Geophysical and astrophysical processes in Earth’s electric field

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Abstract. The work on detection of geophysical (lunar tides) and astrophysical (gravitation-wave relativistic binary star systems) impact on Earth’s lower atmosphere electric field is lead in Vladimir state university since 1999. The electric and geomagnetic fields are monitored at the Vladimir state university experimental physical base in infralow frequency scale in which the gravitation-wave frequencies of relativistic binary star systems are suited. Experimental research are lead in order to detect the fact of anomalous behavior of components in vertical Earth’s electric field spectrally localized at the lunar tides frequencies and double of relativistic binary star systems rotation frequencies and to estimate amplitudes of the such components.

1. Introduction
The work on detection of geophysical (lunar tides) and astrophysical (gravitation-wave relativistic binary star systems) impact on Earth’s lower atmosphere electric field is lead in Vladimir state university since 1999 [1]. Theoretical foundation of quasistatic electromagnetic and gravitation fields’ interaction are found in [2-3]. The periodic gravitation radiation is proved to form a variation of electromagnetic field at frequency of the radiation.

The long (30 years) time series of Earth’s electric field vertical component observations at three Roshydromet stations (Voeikovo, Verkhnee Dubrovo, Dusheti) and General and physical base (Applied Physics Dept., Vladimir state university) are used.

2. Results
The vertical component of Earth’s electric field strength in near-ground layer of Earth’s atmosphere (Ez) are researched at the doubled rotation frequencies of forty three relativistic binary star systems (RBSS) taken from W. J. Johnston list based on [4]: J1614-2230; J1518+4904; J0621+1002; J1022+1001; J1518+0204B; J2145-0750; J2129-5721; J1603-7202; J0437-4715; J1732-5049; J1745-0952; J1045-4509; J1701-3006A; J1157-5112; J1614-2318; J1911-1114; J1804-0735; J2317+1439; J0024-7204H; J0024-7204E; J0218+4232; J1232-6501; J1834+0010; J0034-0534; J1909-3744; J1342+2822B; J1435-6100; J1740-5340; J1641+3627B; J1518+0204D; J0024-7204S; J0613-0200; J0024-7204T; J1701-3006D; J1518+0204E; J0700+6418; J1911-5958A; J2140-2310B; J1012+5307; J1641+3627D; J0024-7204Y.

Figure 1 and figure 2 shows the amplitude spectra estimations of the time series of vertical component of Earth’s electric field strength observed at one of the stations (Dusheti). The estimation
of active value produced by classical spectral analyser is shown versus length of the spectral analysis interval. The analyser is set to the frequency of Earth’s rotation (solar tide S1, 11.5741 uHz) (Fig. 1) and to the fourth harmonic of this frequency (solat tide S4, 46.2963 uHz) (figure 2).

![Figure 1](image1)

**Figure 1.** Amplitude spectrum estimations’ statistics with different intervals of analysis at frequency of the Earth rotation (S1 solar tide). Vertical component of the Earth electric field strength, Dusheti station.

![Figure 2](image2)

**Figure 2.** Amplitude spectrum estimations’ statistics with different intervals of analysis at frequency of the forth harmonic of Earth rotation (S4 solar tide). Vertical component of the Earth electric field strength, Dusheti station.
The figures show that at the Earth’s rotation frequency the spectral estimation lowers toward 0.9 V/m with the analysis interval growth while the mean square deviation continues to lower toward zero. At the S4 tide frequency the spectral estimation lowers toward the value which is approximate to 0.2 V/m.

The classical spectral estimations at the frequencies of lunar tides and gravitation-wave radiation of RBSS asymptotically lower toward zero while the analysis interval length grows. That is the difference between lunar tides and gravitation-wave of RBSS from the solar tides. An example for the lunar tide M2 (period 12.4667 hr., frequency 22.2816 uHz) is shown at figure 3. An example for the gravitation-wave radiation of J1537+1155 (frequency 111.7 uHz) is shown at figure 4. The asymptotical convergence of spectral estimations to zero means that the components of time series at the lunar tides’ frequencies and RBSS are noncoherent.

![Figure 3. Amplitude spectrum estimations’ statistics with different intervals of analysis at frequency of M2 lunar tide. Vertical component of the Earth electric field strength, Voelkovo station.](image)

The classical spectral analyser reacts to the time series of vertical component of Earth’s electric field at the lunar tides’ frequencies and RBSS frequencies as to a pink noise. The behavior shown at figure 4 is typical: no spectral estimation of doubled RBSS rotation frequencies have another behavior.

The analysis interval of constant length is needed in order to analyse the noncoherent components of Earth’s electric field strength. The accumulation while using of such analysis intervals is done not by the interval length growth (that is the way of spectral analysis) but by the growth of intervals’ count (that is the observations’ ensemble formation). Analyser of signal eigenvectors and components (eigenoscope) is introduced in order to detect the noncoherent components [5].

The analyser of signal eigenvectors and components the observations time series representation in basis of ensemble covariance matrix eigenvectors. This representation presents the observed behavior as a summary movement which are parallel to some principal axes defined by the eigenvectors. This representation gives minimal component number for the given error and minimal error for the given components’ number. The time series’ covariance matrix estimation on analysis intervals is decomposed to a weighted sum of partial projector matrices. Form of such a projector matrix is defined by the corresponding eigenvector. The weight of it is defined by the corresponding eigenvalue.
The covariance matrix decomposition allows to analyse correlation properties of observations separately and to detect the informative components which are produced by different causes even in cases of small energy of such components.

Figure 4. Amplitude spectrum estimations’ statistics with different intervals of analysis at frequency of gravitation wave radiation of J1537+1155 relativistic binary star system. Vertical component of the Earth electric field strength, Dusheti station.

Figures 5-7 shows the eigenvectors which have the amplitude spectra localized near M2 lunar tide frequency.

Figure 5. Eigenvector No.178 of covariance matrix which is spectrally localized at M2 lunar tide frequency (left) and the amplitude spectrum (right). The vertical line shows the M2 tide frequency. Vertical component of the Earth electric field strength, Voeikovo station.
Figure 6. Eigenvector No.179 of covariance matrix which is spectrally localized at M2 lunar tide frequency (left) and the amplitude spectrum (right). The vertical line shows the M2 tide frequency. Vertical component of the Earth electric field strength, Voeikovo station.

Figure 7. Eigenvector No.180 of covariance matrix which is spectrally localized at M2 lunar tide frequency (left) and the amplitude spectrum (right). The vertical line shows the M2 tide frequency. Vertical component of the Earth electric field strength, Voeikovo station.

Figure 8 shows eigenvectors No. 131 and No. 132 which are spectrally localized at doubled rotation frequencies of RBSS J0024-7294T and J1701-3006D. Figure 9 shows eigenvectors No.151 and No.152 which are spectrally localized at doubled rotation frequency of RBSS J1518+0204E.

The classical amplitude spectrum analyser equally reacts to the time series of vertical component of Earth’s electric field (look figure 1 and figure 4) and to a model of colored noise with an appropriate amplitude spectrum [6]). The question of gravitation waves’ influence to a vertical component of Earth’s electric field seems to be closed but the analyser makes the difference.
Figure 8. Eigenvectors No.131 and No.132 of covariance matrix which are spectrally localized at doubled rotation frequencies of RBSS J0024-7294T and J1701-3006D (left) and theirs’ amplitude spectra (right). Vertical lines show the doubled rotation frequencies of J0024-7294T and J1701-3006D. Vertical component of the Earth electric field strength, Voeikovo station.

Figure 9. Eigenvectors No.151 and No.152 of covariance matrix which are spectrally localized at doubled rotation frequency of RBSS J1518+0204E (left) and amplitude spectrum (right). Vertical line shows doubled rotation frequency of J1518+0204E. Vertical component of the Earth electric field strength, Voeikovo station.

3. Summary
The fact of anomalous behavior of noncorrelated Earths’ electric field strength components spectrally localized at the doubled rotation frequencies of RBSS.

The eigenoscopy (that is covariance matrix eigenvectors’ and components’ analysis at finite interval) of Earth’s electric field time series allows to detect the components spectrally localized at doubled rotation frequencies of RBSS having the significant amplitudes. The proof base of this behavior is formed.
References

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