Schumann resonances in earth – ionosphere cavity

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Introduction:

Lightning discharges are the source of electromagnetic radiation from ULF to X–rays and gamma rays (Rai 1974). The radiations from ULF to VLF frequencies propagate in the earth – ionosphere cavity to large distances without any appreciable loss of power.

Schumann (1952) studied theoretically the propagation of electromagnetic waves from lightning in the earth ionosphere cavity and predicted the presence of resonant modes due to constructive interference.

The Schumann resonances represent the global lightning activity (Clayton and Polk, 1974; Heckman et.al., 1998) and can be observed at any location of the earth (Sentman and Fraser, 1991; Fullekrug and Fraser – Smith, 1996; Price, 2000).

Many investigators (Williams, 1992; Beamish and Tzanis, 1986; Satori, 1996; Satori and Zieger, 1996; Christian et.al., 2003; Price and Melnikov, 2004; Melnikov et.al., 2004 and others) have widely studied the Schumann resonances and have obtained several characteristics. Long term seasonal and diurnal variations have been studied and explanations provided.

The purpose of the present paper is to study the intensity of ULF waves in the earth ionosphere cavity and the diurnal variation of SR frequencies.

Data Collection and Analysis:

The recording of the Audiofrequency Magneto Telluric (AMT) signal was done at Uniyal Gaon(Uttarakhand), geographic location ($30°23^1$ E,$78°17^1$N). A five channel ADU–06 model of MT recorder was used. It recorded the H_x, H_y and H_z components of the magnetic field along x (North–South), y (east–west) and z(vertical) directions. The electric field components along x and y directions were also recorded.

For each electric field component two EFP06 electrodes were used. The electrodes were fitted in a 20 cm diameter pit. Appropriate steps were taken to make a perfect contact of the electrodes with the soil. For the magnetic field measurement, magneto meters were used. For the present recording a sampling rate of 64 per second was used. TSMP software was used to obtain the average amplitude and power spectra for a period of one hour.

Results and Discussion:

The data for the present study was collected at Uniyal Gaon (Uttarakhand). A continuum recording was made. For the present study one hour data during night time (1 AM to 2 AM), sunrise (morning) hours (5.30 AM to 6.30 AM), noon (1 PM to 2 PM) and sunset (evening) hours (6.30 PM to 7.30 PM) were averaged and the frequency spectrum was obtained for each of the above times.

Fig 1 shows the amplitude spectrum for the recording in E_x and E_y components. In both the components the amplitude is maximum at noon at all frequencies. The night and sunrise observations show almost equal amplitudes at all frequencies in E_x component. The sunset amplitudes are minimum. However for the E_y component the minimum is during night time. A similar picture has been obtained for both the components in power spectrum. However the scenario is different in the magnetic field components H_x and H_y . In both these components the maximum amplitude is at sunrise and the minimum at sunset. In most of the cases for the month of May 2006 the maximum amplitude in electric field components is at noon and the minimum lies at sunset.

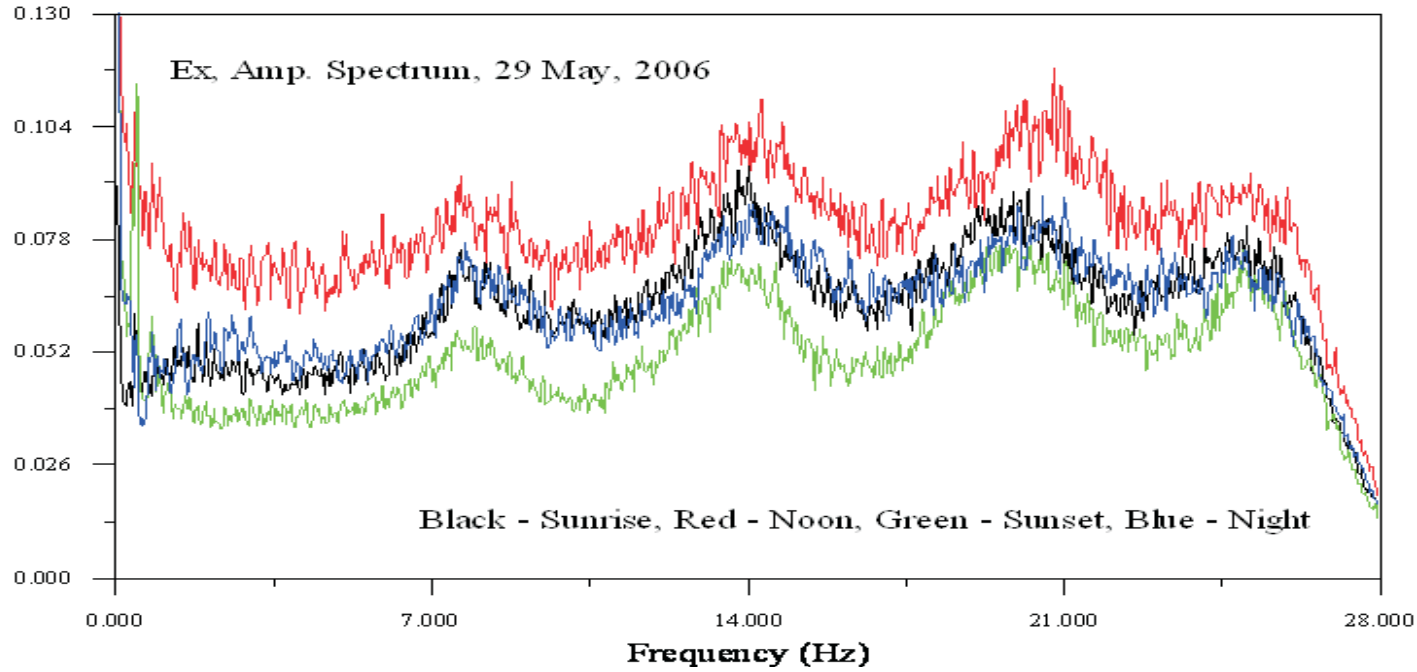
The fundamental mode frequency varies considerably from day to day and at different times of the same day. It ranges from 3 Hz to 8 Hz. In maximum number of cases it falls from 7.6 to 7.8 Hz. The frequencies of the second harmonic vary from 10.5 to 14.5 Hz, the maximum number lies around 14 Hz. The variations in third and fourth harmonics are not so much and they lie around 20 Hz and 25 Hz respectively.

Price and Melnikov (2004) have found in their observations that the maximum in magnetic field components occurred at 1400 UT (noon time in Israel) due to the predominant lightning activity in Africa.

In their observations the frequency of the first mode varied from 7.8 to 8.05 Hz. The first mode displayed a diurnal pattern with two maxima throughout the year, the first around 0300–0500 UT and second broad maxima between 1400 and 2000 UT. In their observations the second mode frequency ranges from 13.75 to 14.45 Hz and the third mode from 20.35 to 20.35 Hz. Higher harmonics were almost constant.

Satori (1996) found that in summer the first mode frequency has a maximum around 1000 UT and the second mode has maxima at 0900 and 1500 UT.

In the present study we have limited our studies upto 28 Hz only. Above this frequency the power line radiation at 50 Hz dominates all the signals. At about 1.5 Hz our records exhibit a strong peak, which we have ignored in the present study. our results are in conformity with the observations of other workers.



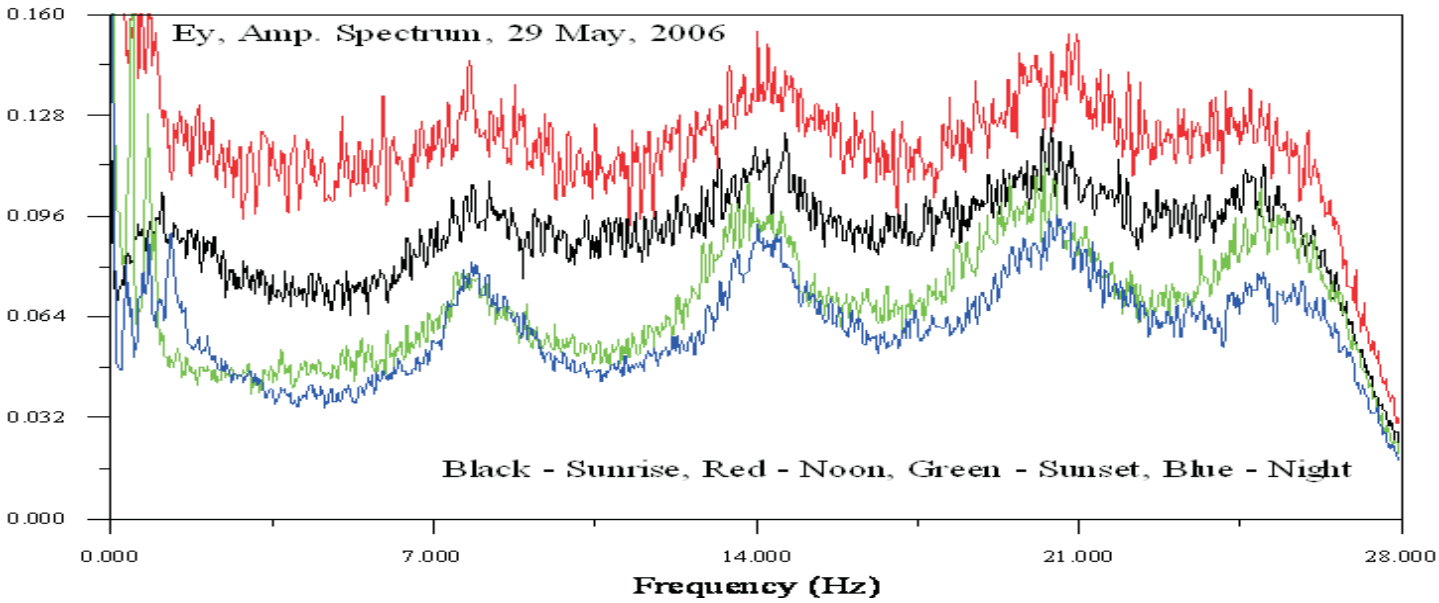


Figure 1: Records of E_x and E_y components for different times of the day

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