The Effect of Recent Venus Transit on Atmospheric Vertical Potential Gradient and ELF-VLF Propagation

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INTRODUCTION

The global electric circuit is characterized by quasistatic electric field observed near Earth's surface Fair Weather Field, (FWF) which is maintained by global thunderstorm activities [1,2]. Thunderstorm activity and lightning again put the Earth- ionosphere waveguide into resonance producing characteristic spectra in ELF and VLF region [3, 4].

Various parameters of the atmospheric electricity are directly related to the global thunderstorm activity and solar radiation.

The discrete spectra of frequencies at 8, 14, 20… Hz due to Schumann resonances are generated by electromagnetic emission from the lightning strokes and can be regarded as excitation of an AC global circuit [2]. Some frequency changes of 10%-20% about the peak values and some amplitude changes are found to be present in the observed data which are attributed by the uncertainties arising from spatial distribution of lightning sources exciting the Schumann resonance modes [5]. Schumann resonance phenomenon as well as their measurement techniques and modern aspects have been described by many workers [6-9].

In three areas, namely atmospheric potential gradient, ELF and VLF, we are taking continuous records where some significant deviations are observed in the values of the involved parameters during the transit of Venus on June 8, 2004. The transit started at 1044 hr local time and continued up to 1653 hr local time, which was visible from Kolkata (latitude: $22^0 34' N$) throughout this period. The local Sunrise and Sunset time were 0452hr and 1822 hr respectively. In this paper, the results of experimental observations during Venus transit will be presented.

EXPERIMENTAL ARRANGEMENT

We take observations from the roof top at a height of 26 meter from ground. The vertical electric field is measured with an ac field-mill which has an aluminum rotor plate of 12 cm. in diameter. The output from the amplifier is recorded through computer sound card at a sample rate of 44,100 per second. The rms value of the recorded signal is used to find the required electric field from the calibration chart. We calibrated the field-mill in a vertical field setup between two large aluminum cover plates, electrically isolated at a given potential through a fixed distance between them. The outer shield of the field-mill is grounded properly to ensure possible field distortions. The sensitivity of the field-mill is $(0.33\pm0.03)\ Vm^{-1}$.

For the observation of Integrated Field Intensity (IFI) of VLF Sferics at 9 KHz, an 8 SWG straight copper wire of 120 meter in horizontal length is used as an antenna. The antenna is sensitive to the vertical electric field component of the electromagnetic signal. The antenna is installed 30 meters above the ground. The signal processor is tuned to the desired frequency. The overall Q-factor of the tuning circuit is around 300. The signal from the tuning stage is rectified and fed to a log amplifier. The time constant of the output from the signal processor is 10 seconds. The data is recorded using a 12 bit ADC at a sample rate of 5.

For observations on Schumann resonances, two square loop antennas in series combination have been used. The length of each side of one of the loops is 1 meter with a total of 75 turns and other with 90 turns having a length of 1.3 meter for each side. The antennas are sensitive to the magnetic field component of the natural Schumann resonance electromagnetic signals. A stereo-preamplifier-integrated circuit with LA3161 chip whose low frequency response starts below 5 Hz, has been used to pre-amplify the signal from antenna. The chip is capable of detecting signals in the microvolt region. The pre-amplified signal is then amplified with a low pass amplifier with upper cutoff at 35 Hz. The amplified signal is recorded using computer sound card at a sample rate of 44,100 per second.

ANALYSES OF THE OBSERVED DATA

(a) Potential Gradient

Fig. 1 represents the temporal variation of vertical potential gradient on 8th June, 2004 during the Venus transit (red line) and its values averaged over other 18 days around that date (blue line) with standard deviations from the average value plotted as error bars. Firstly, we notice that the maximum and minimum values of the potential gradient on the day of the transit are around 300 Vm^{-1} and 50 Vm^{-1} respectively. But during the same period on other days, it is around 205 Vm^{-1} and 152 Vm^{-1}, respectively, the high values owing to the high level of pollution at the place. Secondly, the curve during the transit shows significant deviation from the average values as the variation is well beyond the standard deviation of the average trend. There is sudden enhancement of potential gradient up to around 300 Vm^{-1} after the start of the transit and then the gradual decrease up to around 50 Vm^{-1}.

(b) Schumann Resonances

The temporal variations of the amplitudes of first three Schumann resonance modes on 8th June, 2004, during the Venus transit, together with their averaged values of 18 days are shown in Fig. 2. Standard deviations from the average values have been plotted as error bars in the average plot. Standard deviations have been calculated over 2nd and 3rd quartile of the frequency distribution curve. It is seen that average amplitude of the first mode line in the average value graph is 0.025 A.U. (Arbitrary Unit) except a sharp almost 3 fold increase at 14 hr local time, whereas on the day of transit, the corresponding amplitude decreases gradually from 10 hr to 16 hr from 0.06 A.U. to 0.03 A.U. After 16 hr, the amplitude increases. The second mode amplitude in average value graph remains steady at 0.01 A.U. except almost a two fold increase at 14 hr local time. On the day of transit, the corresponding amplitude shows the gradual decrease from 0.035 A.U. to almost zero at 13 hr local time which then gradually increases. The third mode amplitude in the average graph remains the same except a depression between 13hr to 14 hr local time, whereas on the day of transit, the amplitude decreases from 10 hr local time to 13 hr local time and shows a peak at 14 hr and then the amplitude decreases up to 15 hr local time and then again increases.

(c) VLF Atmospherics

A comparative picture of the IFI at 9 KHz atmospherics on 8th June, 2004, during the Venus transit (blue line) and its 18 days' average value over the same period (black line) is presented in Fig. 3. The dotted curves represent standard deviation. On the day of transit, there are some unique peaks that appear just before and after the beginning of the transit. The peaks are in decreasing order of magnitude. The IFI then slowly increases to a steady value showing considerable fluctuations before and after the end of the transit also.

It is worthwhile to mention that in both the measurements, both potential gradient and VLF IFI lie just after the beginning of transit and before the end of transit beyond the standard deviation limits of the average variation. In case of potential gradient, it decreases from higher value to a lower value whereas in case of VLF IFI, it increases from lower value to a higher value. In Schumann resonance also, we get a similar trend as potential gradient.

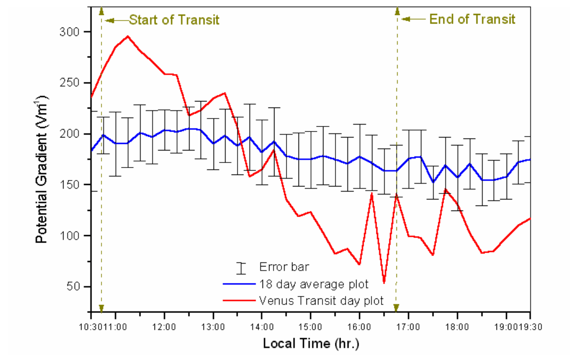

Fig.1: Variationof atmospheric vertical potential gradient on the day of Venus transit, 8th June, 2004 (red line) and average variation of the same parameter around 8th June for 18 days (blue line)

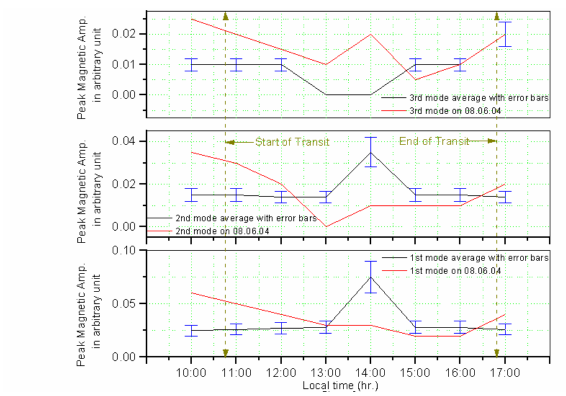

Fig. 2: Variation of peak magnetic amplitude of the three modes of Schumann resonance spectra on the day of Venus transit, 8th June, 2004 (red line) and average variation of the same parameter around 8th June for 18 days (black line)

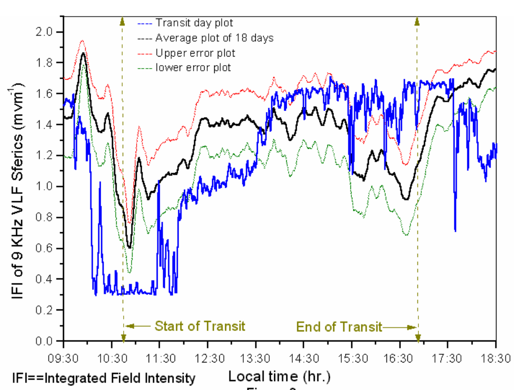

Fig. 3: Variation of atmospheric Integrated Field Intensity (IFI) at 9 KHz VLF on the day of Venus transit, 8th June, 2004 (blue line) and average variation of the same parameter around 8th June for 18 days (black line)

In the cases of potential gradient and VLF Sferics and also in the case of first and second mode of Schumann resonance, the “effect” of the Venus transit reverses its nature at about 1400 hour local time which is probably contributed by regional thunderstorm centre in SE Asia. The behaviour of n=3 mode (SR) curves are not properly understood.

The Atmospheric temperature recorded at an India Meteorological Department observatory about 10 km from observation site did not show any outstanding change during transit. Relative humidity throughout the day was a little bit higher than normal.

DISCUSSION

The commonly accepted model explains FWF near the ground by the dynamic equilibrium between charging currents from lightning activity and the leakage current of the Earth-ionosphere spherical capacitor [2, 10, 1]. The idea is corroborated by measurements Fullekrug et al. [10] who demonstrated a similarity of monthly averaged pattern of FWF and ELF amplitude. We have observed a correlation with VLF amplitude also on the day of Venus Transit.

During the transit of Venus, it obstructs 1/1000th part of incident solar radiation coming to the Earth, since the angular diameter of Venus compared to that of the Sun as seen from the Earth is of the ratio 1:32. Therefore, apparently the transit of Venus should have no significant effect on any terrestrial phenomenon. But, in spite of this fact, the changes observed in the atmospheric parameters at Kolkata during the transit of Venus are quite significant. This anomaly may be explained in terms of very large extent of the atmosphere of Venus with 96% CO_2 that produces atmospheric pressure of about 92 Bars [11]. Because of very high content of CO_2, and nitrogen, [12] its atmosphere absorbs high frequency radiations, protons as well as other ionizing particles from the Sun thereby depleting to a considerable extent the solar radiation reaching the Earth. Hence, during the transit, there will be some changes in the depth of interaction between Earth's magnetosphere and solar radiations which influence the collision frequency and rate of ionization within the Earth-ionosphere cavity. These in turn introduce perturbation in the atmospheric electrical conductivity [13] which may rise to the changes that have been observed.

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