Application of Titius − Bode Law in Earthquake Study

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Abstract

In the ITRF model, station motion is described by the piecewise linear model. However, the actual station motion is more complicated and includes other effects such as seasonal and irregular position variations as well as jumps and exponential relaxation after large earthquakes. So, the studies on the earthquake time distribution and prediction is of large importance for the assessment of the ITRF stability.

This article introduces application of the commensurability revealed by Titius-Bode Law in earthquake prediction study. The results show that most of the world's major earthquake occurred at their commensurable points of time axis. The EQ 7.0 occurred in Lushan of China on 2013-04-20 and the EQ 8.2 occurred in Iquique of northern Chile on 2014-04-01 both occurred at their commensurable points of time axis. This provides an important scientific basis for the prediction of major earthquakes, which will occur in the area in future.

Introduction

During recent years huge earthquakes (EQ) frequently occurred and made surprise attacks on many places of the globe, especially in the south and east of Asian, and around the seismic belt around the Pacific Ocean. Since the EQ Ms9.0 occurred in Sumatra in 2004, then the EQ Ms8.0 in Chile in 2010, the EQ Ms9.0 in Honshu in 2011, the EQ Ms8.2 in Chile in 2014 etc. They caused strong impact to the expecting continued developing economy and the tranquility of human society of the world. Frequent exceptional strong disasters of EQs remind that we must strengthen our research on cause of formation, mechanism, prediction and forecast of the EQs, and achieve the goal of advancing the development of Earth science and mitigation of seismic disasters. We have therefore in-depth studied the commensurability revealed by Titius-Bode Law. On the basis of many years' research and development of Titius-Bode law we compiled a Fortran program. By the program we systematically analyzed major earthquake in the world since 1900.0., and found that most of the world's major earthquake occurred at their commensurable points of time axis (Hu et al., 2013). The EQ 7.0 occurred in Lushan of China on 2013-04-20 and the EQ 8.2 occurred in Iquique of northern Chile on 2014-04-01 both occurred at their commensurable points of time axis. This once again proves the universality of the commensurability.

Titius-Bode law and its expansion

From Titius-Bode law the distance of the planet n from the sun can be expressed as:

$$a_n = 0.4 + 0.32 \times 2^{n-2} \,. \qquad (1)$$

It also can be written as the following form:

$$\beta = \frac{a_{n+1}}{a_n} \,, \qquad (2)$$

where a_n is the distance of the planet n to the sun, reckoned in astronomical unit, and n is the number of the planets away from the sun to the far side. For Mercurythe number n is not 1, instead it is taken as $-\infty$. β is the commensurable value for the planets in the solar system (Zhang et al. 1980). As Weng Wenbo (Weng, 1981), afamous Chinese geophysicist, pointed out: the commensurability is one of the orders in the natural world. The equation (2) itself brings light to the distribution law of the matter in a space region, and for time domain the commensurability can be expressed as(Weng, 1981)

$$\triangle X = \frac{X_{i+\triangle i} - X_i}{K} \,, \qquad (3)$$

here K is an integer. If the above relation is tenable, then the data set X_i is commensurable. $\triangle X$ is the commensurable value of the data set $\{X_i\}$ and X_i and $X_{i+\triangle i} \in \{X_i\}$. The subscript $\triangle i$ is difference between sequential number of the two arbitrary data in the data set $\{X_i\}$.i.e. the difference between the serial number of first columnof table **??**.(See table 1).In our practical analysis and computation, $\triangle i \equiv 1$. If K is equal to 1, then $\triangle X$ is the period of $\{X_i\}$(Weng, 1981).

Prediction on the Lushan EQ 7.0 in China of 2013 and the Iquique EQ 8.2 in Chile of 2014

An EQ 7.0 occurred in Lushan, China on 2013-04-20. We point out that the expanding time points in its time axis are the time point when a future EQ may occur (Hu et al.,2013). In the paper we analyzed the commensurability of earthquakes in the Sichuan-Yunnan region since 1900.0 and obtained its commensulable value is 2.44 year. Its previous EQ of M7.0 is the Wenchuan 8.0 occurred on 2008-05-12 i.e. 2008.36, so

$$2013 - 04 - 20 = 2008.36 + 2.44 \times 2 = 2013^y 3^m 29^d + 22 days \,.$$

It occurred just at the commensurable point equal to 2 times of its time axis. Its absolute error is 22 days. Its relative error is 0.03.

An EQ 8.2 in Iquique,northern Chile, occurred on 2014-04-01. In the paper (Hu et al., 2013) we have also analyzed the EQs in south-central Chile and found its commensulable value is 0.59 years. For strict scientific purposes, the EQ events we select are expanded to include northern Chile, and obtained their commensulable value is still 0.59 year by means of calculation and analysis of the Fortran program (Table 1). The previous EQ 8.0 in Chile occurred on 2010-02-27, ie. 2010.15, so

$$2014 - 04 - 01 = 2010.15 + 0.59 \times 7 = 2014.28 = 2014^y 04^m 12^d - 11 day \,.$$

It occurred just at the commensurable point equal to 7 times of its time axis. Its absolute error is 11 days. Its relative error is 0.05.

Concluding remarks

Research has shown that Titius-Bode law not only is applicable for the planets of the solar system, but also applicable for satellites of Jupiter, Saturn and Uranus etc., only their concrete expressions have different forms (Zhang et al. 1980). Titius-Bode law itself brings to light the distribution law of the matter in a space region, and the expanding Titius-Bode law reveals the time law of the occurrence of the events in a specified space region. It can be seen that the commensurability is present in various natural phenomena and has universality. Therefore, astronomical achievements not only provide service to astronomical developments, but also to other scientific research, such as applied geoscience. It is helpful to study the complicated relationships among various matters, and thus merits further in-depth research.

Table: Commensurability of EQs in Chile since 1900.0

No	EQs	date	M	$X_{i+1}-X_i$	K	$K\triangle X$	$X_{i+1}-K\triangle X$
1	19040319	1904.21	7.0				
2	19060817	1906.62	8.2	2.41	4	2.36	.05
3	19060830	1906.66	7.1	.04	0	.00	.04
4	19061226	1906.98	7.0	.32	1	.59	-.27
5	19090608	1909.43	7.2	2.45	4	2.36	.09
6	19100906	1910.67	7.1	1.24	2	1.18	.06
7	19110915	1911.70	7.1	1.03	2	1.18	-.15
8	19140130	1914.07	7.5	2.37	4	2.36	.01
9	19180520	1918.38	7.6	4.31	7	4.13	.18
10	19181204	1918.92	7.5	.54	1	.59	-.05
11	19221107	1922.85	7.1	3.93	7	4.13	-.20
12	19221111	1922.86	8.7	.01	0	.00	.01
13	19250515	1925.36	7.1	2.50	4	2.36	.14
14	19270414	1927.28	7.2	1.92	3	1.77	.15
15	19281201	1928.92	7.7	1.64	3	1.77	-.13
16	19310318	1931.20	7.1	2.28	4	2.36	-.08
17	19330223	1933.14	7.2	1.94	3	1.77	.17
18	19360713	1936.53	7.1	3.39	6	3.54	-.15
19	19390125	1939.06	7.7	2.53	4	2.36	.17
20	19390418	1939.29	7.3	.23	0	.00	.23
21	19401004	1940.76	7.1	1.47	2	1.18	.29
22	19420708	1942.51	7.0	1.75	3	1.77	-.02
23	19430314	1943.20	7.1	.69	1	.59	.10
24	19430406	1943.26	8.2	.06	0	.00	.06
25	19450913	1945.70	7.0	2.44	4	2.36	.08
26	19460802	1946.58	7.1	.88	1	.59	.29
27	19490420	1949.29	7.1	2.71	5	2.95	-.24
28	19490425	1949.31	7.2	.02	0	.00	.02
29	19530506	1953.34	7.5	4.03	7	4.13	-.10
30	19600521	1960.38	8.2	7.04	12	7.08	-.04
31	19600522	1960.39	7.9	.01	0	.00	.01
32	19600522	1960.39	9.6	.00	0	.00	.00
33	19600620	1960.46	7.0	.07	0	.00	.07
34	19601202	1960.92	7.2	.46	1	.59	-.13
35	19620214	1962.12	7.5	1.20	2	1.18	.02
36	19650328	1965.23	7.4	3.11	5	2.95	.16
37	19661228	1966.98	7.7	1.75	3	1.77	-.02
38	19671221	1967.97	7.4	.99	2	1.18	-.19
39	19710709	1971.51	7.8	3.54	6	3.54	.00
40	19740818	1974.62	7.1	3.11	5	2.95	.16
41	19750510	1975.35	7.7	.73	1	.59	.14
42	19811016	1981.79	7.1	6.44	11	6.49	-.05
43	19811107	1981.85	7.0	.06	0	.00	.06
44	19831004	1983.75	7.7	1.90	3	1.77	.13
45	19850303	1985.16	8.0	1.41	2	1.18	.23
46	19850304	1985.17	7.4	.01	0	.00	.01
47	19850409	1985.26	7.1	.09	0	.00	.09
48	19870305	1987.17	7.6	1.91	3	1.77	.14
49	19870305	1987.17	7.0	.00	0	.00	.00
50	19870808	1987.60	7.2	.43	1	.59	-.16
51	19880119	1988.05	7.0	.45	1	.59	-.14
52	19880205	1988.09	7.2	.04	0	.00	.04
53	19950730	1995.57	8.0	7.48	13	7.67	-.19
54	19971015	1997.78	7.1	2.21	4	2.36	-.15
55	19980130	1998.07	7.1	.29	0	.00	.29
56	20050613	2005.44	7.8	7.37	12	7.08	.29
57	20100227	2010.15	8.8	4.71	8	4.72	-.01

- $\triangle X = 0.590$; $\sigma_{n-1} = 0.142$

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