THE NON-LINEAR INTERACTION OF THE PLANETARY GRAVITATIONAL FIELD ON EARTHQUAKES

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M. E. Nitsche[1]

[1]Institut Z & S, Bachstraße 13, D-72415 Grosselfingen, zunds@t-online.de

1. Introduction

A change of the paradigm in the natural sciences can be observed in the last two decades. It is the change of the sciences. The new direction is to the nonlinear science, to the nonlinear dynamics and to the complex systems. The new efficient computers possess the necessary capacities. Small, weak changes can cause quite strong future changes in complex systems which is typical for that. In addition, the research of complex systems requires a much stronger interdisciplinary research. The subject of my investigations is the extremely weak correlation effect of the changes of the planetary gravitational field with material structures on the earth. The influence of the fluctuations of the gravitation is examined. The influence is caused by the large bodies of the planet system on the evolution of the earth and its different material structures. This research is naturally still in the beginnings. A subsection of this complex research program is the triggering of earthquakes. The output hypothesis is the following: Tensions in the earth's crust, how they exist before an earthquake, can be triggered also, apart from many other causes, by the fluctuations of the planetary gravitational field. If thus in the time window of an earthquake such special fluctuations or conditions arise, then they can be also the cause of the earthquake. Always in competition to other reasons of course.

2. The model of the gravitational interaction

The fundamental Newton's movement-equation of N mass-points has the form:

$$\ddot{r}_i = G\sum_{\substack{j=1 \\ j\neq i}}^{N} M_j \frac{r_j - r_i}{\left|r_j - r_i\right|^3} \qquad (1)$$

r_i, r_j = vectors of the planets i, j with the masses M_i and M_j; G = gravitational-constant.

It is however not in a favourable form for the present problem.
From the helio-centric view, circle-frequencies $\omega_{i,j}$ can be declared. These circle-frequencies are relatively stable in the time.

$$\omega_{i,j} = \frac{2\pi}{T_{i,j}} \qquad (2)$$

$T_{i,j}$ = Time from conjunction to conjunction of the planets i and j.

Only directional-invariant processes are examined. One can write for the alterations of the planets - power (in a first approximation):

$$F_{i,j} \propto f_{i,j}(t) + k_{i,j}(t)\cdot\cos(\omega_{i,j}\cdot t) \qquad \text{t = time} \qquad (3)^*$$

** The relationship (3) follows from the vectorial addition of the powers F_i and F_j.*

$$\mathbf{F}_{i,j} = \mathbf{F}_i + \mathbf{F}_j$$
$$\mathbf{F}_{i,j}^{\ 2} = \mathbf{F}_i^{\ 2} + \mathbf{F}_j^{\ 2} + 2\cdot\left|\mathbf{F}_i\right|\left|\mathbf{F}_j\right|\cos(\alpha)$$

From a geo-centric view, the cosmic cycles are not quite so stable, therefore it is simpler, instead of $\omega_{i,j}$ to put the angle $\alpha_{i,j}$ (under which the planets i, j from the earth appears), in (3).

$$F_{i,j} \propto f_{i,j}(t) + k_{i,j}(t) \cdot \cos(\alpha_{i,j}) \tag{4}$$

The weak gravitational-field-fluctuations, especially its cosine-share, can be considered as a type of stimulation-field-strength on matter.
The terms $f_{i,j}(t)$ and $k_{i,j}(t)$ are relatively stable.

$$F_{i,j} = f_0 + k_0 \cdot \cos(\alpha_{i,j}) \tag{5}$$

The interactions of these "waves" (5) with matter and their different structures, will be not-linearly. In analogy to other not-linear interactions with matter (for example not-linear optics) one can put (with 7) a general correlation-function $H_{i,j}$ for the influence of two planets i, j.

$$H_{i,j}(\alpha) = \gamma_1 F_{i,j} + \gamma_2 F_{i,j}^2 + \gamma_3 F_{i,j}^3 + \ldots \tag{6}$$

with
$$\gamma_1 = \frac{k_1}{k_0}; \gamma_2 = \left(\frac{k_2}{k_0}\right)^2; \ldots\ldots \tag{7}$$

The conversion into a Fourier-serial is better suitable.

$$H_{i,j}(\alpha_{i,j}) = a_0 + a_1\cos(\alpha_{i,j}) + a_2\cos(2\alpha_{i,j}) + a_3\cos(3\alpha_{i,j}) + \ldots \tag{8}$$

The form (8) of the correlation-function shows the formation of "higher harmonics" by the interaction with matter.
The problems of the correlation-function are the coefficients a_k and the meaning of H.
The planets represent natural oscillators on a big scale. Such a rhythm is determined by the time period from conjunction to conjunction of two planets. These are relatively stable frequencies over a long period of time.
In my researches I restricted myself to the polar qualities which are associated with the concepts of “stability” and “instability”. The change from stable to unstable conditions and vice versa, can be observed in the evolution of many complex systems.
If one translates such criteria for stability and instability into a planetary cycle, one gets a sequence development (after a Fourier-transformation).

$$H_{i,j} = \sum_{s=1}^{N\cdot 12-1} a_k \cos(s\cdot\alpha); mit(k = s \bmod 12)$$
with $a_k = \{0,1,-2,3,-5,0,3,0,-5,3,-2,1\}$ (9)

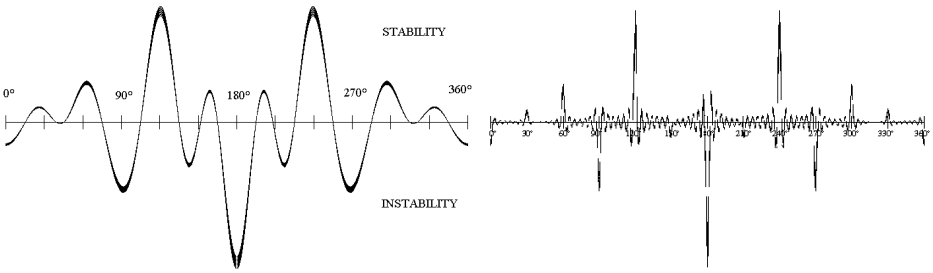

Figure 1. Correlation function 1. order (left) and 7. order (right) after equation (9).

The correlation function H (9) was not only developed for earthquakes.
Tensions in the earth's crust are mostly the cause of earthquakes. If these tensions have reached a critical state, there can be vibrations of different strengths.
The first hypothesis that was explored is as follows: If these tensions are in a critical condition, then also the fluctuations of the planetary gravitational field can cause these vibrations. The probability for an earthquake becomes higher if the fluctuations show unstable conditions.

3. The triggering of earthquakes

First, the 41 strongest earthquakes of the last century were explored [1].
As a result of this research, we could state the following: earthquakes can also be stimulated by the planetary fluctuations of the gravitational field. This has been proved with a probability of being wrong of 0.6%.
Maybe, that result is only an artefact? Or it is truly valid for strong earthquakes only?
Two groups of earthquakes were examined in order to explore that. These two groups (157 events) are complete in two time periods (2000 and 2001).
I received the following result: The earthquakes behave abnormally, also in such, relatively small time periods. The event of an earthquake is not always absolutely random to the correlation-function H [2].
Can one use the result for a forecast of earthquakes?
In order to clarify this question, further earthquakes were examined. The results give cause for hope.
The following database was used: Earthquakes of magnitude 6.5 or greater or ones that caused fatalities, injuries or substantial damage [3].
This are 420 earthquakes in the years from 1997 to 2001.
The following questions were examined:
1. Which order of the correlation function describes triggering of earthquakes best?
2. Which meaning or weight has the individual planet?

The results are for 1000 control-groups. Each group has 420 members. The Monte Carlo simulation was used. The control-groups, that have a bigger value, stand in the table (in percent [%] declared)
The correlation function H, the absolute value of H (sum of all matrix-elements), the first derivative H ' and the absolute value of the first derivative H ' (sum of all matrix-elements) is printed in the table. All elements with a mathematical probability of being wrong smaller than 5% are fat-printed. The absolute value of H (sum of all matrix-elements) represents the wave-energy of the planetary fluctuations.
If the weight of the planets orients itself at the actual gravitation strength, then we have the influence of sun and moon primarily. The other planets have then only a marginal influence.

The following planet priorities (weights) were used in line 4 of the table: sun: 57.00; moon : 10.24; mercury: 0.31; venus: 0.77; mars: 0.30; jupiter: 1.87; saturn: 0.84; uranus: 0.28; neptun: 0.22; pluto: 0.01;

Planets/order		1	2	3	4	5	6	7	8	9
All planets have the weight 1.	H abs(H) H' abs(H')	23,7 10,6 44,8 19,6	47,3 29,9 12,0 14,4	26,8 58,3 74,3 5,9	60,0 55,1 76,6 30,6	43,7 52,1 84,3 43,1	42,3 57,9 64,2 35,0	52,1 49,4 71,3 41,9	44,4 59,7 59,3 22,3	49,6 47,5 34,9 55,3
Only the big-planets have the weight 1	H Abs(H) H' abs(H')	37,9 **0,7** 59,7 29,6	65,3 **2,3** 6,3 6,2	36,3 9,1 29,8 **2,6**	61,9 7,7 18,2 **4,5**	63,3 **4,7** 60,6 14,5	75,5 13,4 34,7 **4,7**	70,2 11,3 47,7 **3,6**	47,7 14,9 37,3 **4,9**	69,5 9,9 27,3 9,7
Planets weight is oriented at the gravity.	H abs(H) H' abs(H')	47,8 **0,8** 94,5 75,3	34,9 **1,0** 81,2 29,2	16,7 **0,5** 76,1 21,2	32,2 **0,2** 47,0 22,6	47,9 **0,1** 70,4 8,7	83,2 **0,6** 14,6 **3,1**	88,2 **0,1** 9,6 5,2	88,5 **0,0** 16,7 5,7	78,3 **0,1** 33,3 **4,5**
sun and moon alone	H abs(H) H' abs(H')	48,9 **1,0** 94,7 76,2	26,9 **1,3** 84,0 25,0	14,3 **0,7** 77,5 19,8	27,3 **0,2** 59,3 23,0	42,1 **0,2** 72,9 9,9	76,5 **0,5** 11,2 5,3	82,2 **0,1** 8,5 5,5	87,1 **0,0** 26,7 8,0	76,7 **0,1** 33,2 6,0
sun, moon, jupiter and saturn weight: 1	H abs(H) H' Abs(H')	83,6 **0,3** 57,8 62,3	**96,9** **2,6** **2,8** 8,7	78,4 **0,6** 13,0 7,8	91,6 **1,4** 9,0 **2,9**	**95,6** **0,7** 57,6 **4,3**	**95,9** **3,2** 45,4 **1,0**	**96,0** **2,8** 11,0 **2,5**	91,3 **3,0** 16,6 **1,9**	84,0 **2,0** 23,9 **2,2**
sun, moon, weight: 2 jupiter, saturn weight: 1	H abs(H) H' abs(H')	81,6 **0,4** 80,9 71,6	86,3 **1,3** 15,2 12,9	53,2 **0,2** 23,0 12,4	76,1 **0,1** 15,6 **4,2**	85,7 **0,1** 64,4 **2,7**	93,7 **1,0** 31,0 **1,1**	**95,7** **0,5** 10,4 **1,5**	91,5 **0,4** 16,8 **1,6**	82,4 **0,5** 27,8 **1,2**

Table 1. The mathematical probability of being wrong for 1000 control groups. H is the correlation function, abs(H) the absolute value of H (sum of all matrix-elements), the first derivative H ' and the absolute value of the first derivative H ' (sum of all matrix-elements) is specified.

The figures 1 and 2 show an example. The correlation function and the sum of the absolute values of the elements of the matrix are represented for one month. The month was selected in such a way that it shows the model of the triggering of earthquakes by the planetary fluctuations. In this month (2001-6) 11 earthquakes took place. For the computation of the probability for these 11 events 1000 control groups with order 6 were used. The following results were received (probability of being wrong): correlation function H (99,6%), absolute value of H (5,2%), the first derivative H ' (16,1%) and absolute value of the first derivative H ' (32,3%).

The arrows with a circle mark possible triggering by the planetary fluctuations.

There are many reasons for triggering of earthquakes. In this month however 4 earthquakes were possibly released by the planetary fluctuations. The fluctuations of the planetary gravitational field always are in competition to other release mechanisms.

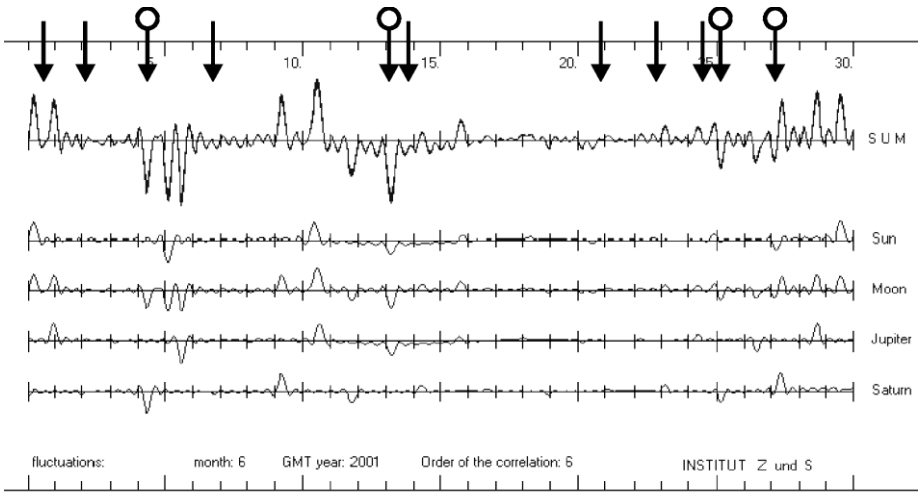

Figure 2: The correlation function H is represented for one month (2001-6). The arrows with a circle mark possible triggering by the planetary fluctuations.

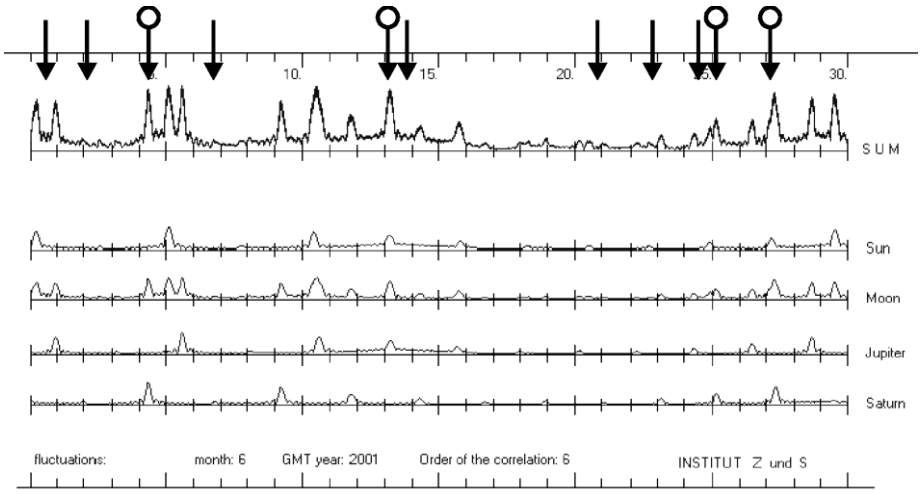

Figure 3: The sum of the absolute values of the elements of the matrix is represented for one month. The arrows with a circle mark possible triggering by the planetary fluctuations.

The past investigations show the following results:

1. The higher orders of the correlation function describe triggering of the earthquakes better.
2. The accurate consideration of the gravitation strength leads to no better results.
3. The correlation is weakly, however not to be neglected.

4. The model of triggering

For the further investigations a better hypothesis can be accepted. For triggering of earthquakes a threshold energy exists. This threshold energy is constantly reduced. The releasing factors compete with one another. Such factors result also from the fluctuations of the planetary gravitational field.

Earthquakes take place at each time. If threshold energy for triggering constantly decreases, then also the time comes for triggering by the fluctuations of the planetary gravitational field. It is a characteristic of nonlinear systems, also small outside energies can lead to large changes.

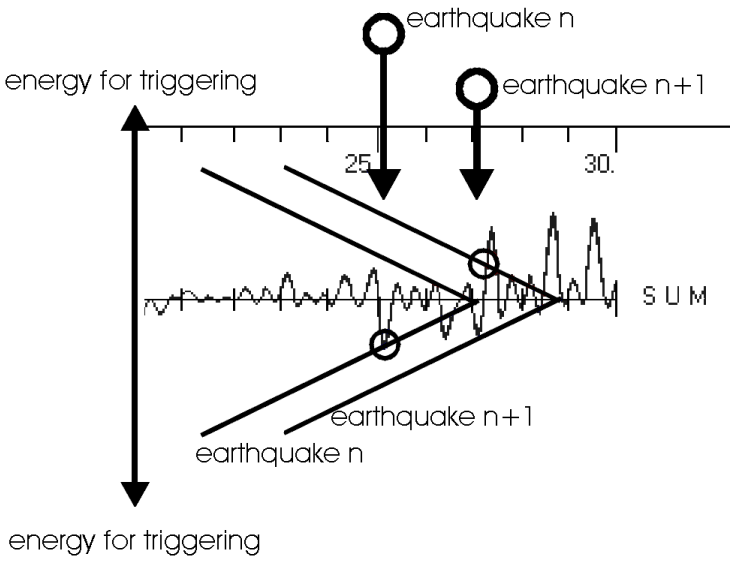

Figure 4: Schematic Model of the earthquake-triggering, released by the fluctuations of the planetary gravitational field. Tensions in the earth's crust can become an earthquake by the fluctuations of the planetary gravitational field. The condition for it is the sinking the threshold energy for triggering. The picture can be compared with figure 2.

5. Conclusion and outlook

The research showed that the fluctuations of the planetary gravitational field can make a contribution for triggering of earthquakes. With these results, new strategies for the research can be set up.

The rotation of the earth was not considered. It could be an important factor for triggering of earthquakes. In a next step, this gravitation center of the earth will be considered.

It is a large mathematical expenditure to introduce the factor $\boldsymbol{\gamma}_{i,j}$ **(**for $\mathbf{H}_{i,j}$), which helps to find an adaptation to the problem we explored. This factor $\boldsymbol{\gamma}$ has the function of a frequency-filter. But such an optimisation is necessary for the forecast of earthquakes. It will be an element of a probability based forecasting of earthquakes: maybe in supplement to a model constituted by point processes generated by transitions of a Markov chain.

Our planetary system is a huge complex system. The nonlinear dynamics of this system has an influence on the triggering of earthquakes. That seems to be now a fact and it is the cause for further research.

6. References

[1] Nitsche, M. E., 2001: Planetare Fluktuationen der Gravitation und ihr Einfluss auf komplexe Systeme, Institut Z & S

[2] Nitsche, M. E., 2001: Are the Stabilizing and Destabilizing Influences of the Planetary Gravitational Field on the Structural Formation of Complex Systems Real? - Triggering of Earthquakes –
Lecture on the 2002 Annual Conference of the International Association for Mathematical Geology; Berlin, Germany
http://www.zunds-institut.de/earthquakes/lecture.htm

[3] "Earthquakes of magnitude 6.5 or greater or ones that caused fatalities, injuries or substantial damage."
Compiled by Waverly J. Person
USGS National Earthquake Information Center
http://www.usgs.gov/
http://neic.usgs.gov/neis/eqlists/significant.html