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Titan cyclic activity mechanism and possible regime of its forced and free librations

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Abstract. The hypothesis is developed, that the mechanism of the forced relative displacements of shells of the Titan is responsible for observably asymmetry of hemispheres, for activity and cyclicity of the processes occurring in its shells. In given report I present new dynamical illustrations to an organization of the natural processes on Titan: cyclic atmospheric processes, polar asymmetry of structure of an atmosphere, concentration of lakes and bogs in polar zones of the Titan. The phenomena of polar inversion of activity of processes, free and forced librations of the Titan with the big amplitudes are predicted.

1 Introduction. In the paper of 2002 [1] I in particular wrote: “The important conclusion of the carried out research is the establishment of the high endogenous activity of the Titan. It is possible, **that it is the second world in Solar system (after the Earth) where all natural processes roughly prove: atmospheric processes and processes in an oceanic shell, tectonic processes and volcanic activity**. In this connection exclusive interest is represented with landing to a surface of the Titan to 2004 of a space vehicle from a board of station "Cassini" started to Saturn in 1997”.

“We in the right to assume, that on the Titan observed active volcanic activity, occurred in the past and occurred in present planetary changes of a face of the Titan in the form of dome formations and uplifting of some zones and areas, ordered system of cracks and the valleys connected to it along which a moving of ice masses is observed. On the Titan there are rough and intensive atmospheric processes. Natural processes on the Titan also are uniform, as well as on the Earth. They are dictated and are directed by the same mechanism - the mechanism of the swing, wobble and wanderings of the Titan shells. Natural processes are cyclic, are characterized by the uniform frequency basis determined by frequencies of perturbed orbital motions of the Titan, the Saturn and other celestial bodies. **The methane ocean of the Titan, quite probably, represents system of the seas which formation was caused by the directed radial displacement of shells of the Titan.** All shells of the Titan, including ocean and an atmosphere, are deeply dynamically mutually connected and penetrated with uniform rhythms and cycles in the existence and evolution.” ([1], p. 72). All stated assumptions about the high activity of Titan, about cyclicity of its natural processes, concentration of the seas in polar zones of opposite hemispheres etc. have obtained clear confirmations by realization of the space – mission “Cassini”.

2 Concentration of fluid masses of the Titan near to the polar zones. The Cassini’s imeges confirmed that most of the many lakes and seas are concentrated at northern polar region. These seas are most likely filled with liquid ethane, methane and dissolved nitrogen [2]. The view of Titan's south pole reveals the intriguing dark feature named Ontario Lacus and a host of smaller features dotting the south polar region. The northern features, the sizes of small seas, are either completely or partially filled with liquid hydrocarbons.

The analytical solution of the problem about forced relative oscillations of the core and mantle of the planet (Earth) separated by a viscoelastic layer has shown that oscillations with annual, decadal periods and with the periods of planetary secular perturbations have mainly the polar character [3]. Moving and gravitating core organize and control asymmetrical polar tides of fluids of the planet. In the case of Titan its crust and bottom shell are separated by oceanic shell and similar conclusions about polar relative oscillations of shells have place. With a reference to the Titan it means, that its fluid masses during the evolution under action of the specified mechanism could tend of asymmetric concentration in polar zones. This phenomenon of concentration of fluid deposits in various physical states (water, ice, liquid methane, etc.) in polar

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regions of these bodies is universal and widely should be observed on planets and satellites of solar and others planet systems. The data of modern observations in really give confirmations to the specified theoretical conclusion [1].

3 Cyclic activity of Titan. Tidal and shell-dynamics interactions of the given celestial body with external celestial bodies lead to variations of its tensional state and as consequence to variations of different planetary processes including variations of seismic activity [5]. 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 corresponding characteristics of perturbed Titan orbital motion we have obtained evaluations of periods of variations of seismic activity of Titan: T_{anom}= 15.9455; T_{drac}= 15.9444; T_{syn}= 15.9661; $T_{synod}/2$= 7.9846; $T_{drac}/2$= 7.9722; $T_{drac}/3$= 5.3148 and oth. These periods are multiple to periods analogous to sinodyc, anomalistic, draconic periods of the lunar orbital motion. Another long-periodic variations of the Titan processes (seismic, atmospheric and others) are caused by orbital motion of Saturn and by mutual action of Saturn and satellites, and probably of Titan librations.

4 The cyclicity of Titan's methane clouds. "The most robust cloud feature observed on Titan over the past several years, its south polar clouds, have completely dissipated. Certainly the seasonal cycle of insolation has much to do with this event. But cloud features at midlatitudes are not in-phase with the distribution of solar forcing, so some internal mechanism must be providing a time-lag. We present results of an axisymmetric global circulation model of Titan with a simplified suite of atmospheric physics forced by seasonally varying insolation" [4]. The basic interval of variations makes 15.98 days, i.e. the period of orbital motion. Minima are displaced relatively to previous maximum approximately on 6.5 days. On the data [4]. This phenomenon gives the first confirmation to prediction of existence of variations of natural processes on Titan with diurnal (orbital) period [1], [5].

5 About possible regime of forced and free librations of Titan. First data about Titan rotation testify that this satellite makes librations, turns with big amplitudes [6]. We can assume that observed changes in orientation of Titan indicate on forsed and free librations of the upper shell of the ice crust of Titin decopled with supper shell due to existence of ocean layer [6]. It is possible, that long-periodic librations of the Titan in longitude are reflected in the appropriate variations of natural processes, including observably changes of a cloudy cover. For a rigid model of the Titan this period is estimated in 2.09 yr. [7]. However for two-layer model uncoupled with each other shells (as it is supposed in the case of Titan) it can be much less and make all about 0.3-0.4 years. The specified values of periods allow to estimate the ratio of the polar moments of inertia of the crust and of all Titan: $(2 \div 4) \cdot 10^{-2}$. In result we come to a conclusion, that the amplitude of forced librations in a longitude of the Titan, appreciated on the basis of the elementary model of a rigid non-spherical body [7], for layered model should be increased in $25 \div 50$ times i.e. to make about 3' $\div$6'. The amplitude of free librations (evaluated on values of the maximal displacements of details on the surface of Titan) can be appreciated in 1 - 2 degrees. The given estimations have rather approached character. More full research of forced and free librations of Titan will need more detailed data of observations.

6 Conclusions. A cyclicity of variations of atmospheric processes of Titan with period equal to its orbital period, predicted by the author, has obtained a confirmation. The existence of the seas in antipodal areas, also predicted by the author, has obtained confirmations on results of Cassini mission. The observed displacements of details of Titan surface on Cassini images partially can be explained by significant on amplitude of free and forced librations in longitude, by assumption about decoupling of the crust and by existence of under-crust liquid ocean. The partial suport of RFBR grants N 08-02-00367, N-09-02-92113-JF is acknowledged.

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