Lunar Tidal Effects on the Bottom Side of the Ionospheric Plasma With Variation of Local Magnetic Field in Mid-Latitude

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Abstract: Ionosphere is a part of the atmosphere which is formed due to solar ultraviolet radiation on the atmosphere. It continues from high altitudes to near the Earth's surface. It is divided into different layers such as D, E, and F and… due to the ionization rate and the density of electron, ions and some other factors. Ionosphere is known as an environmental plasma conditions. One of the interesting phenomena in the Ionosphere is the plasma occurrence of E_S. This phenomenon is occasional and it may disappear in short time range. We are searching for the correlation between two phenomena as E_s-plasma layer height and the earth geomagnetism activities. To do this, we study the correlation of these two parameters at the four main moon phases. When the moon is experiencing one of its main phases, the tide goes in and out to its maximum or minimum values. As the gravitational forces cause tide to occur through affecting the surface tension of the sea waters, they take the same effect on the Ionosphere and the E-layer and cause the lunar tidal effects in this layer. Our investigations in the Ionosphere Station at Boulder, Colorado which located in the mid-latitude-that have been done in periods categorized by the mid-day tides, revealed that in each period, the variations of the correlation coefficient between Es-plasma layer height occurrence and the earth geomagnetism activities are the same for each main phases of moon in different months.

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1- Introduction

Ionosphere is in the region between fully ionized plasma and neutral atmosphere and composed of Plasma which is magnetized in the presence of earth's magnetic field. Therefore, Ionosphere is a partially ionized plasma in which both neutral and charged particles with electrical conduction exist. Furthermore Coulomb forces between particles and also the effects of collision between neutral particles, exist in ionosphere. Cosmic radiations function in the formation of lower layers of Ionosphere or its upper layers depend on the power of solar radiations directly or indirectly. Electron density in the earth's Ionosphere shows three different layers which their distance and their in between borders also their existence change with day and night and seasons. Solar radiation on earth's Ionosphere produce electrons and ions. The amounts of these ions related to the energy levels of solar radiations and composition of ionosphere in different height where ionization is occurred. As soon as the emergence of ions, several processes will take place which change the type of ions and also reduce the number of electrons and therefore the ions themselves. The contest between ionization phenomena, distribution of ions and electrons, geomagnetic effects and the motion of mass determines the quantity of all ions and electrons. All these processes constitute the ionosphere. In this study ionospheres' plasma of E and Es-layer are under consideration. E layer, that is day time layer is limited to 90 to 140 kilometer above the earth surface. Ionization of molecules is dominant process in this layer and the tendency of electron-ion for recombination is seldom. In this region, equilibrium between ionization and recombination determines electron density. Region E contains conventional E layer and sometimes unconventional Es layer. Small and thin plasma clouds which are results of intensive ionization, characterized as sporadic Es- plasma layer. emission of ions flux (such as Na^+, Mg^+, Fe^+) with long durability which are described by dynamical processes are cause of these layers occurrences [5]. Es is the term for very high values of ionization in the height of E layer which has limited thickness about 0.6-2 Km and apparent height about 90-120 kilometers above the earth surface. Researches show that the Es-layer occurs in the heights of E region, but it could not be explained by a unique theory because several phenomena are involved to its formation. Variation in the speed and direction of neutral solar wind, in accordance with earth's magnetic field known as an essential elements in the Es formation mechanism in mid-latitude

(White Head 1989,1970,1960). Furthermore moon's tidal waves, gravitational and planetary waves have a major role in its occurrence, controlling the stability of Es-plasma in mid-latitude [6]. In order to investigate the effects of lunar tidal effects on the Es-Plasma occurrence We will make use of available data. Regular hourly measurement of the height of the Es layer within special days and in different months have done in Boulder Colorado N40°E255 observatory. We obtained results of these measurements in diagrams and tables. Analysis and statistical investigations are as follows.

1) In order to show the effects of lunar tidal effects in lower layer, the hourly data of the height of Es layer in days for four main phases of moon (new moon, half-moon, full moon, second half-moon) occurs are used.
2) K indexes, relevant to earth's geomagnetic activities in special days (at the time of main phases of moon) are obtained from Boulder Colorado station.
3) For statistical analysis of correlation between height of the Es- plasma layer and geomagnetic activity of earth, the method of determination of correlation coefficient between two sets of data (obtained from MATLAB) is used.
4) Correlation coefficients at the time of main phase of moon for three periods (D, E, J) are calculated and results are compared.

2- The concept of tide

Lunar tide emanates from type of gravitational force different from that of earth's and the first who explained it scientifically was Isaac Newton. Planets always gravitate towards each other and the sun also not only attracts earth but also attracts other planets in the solar system. As other planet attract the sun then moon also attract earth by its gravitational force. This force in each hour of a day has more effect on the regions on the earth which are nearer to the moon and since water can be easily attracted by gravity then moon pull it more hardened and consequently high water occurs. When some part of the earth is placed at a great distance from the moon then tidal effect of the ebbs occurred. Lunar tide is the direct consequent of gravitational effects of the moon and sun on the earth. Generally tidal forces are bound up with the binary systems. Gravitational attraction effects of the moon and sun are in the first and fourteenth days of lunar month where the sun and moon are line-up and intensify their effects. At this time, in ebb tide push the water go downer from its ordinary state and in high tide it comes upper. These tides are called spring tides.

On the other hand at the first and second quarter period of the months intervals in which the moon and sun are at right angle the intensity of tides reaches into its minimum. We know these tides as neap tides.

3- Moon's tidal effects on the height of Es-plasma layer

To show moon's tide effects on inferior layer, the hourly data of the height of the Es-layer at days of four main phase of the moon (new moon, first quarter, full moon, second quarter) are used. The results of different studies show that tide occurs twice a day. It means that if ebb occurs at any given time, approximately 6 hours later high tide current can be seen and again this process successively repeat. At new moon (first day of lunar month) or full moon (fourteenth day of lunar month) tide reaches to its maximum and at the half-moon goes to its minimum. In this section the height of the Es-plasma layer in different hours of the days of main phase of moon are shown. This investigation has performed for the years 2011 and 2012. Figure 1, 2 and 3 are samples of variation in Es-layer's height versus the hours of a day.

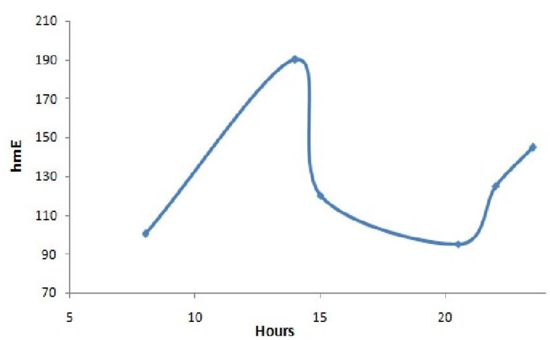

Fig .1 Full moon, November 10th, 2011

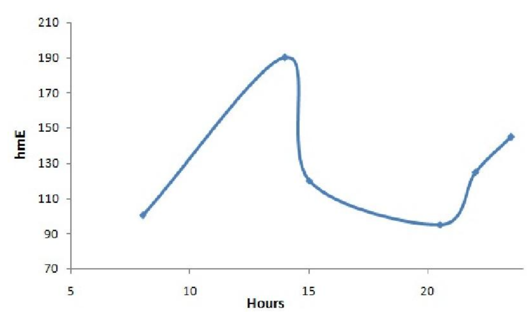

Fig .2 New moon, November 25th, 2011

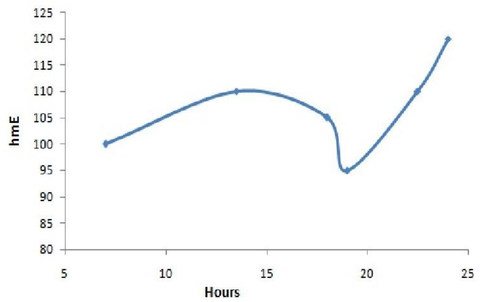

Fig. 3 Third quarter of moon phase, November 2nd, 2011

Each diagram shows twice ebb and high water in a day. These diagrams show also that when moon is new or full, the Es-plasma layer is higher in height than its position in the first and third quarter time of moon phases. Gravitational forces which cause surface tension of seas and make tide, affect Es-layer and lead to follow the tide in this layer.

4- Investigation of lunar tide in special periods

Lunar tide movement is one of the most important theoretical process. It shows the interaction between atmosphere and external forces like tidal attraction of the moon. The oscillations of surface pressure of midday lunar tide are the best type of lunar tidal effect. Champman and many of his colleagues investigate this period in more than 70 regions in south and North America. The investigation showed that lunar tides' distribution is related to the seasons and maximum domain occurs along north summer and also daily high tides reach to their full extent in south winter. Generally mid-day lunar tides are investigated in three periods as follows:

Period D: November, December, January, February
Period J: May, June, July, August
Period E: March, April, September, October (equatorial months)

Period D: As they called south revolution months which contain November, December, January and February. Also the point of north revolution (summer revolution) occurs in June (20th or 21th).

Period E: This period is related to the Vernal Equinox and autumnal Equinox. Vernal Equinox or north equinox occurs on 20th March. At the occurrence of vernal equinox in northern hemisphere, autumnal equinox occurs on 22 or 23th September in southern hemisphere. Therefore, the Period E (equatorial months) contains March, April, September and October.

5- Determination of correlation coefficient between height of Es-plasma layer and geomagnetic activity

For statistical analysis of correlation between height of the Es-plasma layer and earth's geomagnetic activity, we use the method of determination of correlation coefficient between two sets of data.To do this, correlation relation between height of the Es-plasma layer and K coefficients, related to the earth's geomagnetic activities in mid-latitude, filed in the Ionosphere Station at Colorado (Boulder Colorado N40°E255°), are investigated in months of 2011 and 2012.

Figs. 4, 5 and 6 show variation between height of Es-plasma layer and K coefficients with first order curve fitting and correlation coefficient between these two parameters at days of main phase of moon.

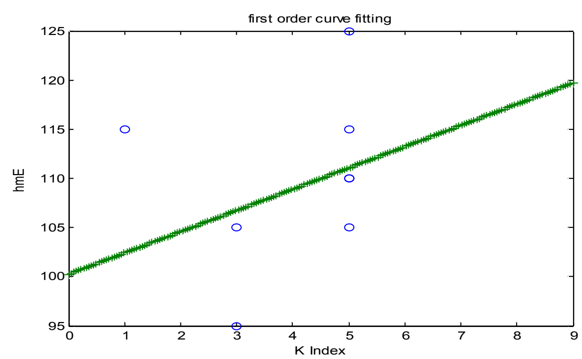

Fig. 4 Variation of hmE vs. K-index on March 8th, 2012 (full moon)

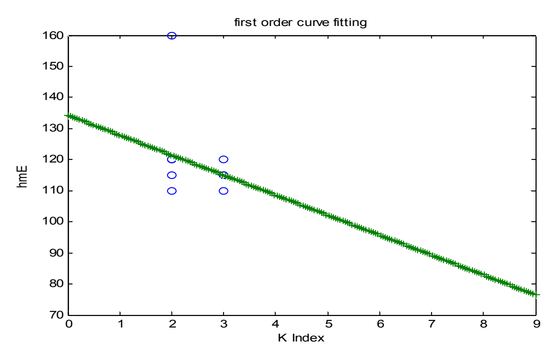

Fig. 5 Variation of hmE vs. K-index on March 14th, 2012 (third quarter)

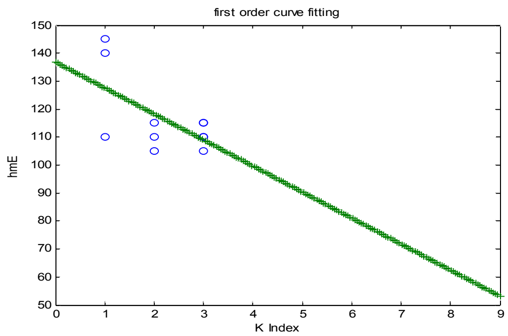

Fig. 6 Variation of hmE vs. K-index on March 22th, 2012 (new moon)

6- Investigation of correlation coefficient

In this section, correlation coefficients between height of Es-plasma layer and geomagnetic activities of earth in 2011 and 2012 in E, D and J periods are categorized in tables as below.

6-1 In the year 2012 and in period J,when moon is new correlation is negative and almost strong, and at the time when we have full moon correlation is positive and strong. Moreover, when the moon is in the first quarter correlation coefficient is positive while in the other hand in third quarter correlation is negative and weak. Correlation coefficients of this period are showed in Table 1.

6-2 In the year 2012 and in period E, when moon is new correlation is very strong and negative and it is positive at full moon time. Correlation at the first quarter is weak and positive and negative at the third quartet. Table 2 shows correlation coefficient of this period.

6-3 In the year 2012 and in period J, we have negative and weak correlation at new moon and positive and weak at full moon. Correlation at the time of first quarter and also third quarter is positive and weak. These are showed in table 3 as follows.

6-4 In the year 2011 and in period E, correlation at the time of new moon is so strong and positive and at full moon is weak and negative. In this period correlation at the first quarter and also at the third quarter is positive and weak. Table 4 contains these coefficients.

6-5 In 2011 and in period D, at the time when moon is new, negative and weak correlation is observed. In this period, correlation at the time of both first and third quarter is negative and almost weak. Table 5 shows these coefficients.

As seen for some periods like E in the year 2011, when the moon is full, there is no relationship between correlation coefficients due to processes like solar tab, magnetic hurricanes, distribution of ionospheres' plasma under the influence of solar and magnetic disturbances which cause to changes in solar activities and lead to changes in ionospheres' parameters (such as height and the extent of maximum density in different layers).It should be noted that in August the year 2012, full moon phenomenon occurred twice that the second is named blue moon. This is why correlation coefficient is noted twice.

7-Conclusion

From investigation of data and diagrams, twice tides in the height of Es-plasma layer can be observed each day and these heights reach to their minimum and maximum at the time of main phase of moon. Ultimately by comparing tables and investigation of correlations, it could be concluded that variation in correlation coefficient between height parameters of Es-plasma layer and geomagnetic activities of earth in each main phases of moon at different months of a year period are the same.In this research correlation between height of Es-plasma layer and geomagnetic activities of earth in mid-latitude was investigated. As a suggested project, the correlation between height of Es-plasma and geomagnetic activities in long and short-latitude can be investigated by the use of different theories. This research is done in Es-plasma layer. This study can be done in other layers of ionosphere in future.

Table 1. Correlation coefficients, period J in 2012

Moon Phases	New Moon	First Quarter	Full Moon	Third Quarter
May	-0.45	0.10	0.54	-0.11
Jun	-0.32	0.58	0.55	-0.17
Jul	-0.51	0.32	0.46	-0.15
Aug	-0.48	-0.18	0.51 - 0.56*	-0.31

Table 2. Correlation coefficients, period E in 2012

Moon Phases	New Moon	First Quarter	Full Moon	Third Quarter
Mar	-0.62	0.31	0.33	-0.22
Apr	-0.67	0.23	0.48	-0.61

Table 3. Correlation coefficients, period J in 2011

Moon Phases	New Moon	First Quarter	Full Moon	Third Quarter
Jun	-0.08	0.23	0.01	0.22
Aug	-0.21	0.01	0.05	0.11

Table 4. Correlation coefficients, period E in 2011

Moon Phases	New Moon	First Quarter	Full Moon	Third Quarter
Oct	0.73	0.17	-0.37	0.35
Sep	0.67	0.24	-0.12	0.27

Table 5. Correlation coefficients, period D in 2011

Moon Phases	New Moon	First Quarter	Full Moon	Third Quarter
Nov	-0.14	-0.34	0.08	-0.29
Dec	-0.17	-0.48	-0.26	-0.32

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