POSSIBILITY OF LIGHTNING WAVE PROPAGATION IN VENUSIAN ATMOSPHERE. J. P. Pabari[1], S. Jitarwal[1], D. Kumar[2], D. K. Patel[1] and S. Nambiar[1], [1]Physical Research Laboratory, Navrangpura, Ahmedabad-380009, INDIA. Email: jayesh@prl.res.in, [2]BITS, Hyderabad-500078, INDIA.

Introduction and Motivation: Venusian atmosphere is a non-homogeneous in nature due to large variation in the conductivity. The sulphuric acid clouds are at the height of about 45 to 65 km from the surface. Lighting is expected to occur within the Venusian clouds as the coulds rotate and experience the charge exchange. It is known that the lightning generates optical signal, electromagnetic waves in ELF and VLF range as well as acoustic waves. Few observations were attributed to lighting in the past, like radio detection from Venera missions, optical detection by Venera 9 orbiter and low frequency electric field variations detected by Pioneer Venus Orbiter Electric Field Detector (Scarf et al., 1980). Probable lightning signals were also observed by Galileo Flyby (Gurnett et al., 1990) and Fluxgate Magnetometer on Venus Express (Russell et al., 2008). Akatsuki mission has a Lightining and Airglow Camera (Takahashi et al. (2008), which is exploring the lightning on Venus. A Lightning Instrument for VEnus (LIVE) is proposed for future mission to detect the lightning on Venus for detailed investigation.

Since the ionspehre of Venus could extend beyond 300 km, the emitted electromagnetic waves have to propagate through it, in order to reach the satellite, which might be observing the signals. The Venus atmosphere play a vital role in the wave propagation, even though the lightining is present. It is therefore, interesting to investigate the nature of Venus atmosphere (being non-homogeneous) and obtain the supporting environment, in order to make the waves reach the orbiter. We have attempted to obtain the atmospheric parameters using the Appleton-Hartee Equation (Helliwell, 2006).

Venus Atmosphere: The wave propagation in the ionosphere is affected by conductivity and permittivity, which in turn define the refractive index of the environment. The Appleton-Hartee Equation (Helliwell, 2006) for the refractive index is given by

$$n^2 = 1 - \frac{X}{1 - iZ - \frac{0.5\,Y_T^2}{1 - X - iZ} \pm \frac{1}{1 - X - iZ}\left[0.25 Y_T^2 + Y_L^2 (1 - X - iZ)^2\right]^{0.5}} \quad (1)$$

where

$$Z = {f_c}/{f} \qquad X = {f_p^2}/{f^2} \quad (2)$$

$$Y_L = {f_L}/{f}$$

$$Y_T = {f_T}/{f}$$

$$f_L = f_H \cos\theta\,;\ f_T = f_H \sin\theta \quad (3)$$

and f_c is electron-neutral collision frequency, f_H is gyro frequency, while f_p is the plasma frequency. The value of magnetic field density (B) is taken as 20 nT (Luhmann et al., 1984).

We have used the range of electron density (Brace et al., 1979), electron temperature (Russell et al., 2007) and neutral density (Russell et al., 2007) for the Venus atmosphere.

Results: The permittiviety and conductivity for the altitudes 120 km, 200 km and 300 km are shown respectively in Figures 1 to 6.

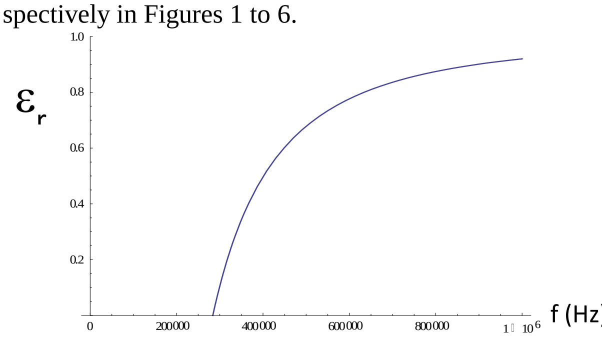

Figure 1: Permittivity (y-axis) vs. frequency (x-axis) for 120 km altitude

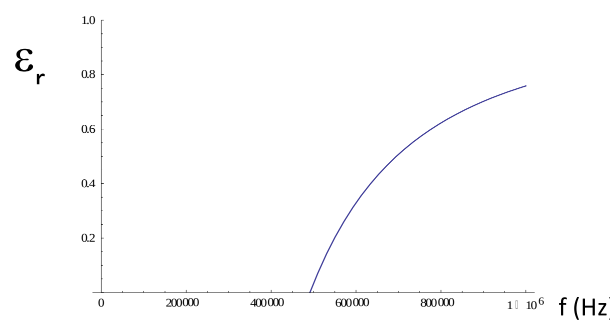

Figure 2: Permittivity (y-axis) vs. frequency (x-axis) for 200 km altitude

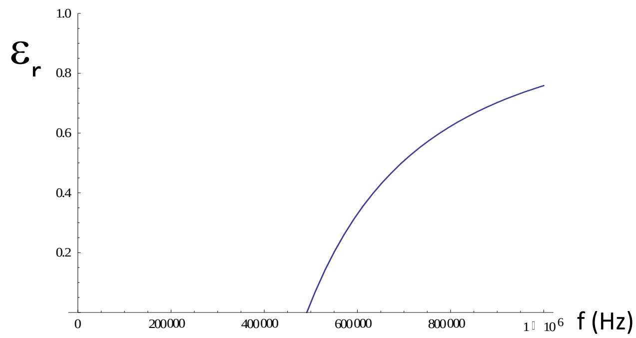

Figure 3: Permittivity (y-axis) vs. frequency (x-axis) for 300 km altitude

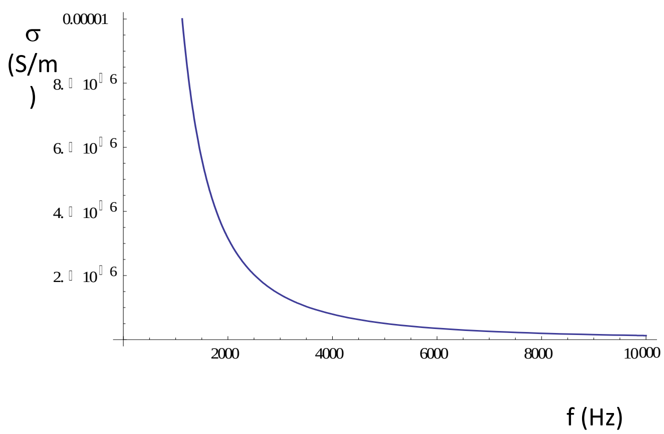

Figure 4: Conductivity (y-axis) vs. frequency (x-axis) for 120 km altitude

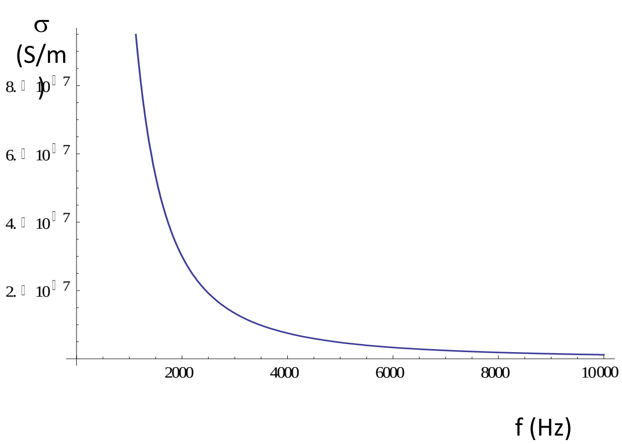

Figure 5: Conductivity (y-axis) vs. frequency (x-axis) for 200 km altitude

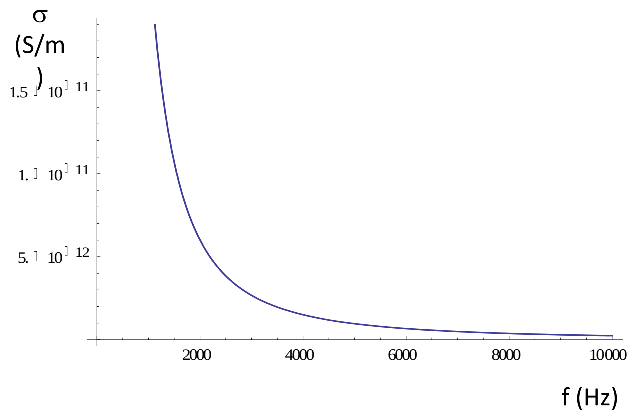

Figure 6: Conductivity (y-axis) vs. frequency (x-axis) for 300 km altitude

Summary and Implications: The results show that the permittivity of the atmosphere is not affected by the change in the altitude. However, the conductivity is greatly affected when the altitude changes from 120 km to 300 km. Further, we observe that the lower frequency waves observe more loss. Whenever, lightning occurs, the waves may be propagated through such environment. Despite the variations, there still exists the possibility of wave propagation in the Venusian environment, which may be observed by an instrument on the orbiter.

References: [1] Scarf et al. (1980), IEEE Trans. Geo. Re. Se., GE-18, 1, 36-38. [2] Russell et al. (2008), JGR, 113, E00B05, 1-8. [3] Takahashi et al. (2008), SSR, 137, 317-334. [4] Helliwell, Robert (2006), Whistlers and Related Ionospheric Phenomena (2nd ed.), Mineola, NY: Dover, pp. 23–24. [5] Luhmann et al. (1984), JGR, 89, pp. 362-368. [6] Russell et al., (2007), Geophysical Monograph Series, pp. 1-18.