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Gravitational Chirality for the determination of earthquake magnitudes through high-frequency energy radiation: Application to the February 27, 2010 Chile Earthquake and Japan Earthquake on March 11, 2011.

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Abstract

In this short paper, we define and determine the connection between the Rikitake's theory (seismic P-waves), and the Hora's relation (high-frequency energy radiation from the arrival time of a P-wave) under chiral approach. We consider the possibility that gravity breaks parity, with left and right handed gravitons coupling to matter with a different Newton's constant and show that this would affect the earth dynamics and induce strong earthquakes. This theory is applied to determine the amplitude of the strong earthquakes in Chile and Japan. This verification is a support to the proposed early detection system which gives information of the maximum displacement of an earthquake during high-frequency energy radiation arising from the arrival time of a P-wave at a specific location.

Keywords: chiral waves, gravity, earthquake, P waves, radiation, rotation

I. Introduction

Earthquakes occur primarily along plate boundaries; the frequency and type of events vary with the type of boundary. Plates interact with one another in one of the three ways: they diverge, converge or slide past one another. Scientists have known for decades that the ongoing movements and collisions of the plates, a so-called push/pull mechanism, are responsible for sculpting continental features around the planet, usually where plates are either moving apart or coming together. Gravity and mantle convection are two driving forces for the movement of plates. Phenomenologically, between plates we have the Newton's law, $\vec{F}_N - \vec{F}_f = m\vec{a}$ where $\vec{F}_N$ is the Newton's gravitational force proportional to G_N, $\vec{F}_f$ is the friction force between plates. When the derive velocity is constant, $\vec{a} = 0$ so $\vec{F}_N - \vec{F}_f = 0$. However if G_N changes for short time instants, we can have a trigger to produce a earthquake. In this paper, in connection with gravity, we consider the possibility that gravity breaks parity, with left and right handed gravitons coupling to matter with a different Newton's constant and show that this would affect the earth dynamics and induce strong earthquakes. Also, Should there be a cosmic background of gravity waves, the effect would translate into anomalous CMB polarization [1,2] . Following [1], we can parametrize the chiral asymmetry by:

$$G^{R/L} = G_N (1 \mp \frac{1}{\gamma})^{-1} \quad (1)$$

Where G_N is the Newton's gravitational constant, R(L) means Right (Left) polarized gravitons, γ is the Immirzi parameter which is related to the chiral electromagnetic parameter T by $1/\gamma = k_0 T$, where $k_0 = \omega / c$ is the wave number of the electromagnetic radiation. A large γ means no measurable chirality. The sign of γ matters and $\gamma > 0$ means stronger gravity for R gravitons and if $|\gamma| < 1$ then gravity becomes repulsive for one of the R or L modes. This effect can produce strong anomalous forces in earthquake phenomena due to the factor $1 \mp \frac{1}{\gamma}$ if strong bursts of chiral gravitational waves reach the Earth. Also, some implications of gravitational chirality that would improve the prospects of gravitational wave detection in Cosmic Microwave Polarization (CMB) experiments.

General relativity is parity symmetric, so it is pertinent to ask how radical the modifications of its principles need be to allow parity asymmetry in the form of $G^L \neq G^R$. Chiral gravitation has been associated with a Chern- Simons term [3,4] coupled to a dilaton, or the presence of spinors . But none of these mechanisms induce parity breaking at leading order in the graviton propagator, as is implied by

$G^L \neq G^R$. But the possibility of such a leading order effect can be motivated from several considerations including Euclidean gravity and the fact that CP violating instanton effects are expected to arise in a path integral quantization of chiral actions such as the Plebanski action [5].
There is a lot of observational evidence concerning rotational motions on the Earth's surface excited by earthquakes, we can infer the existence of rotational motions in earthquake focal zones. It is observed that rotational motions (twist) in earthquake sources naturally excite rotational seismic waves, solitons and chiral waves [6,7,8].
The key idea of this article consists in to verify the description of rotational seismic waves into a chiral regime [13,14] by considering chiral rotational seismic waves excited in earthquake sources in strong earthquakes which produce tsunami events. We can distinguish two kinds of rotational seismic waves: (1) rotational longitudinal waves, that is, PR waves; and (2) rotational shear waves, that is, SR waves. Rotational seismic waves propagate faster in solid rocks and much slower in fractured media along tectonic faults. It has been observed that these waves may have a form of rotational seismic solitons and that they can trigger earthquakes [9]. Because of the fact that solitons can propagate without any loss of energy, these waves are extremely important carriers of seismic energy.
The existence of rotational motions excited by earthquakes [10] and measurements of seismic spin and twist waves were obtained also by other authors [6-8]. Most earthquakes occur under a certain high level of confined pressure. The constitutive law during an earthquake is controlled by a macroscopic property of the fault such as macroscopic roughness of the fault, thickness of the fault gouge layer, geometry of the fault, the macroscopic change of the fault strength, and so on.
If we considerer a large plate of Earth's crust, for example from Antofagasta, Chile Region, point P_1 and Arica, Chile, point P_2, the Newton force obtained from this chiral gravity theory can give a difference of cosmological forces between region P_1 and P_2, which may be to allow or trigger a large earthquake.

II. Basic theory and determination of strong earthquake magnitudes

Basic theory of seismic waves

There are two classes of seismic waves: body waves and surface waves. Body waves travel through the interior of the Earth. Two types of body waves are recognized: P waves and S waves. P waves are the fastest seismic waves, and consequently, the first to arrive at any given location. Because of this fact, they were initially referred to as the primary waves of an earthquake. "Primary" was later shortened simply to "P". Travelling at a speed typically around 60% that of P waves, S waves always arrive at a location after them, the "S" stands for secondary. Torsion waves, often called S waves, represent the spiraling motion of particles twisting between inner structures. P waves are usually the first to be recorded on a seismogram because they travel the fastest. S waves usually have more height, or amplitude, than P waves. The amplitude of the waves can help to reveal information about the magnitude of an earthquake and the circular polarization can reveal the origin of earthquake.
The change in the velocity of the P-wave is found by measuring the change in the ratio of the P-wave velocity to the S-wave velocity V_p / V_s. The V_p / V_s ratio is obtained from an analysis of the travel times of P- and S- waves [8]. Denoting the arrival times of P- and S-waves by t_p and t_s respectively, the S - P time versus t_p relation can be expressed by a straight line on the $(t_p - t_s), t_p$ plane. The inclination (m) of the line is given as: $m = -(t_p - t_s)/t_p = \Delta t / t_p$. Here, m is related with the normalized chiral wavenumber $k_c / k_0 = 1/1 \mp k_o T$. Here we make the connection $k_o T = \gamma^{-1}$ of the high-frequency energy radiation and the gravitational factor γ^{-1} from the arrival time of a P-wave. If the propagation path for both waves is assumed to be identical, we obtain: $V_p t_p = V_s t_s$ so that we have: $m = V_p / V_s - 1$. Therefore, it is seen that the V_p / V_s ratio is obtained from k calculated on the basis of travel-time analysis.
Starting from such concepts our aim will be to find a correlation and to support the following empirical relation of Rikitake [9]:

$$\log \Delta t' = 0.75M - 4.27 \qquad (2)$$

where Δt is the time interval measured in years between the detection of anomalous land-deformation and an earthquake occurrence. M is the magnitude of the quake concerned.
Here we assume that the magnitude of an earthquake depends on our information on time starting from the instant when irregularities of the dilatation function take place to the instant of the earthquake occurrence. On the other hand, we know, according to Bullen, [10], the damping effect may be represented by the presence of a factor $k = k_c$, here we make where D is the distance travelled by a wave and k_c is the wave number of the P-wave which is the order of

$10^{-4} km^{-1}$. The interval in which the P-waves travel to k^{-1} is $k_c^{-1}/V_p = k_0^{-1}/((\lambda+2\varepsilon)/\rho)^{1/2}$,where V_p is the velocity of P-waves, ρ the mass density and λ, ε are elastic parameters, here, λ, ε are proportional to $k_o T$.

The magnitude of an earthquake will be supposed also to depend on τ and it is given by $M = \sigma \ln \frac{\Delta t'}{\tau} = \sigma \ln \frac{\Delta t \rho^{-\bar{\chi}(x)}}{\tau}$. Here σ is a certain constant so $\ln \Delta t' \approx \sigma^{-1} M - 10$. If we take $V_p = 7 km/s$ and $\tau \approx 1.43x10^3$, which is a good approximation to $\ln \Delta t' = 0.75M - 4.27$ if $\sigma^{-1} = 1.7$

III. Determination of earthquake magnitudes

When considering the problem of electromagnetic emissions correlated with earthquakes, one is often faced with an overwhelming problem of complexity, because the mechanism of wave generation is not entirely understood. Several observations of Very Low Frequency (VLF) emissions apparently associated with earthquakes, are recorded independently at ground-based stations and on satellites.

Recently, Hara [11-12], developed a new method to determine earthquake magnitudes using the following formula:

$$M = \alpha \log A + \beta \log L + \gamma \log \Delta t + \delta , \qquad (3)$$

where M is an earthquake magnitude, A is the maximum displacement during high-frequency energy radiation from the arrival time of a P-wave, L is the epicentral distance, Δt is duration of high-frequency energy radiation. The duration of high-frequency energy radiation can be estimated by band-pass filtering of first arriving P-waves, $\alpha, \beta, \gamma, \delta$ are 0.79, 0.83, 0.69, and 6.47, respectively (the units of $A, L, \Delta t$ are m, km, and s, respectively). Here we suppose that our high-frequency energy radiation from the arrival time of a P-wave corresponds to our chiral wave with k_c [13,14,15].

To the strong earthquake we applied this method to the February 27, 2010, Chile Earthquake (the origin time: 06:34:14 UTC; the location 35.846°S, 72.719°W after USGS). Data of measurements of high-frequency energy radiation show that the estimated duration is 138.6 sec. The estimated magnitude using the above formula is 8.60. Although this estimate is smaller than 8.8 from the Global CMT and USGS WPhase MT, it is consistent with them considering its uncertainly (around 0.2 in magnitude unit) [11-12].

Figure 1 shows a set of measurements of high-frequency energy radiation. The upper, middle and lower traces are an observed seismogram, the squares of the band-pass (2-4 Hz) filtered seismogram, and its smoothed time series (normalized by the maximum value), respectively. “A” and “F” in the lower trace denote the arrival of P-wave and estimated end of high frequency energy radiation, respectively.

Also we can apply this method to the 2011 off the Japan Pacific coast of Tohoku Earthquake on March 11 (the origin time: 05:46:23 UTC; the location 38.322°N, 142.369°E after USGS). In Figure 1 we show a set of measurements of high-frequency energy radiation

The estimated duration is 170 sec. The estimated magnitude using the above formula is 8.97, which well agrees with M_w 9.0 from JMA, 9.0 from the USGS W Phase moment solution, and 9.1 from the Global CMT solution.

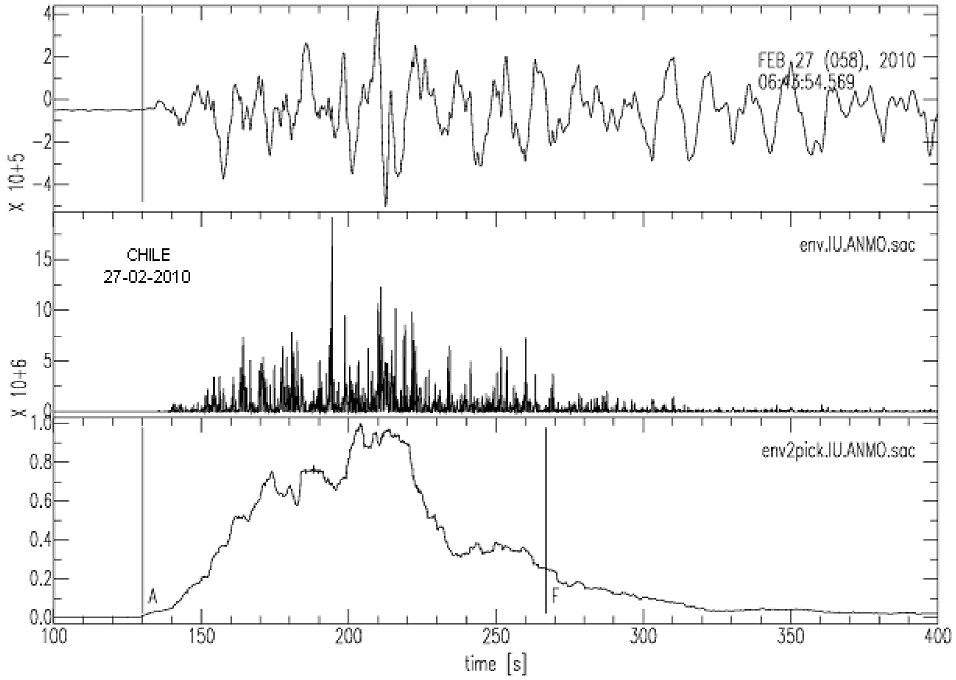

Figure 1. A measurement of high frequency energy radiation of the February 27, 2010 Chile Earthquake.

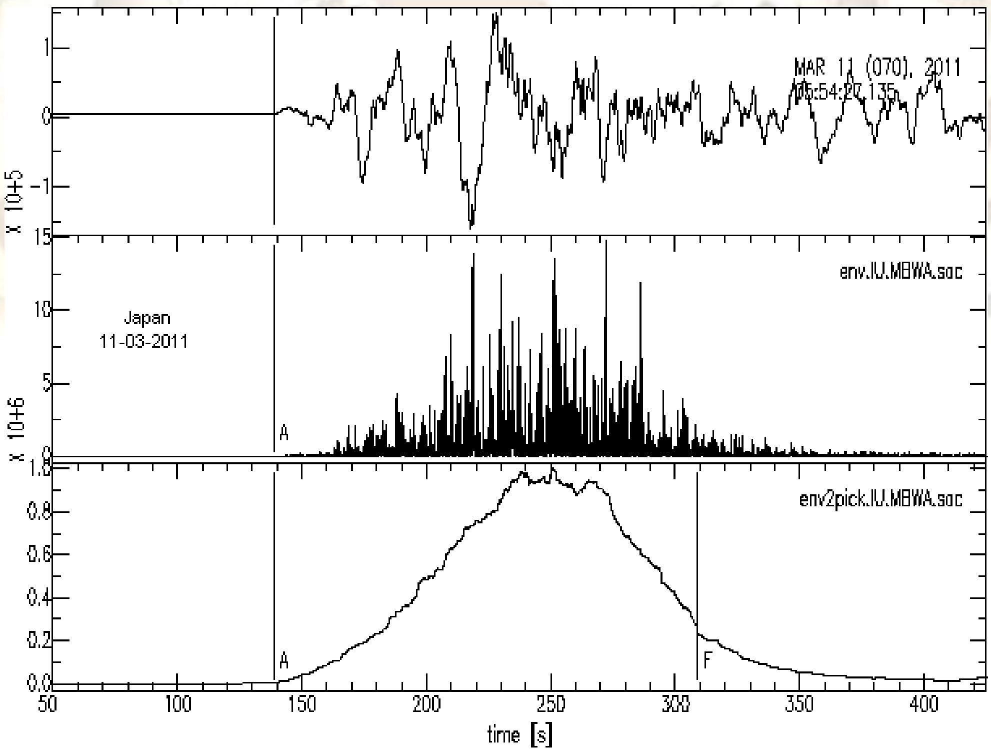

Figure.2 A measurement of high frequency energy radiation of Pacific coast of Tohoku Earthquake on March 11, 2011.(http://iisee.kenken.go.jp/staff/thara/20110311/.htm)

IV. Conclusions

In this short paper, we define and determine the connection between the Rikitake's theory (seismic P-waves), and the Hora's relation (high-frequency energy radiation from the arrival time of a P-wave) under chiral approach. This approach is related to chiral electromagnetic parameter and the gravitational Immirzi factor which is important in gravitational chirality. This connection is a support to the proposed early detection system gives information of the maximum displacement of an earthquake during high-frequency energy radiation arising from the arrival time of a P-wave at a specific location. [9].

This approach may be treated from a theoretical point of view and gives an excellent argument to propose a prediction system to prevent the occurrence of great cataclysms.

References

[1] Contaldi. C, Magueijo. J and Smolin. L, (2008) *Anomalous CMB polarization and gravitational chirality*, Physical Review Letters, 101, 141101
[2] Alexander S. and Calcagni G,(2009) Phys. Lett. B 672, 836.
[3] Alexander S and Peskin M, (2006), Phys.Rev.Lett. 96, 081301.
[4] Xia, J.-Q., Li, H., Wang, X., & Zhang, X. (2008), Astron. & Astroph., 483, 715
[5] Soo C, Phys, (1995). Rev. D52, 3484.
[6] Majewski E, (2008), *Canonical approach to asymmetric continua, in Physics of Asymmetric Continuum: Extreme and Fracture Processes—Earthquake Rotation and Soliton Waves*, R. Teisseyre, H. Nagahama, and E. Majewski (Editors), Springer, Berlin, 209–218.
[7] Teisseyre K P, (2007), *Analysis of a group of seismic events using rotational components,* Acta Geophys. 55, 535–553.
[8] Teisseyre, R. (2009). *New developments in the physics of rotational motions*, Bull. Seismol. Soc. Am. 99, no. 2B, 1028–1039.
[9] Rikitake T. (1996). "*Earthquake Prediction*". Elsevier Scientific Publishing Company, Amsterdam. The Netherlands.
[10] Bullen K. E and Bolt B A , (1959) "*An introduction to the theory of seismology*". Cambridge University Press.
[11] Hara T. (2007) "*Measurement of duration of high-frequency energy radiation and its application to determination of magnitudes of large shallow earthquakes*". Earth Planets Space. Vol. 59, pp. 227-231.
[12] Hara. T (2007) "*Magnitude determination using duration of high frequency energy radiation and displacement amplitude: application to tsunami earthquakes".* Earth Planets Space. Vol. 59, pp. 561-565.
[13] Torres-Silva H and Souza de Assis A, (2010), *Efectos de velocidad y de gravitación en GPS satelitales: un esquema para la predicción y detección temprana de fuertes terremotos*, Ingeniare,. Vol. 18, pp 286-294.
[14] Torres-Silva H (2011). "*Early Prediction and detection of Strong Earthquakes through Chiral Radiation Waves",* Journal of Vectorial Relativity, 6, 2, 1-11.------, *(2008)" Eintein's Theory of Waves in the Presence of Space-Time Tensions*". Ingeniare. Vol. 16 , pp. 78-84.
[15] Torres-Silva H, (2011) *The New unification of gravitation and Electromagnetism*, ISBN 978-956-332- 973-5. First Edition.