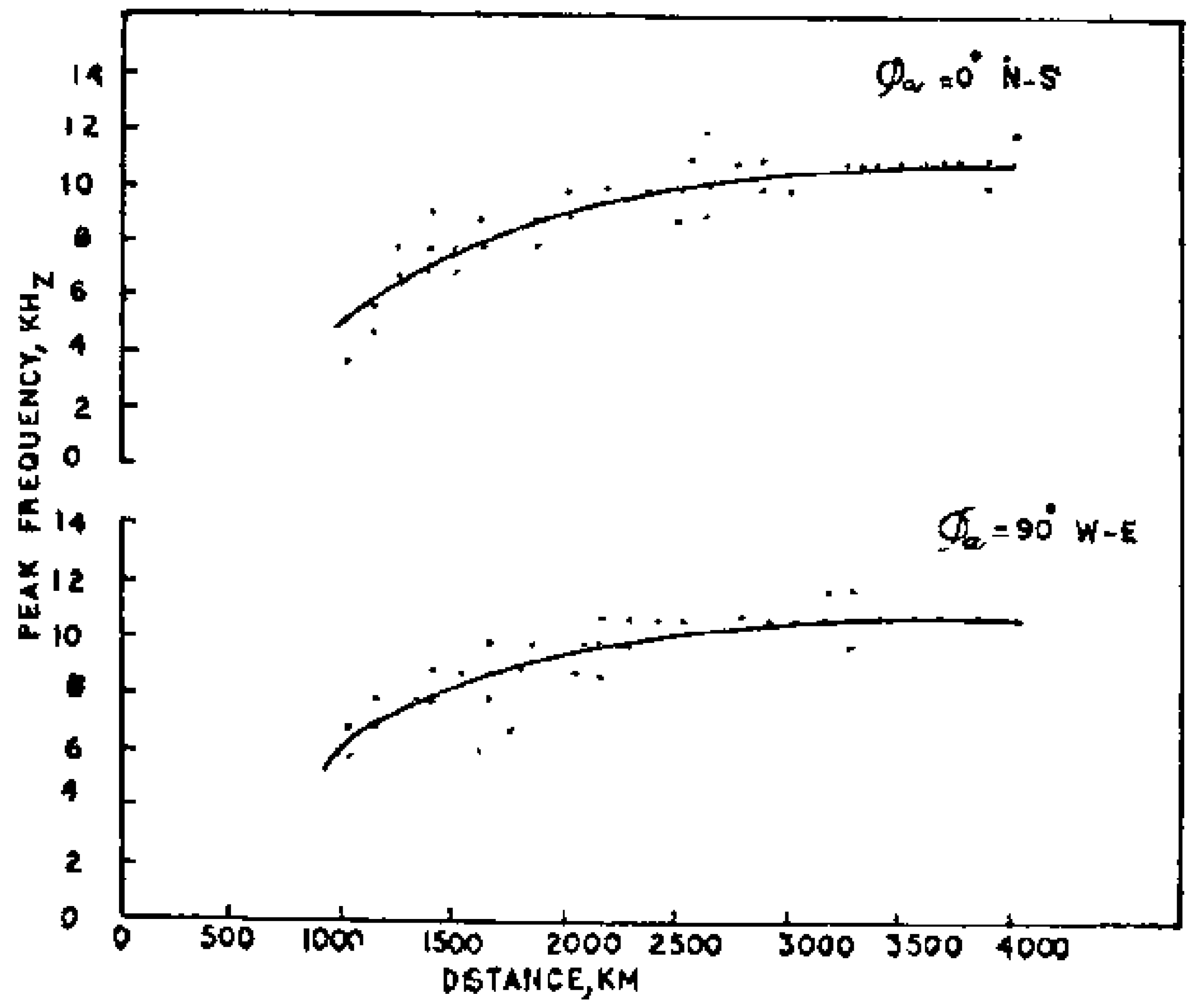

Fig. 1

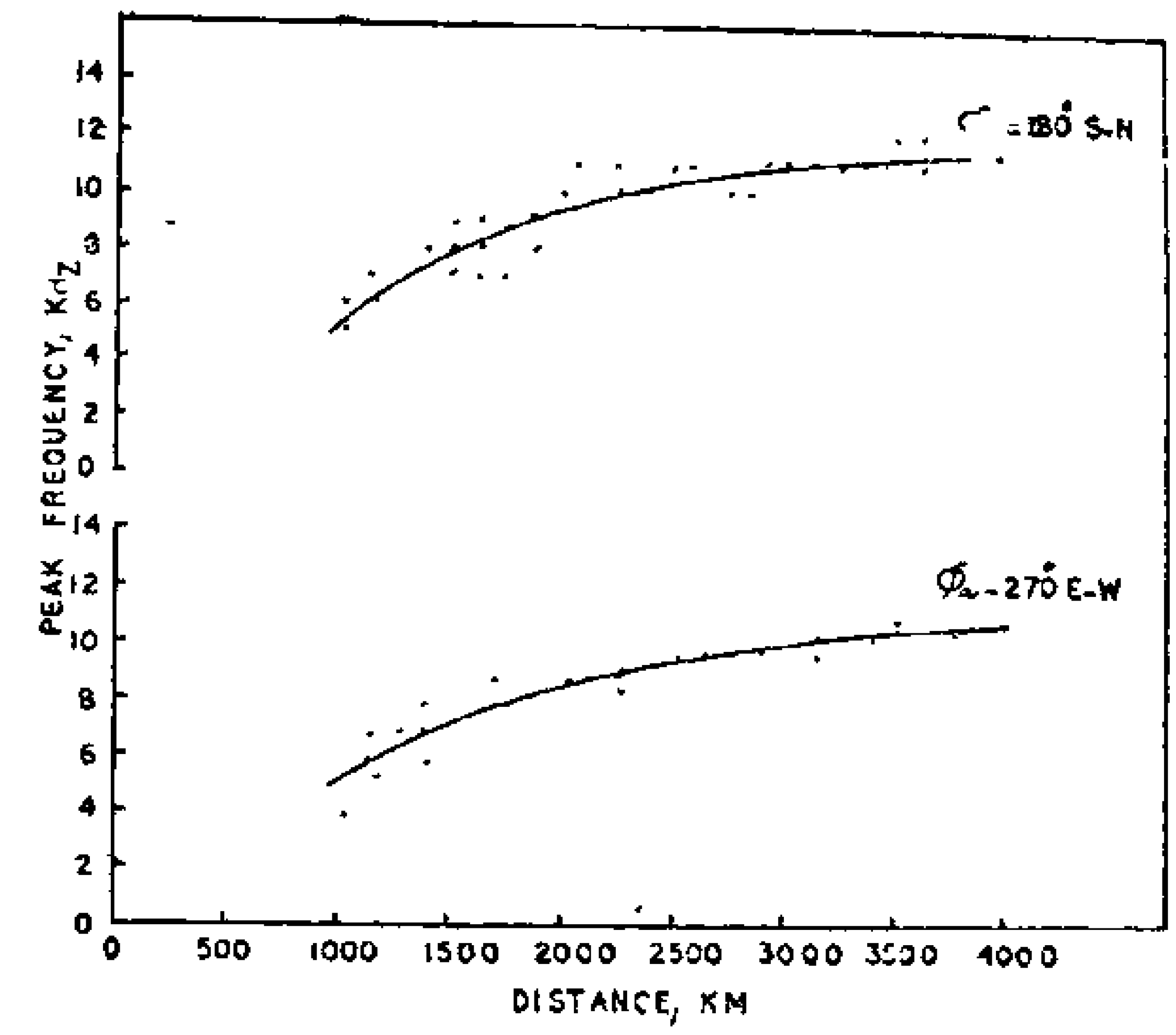

Fig. 2

Figs. 1 and 2. Variation of spectral frequency of atmospherics with distance for the night at different azimuth angles ϕ_a.

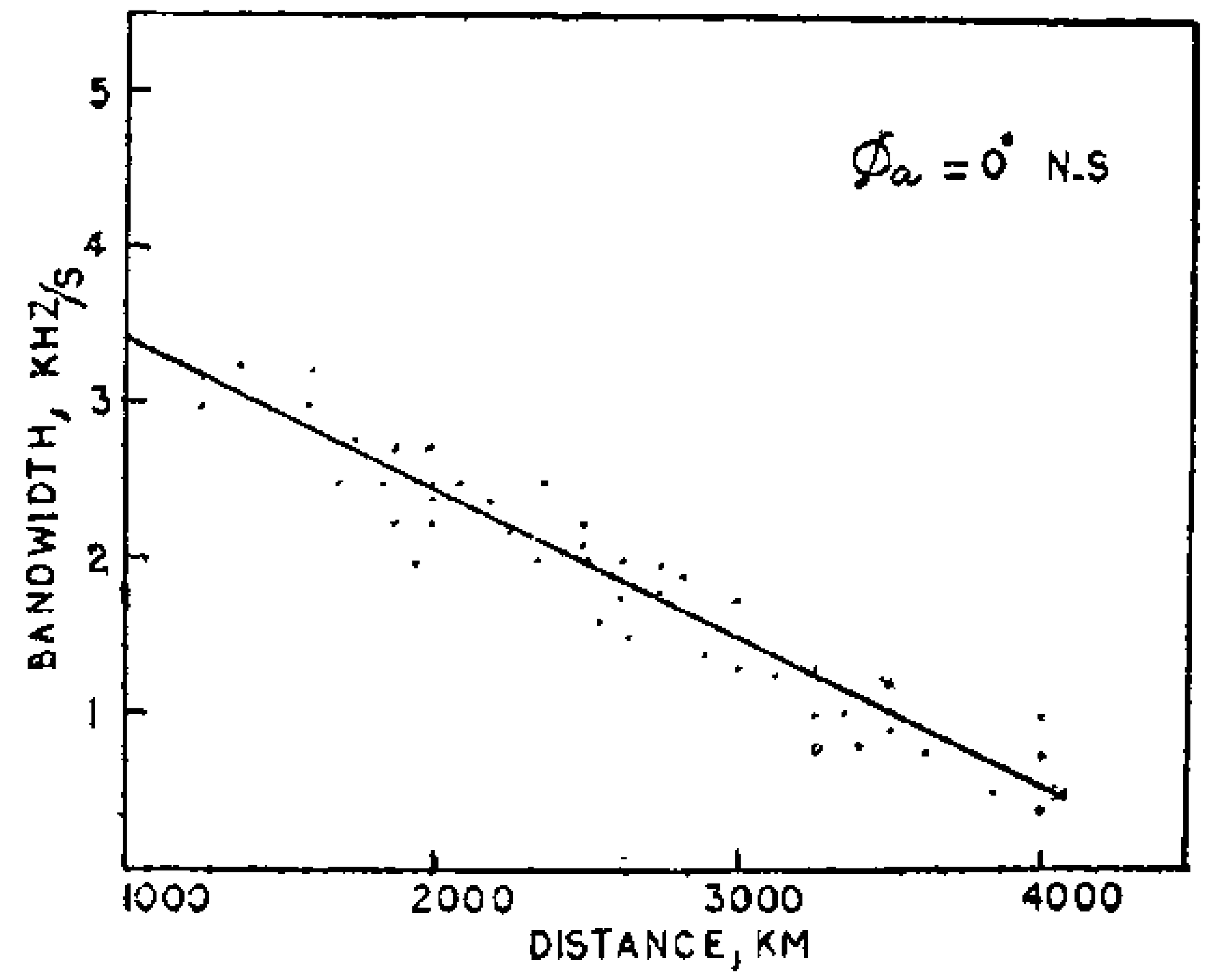

Fig. 3. Bandwidth between half Powerpoints *vs.* source distance of atmospheric at $\phi_a = 0°$.

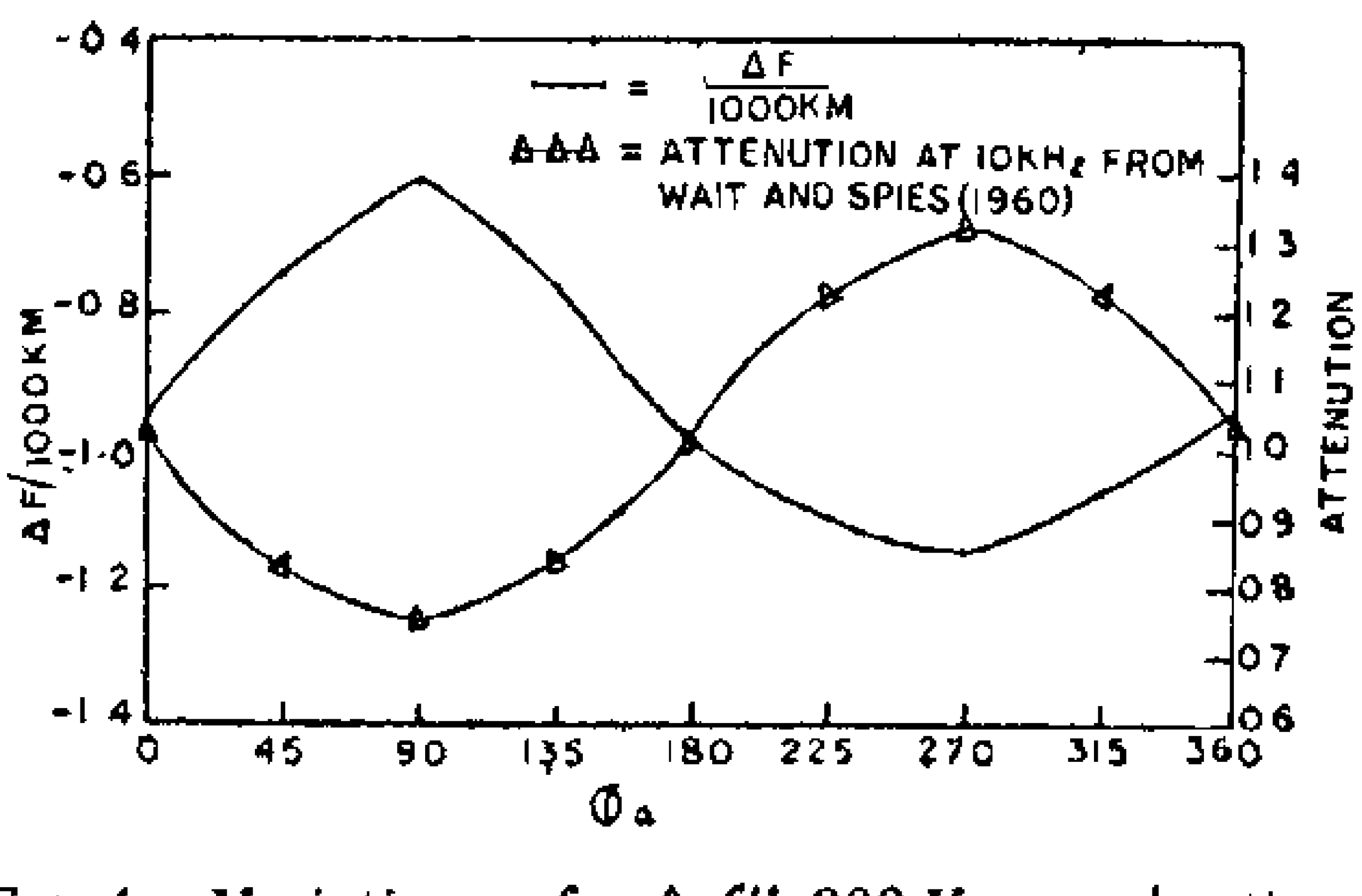

Fig. 4. Variation of Δf/1,000 Km and attenuation at different azimuth angles ϕ_a.

The value of $\Delta f/d$ of the atmospherics travelling North to South and South to North are equal falling between the first two values. If attenuation for any frequency in all directions of travel were to be the same, there would have been no variation in the value of $\Delta f/d$ for different directions of arrival of atmospherics. Our result suggests that the attenuation of VLF radiowaves does depend on the direction of travel. Decrease in bandwidth occurs due to increase of attenuation in the frequency components and *vice versa*.

Wait and Spies[5] have reported from theoretical considerations that the attenuation of VLF radio waves travelling from East to West is higher than that travelling from West to East and reciprocity exists when travelled along N–S and S–N directions. The results of Wait and Spies for the attenuation rate against azimuth at 10 KHz are shown in Fig. 4. The results shown in Fig. 4 support the theoretical deduction of Wait and Spies.

1. Wadehra, N. S. and Tantry, B. A. P., *J. Geomagnetism and Geoelectricity*, 1967, 19, 7.
2. Gopalakrishna, S. and Sitaramaswamy, P., *Curr. Sci.*, 1979, 48, 676.
3. Croom, D. L., *J. Atmos. Terr. Phys.*, 1964, 26, 1015.
4. Taylor, W. L., *J. Res. Bur. Stand. Wash.*, 1960, 64D, 349.
5. Wait, J. R. and Spies, K., *J. Geophys. Res.*, 1960, 65, 2325.