

EARTH, MOON, MERCURY AND TITAN SEISMICITY: OBSERVED AND EXPECTED PHENOMENA

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Tidal and shell-dynamics interactions of the given celestial body with external celestial bodies lead to variations of their tensional state and to variations of different planetary processes including variations of seismic activity. It is clearly observed that variations of lunar seismicity have the celestial mechanical nature and depend from the Moon perturbed orbital motion. Using dynamical analogy in translatory-rotary motions of synchronous satellites and Mercury we have obtained evaluations of periods of variations of seismic activity of the Titan and Mercury. High level of endogenous activity of Titan was predicted earlier [1].

The full elastic energy of luni-solar tides superposition is not additive sum of elastic energies of separated tides and contains additional terms of mutual character, which play significant role in geodynamical life of the Earth [2]. Tensional state of the Earth is characterized by the elastic energy stored in superposition of tides. Part of elastic energy dissipates and goes to warm energy and to an energization of different geodynamical processes in definite rhythms. Correlation of the extreme variations of the elastic tidal energy of the Earth with earthquakes and moonquakes events (in period 1971-1976 years) was established [3]. This regularity of seismic process have used for prediction of the dates of some large earthquakes in 2003 and 2004 years. In particular the date of phenomenal Hokkaido quake of 25 September (M=8.3) was predicted with high accuracy in [3]. Mechanism of differential and cyclic action of the Moon and Sun on the interacting plates has been suggested (as trigger mechanism) for explanation of discovered regularity.

Cyclicities of the Moon seismicity. The relative orbital motions of the Moon and the Earth are identical. Periodicities in their orbital motions in same style influence on the tidal processes on both celestial bodies and, consequently, rhythms at identical periods can be expected in seismic processes for the Moon and for the Earth. First confirmation of mentioned correlations has been obtained for shallow earthquakes (with magnitude >7.3) and shallow moonquakes in period 1971-1976 [4]. Tidal nature of moonquakes has been discussed by an interpretation of results of their spectral analysis [5], [6]. In mentioned papers the periods of the Moon orbital perturbations in 27.4, 13.6, 206 days and some others have been determined.

Our spectral-temporal analysis of the full series of the deep moonquakes from catalogue which has been kindly presented us by Y. Nakamura (7344 events, [7]) have been let us to confirm mentioned periods and to establish some new cyclicities in quake activity of the Moon and to describe a fine structure

of some from orbital periodicities. So were determined variations of Moon seismicity with another periods multiple to orbital draconic (T_{drac}), anomalistic (T_{anom}) and synodic (T_{synod}) periods.

Table 1. Periods of seismic variations.

Moon	Titan	Mercury
$T_{drac}/2=13.611$	(13.608; 2371);	7.9722
$T_{anom}=27.54$	(27.570; 1214);	15.9455
$T_{syn}/2=14.766$	(14.765; 1042);	7.9846
$T_{drac}/4=6.805$	(6.804; 815);	3.9861
$T_{drac}=27.22$	(27.18; 680);	15.9444
$T_{syn}=29.53$	(29.56; 495);	15.9661
$T_{syn}/3=9.844$	(9.840; 373);	5.3230
$T_{drac}/6=4.537$	(4.535; 354);	2.6574
$T_{syn}/4=7.383$	(7.380; 348);	3.9923
$T_{drac}/3=9.074$	(9.071; 314);	5.3148
$T_{anom}/4=6.884$	(6.871; 289);	3.9864
$T_{drac}/8=3.403$	(3.395; 285);	1.9961
$T_{anom}/5=5.508$	(5.500; 261);	3.1891
$T_{syn}/11=2.685$	(2.685; 253);	1.4517
$T_{drac}/5=5.444$	(5.455; 249);	3.1889
$T_{anom}/8=3.442$	(3.470; 249);	1.9932
$T_{synod}/8=3.692$	(3.735; 236);	1.9961
$T_{synod}/7=4.219$	(4.205; 234);	2.2813

From another the more remarkable and observed periodicities of the Moon activity are (in days):

- 441.800 [436.9 ± 8.7], (819);
- 366.9 [347.5 ± 11.3], (661);
- 206.6 (847);
- 441.8 [436.9 ± 8.7], (819);
- 227.9 (564);
- 299.5 (515);
- 258.5 [250.2 ± 3.6], (393);
- 148.9 (484);
- 81.73 [81.8 ± 0.4], (360);
- 61.13 (324);
- 106.8 [107.5 ± 0.9], (305);
- 101.3 (295);
- 68.13 (291);
- 138.1 (280);
- 178.3 [178.1 ± 2.3] (274);
- 161.1 (271);
- 117.3 (256);
- 58.78 (242);
- 34.300 [34.5 ± 0.1], (311);
- 33.575, [33.6 ± 0.1] (268);
- 32.75 (500);
- 31.950 [32.0 ± 0.1], (424);
- 14.05 (462);
- 30.024 [30.6 ± 0.1], (344);

25.20 (440);
25.91 (420);
16.495 [17.9 ± 0.1], (240);
13.13 (348);
6.561, [6.5 ± 0.1] (263),
5.710 [5.7 ± 0.1] (250);
3.395 [3.3 ± 0.1],
3.505 [3.5 ± 0.1], (259) and others.

Here in square brackets are given values of periods obtained independently by Dr. Kaftan V.I. and in parentheses are given conditional amplitudes of corresponding seismic variations. Obtained results were analyzed and compared with similar results obtained for a random temporal distribution of quakes. The main conclusion is: the seismic rhythms on the Moon have the celestial- mechanical nature and are dictated by gravitational influence of the external celestial bodies. Although, the spectral-temporal analysis has revealed some temporal instability of some rhythms observed [6]. As known the many from the Earth processes are characterized by a similar behavior. To explain observed cyclicities in the moon seismicity we study a possible role of the orbital and rotational tides and a role of mechanical interaction between non-spherical mantle and core of the Moon induced by gravitational action of the Earth and the Sun.

Variations of the Earth seismic activity. We have been fulfilled statistical analysis of differences of dates of big earthquakes (in last 30 years, [9]) and close dates of extremes of tidal elastic energy. Obtained results in general confirm correlation of these dates and a new phenomenon of displacements of dates of the big quakes on 1.5-2.0 days with respect to the dates of extremes of elastic energy has been observed.

We can dear to suggest that variations of elastic tidal energy exert some control on seismic processes. It is important to note that the crossed term of the elastic energy plays a relevant role in the observed correlation with seismic events. It seems natural: part of the elastic energy accumulated with every orbital cycle of Moon (and Sun) dissipates to inner geodynamical processes that its variation drives.

For explanation of observed regularity of a seismic process we have been suggested a mechanism of differential and cyclic action of the Moon and Sun on the interacting plates. This mechanism is a trigger mechanism which control big seismic events in different time-scales.

Cyclicities of Titan seismicity. Titan is synchronous satellite of Saturn with parameters of orbital motion similar to Moon motion. In assumption that the mechanisms of endogenous activity of Titan and their displays are identical with the Moon we can give some first evaluations of periods of variations of Titan processes including its seismic activity. These periods are given in analogy with observed lunar

variations of seismicity (in Table 1). Here we have used known model of the Titan orbital motion [8].

Cyclicities of Mercury seismicity. The translatory – rotary motion of Mercury is also resonant. In assumption that the mechanisms of endogenous activity of Mercury and their displays are identical with the Moon we can remark on the possible variations of Mercury processes including. So must be observed variations of the seismic activity of Mercury with periods multiple to period of its orbital motion 87.969 days (some from them are given in Table 1).

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