Why are gravitational waves detections so close to New/Full Moon?

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Abstract. Of the 11 gravitational waves detections up to date, seven occurred within 43 hours of New/Full Moon or perihelion and four within the two weeks between the 2017/8/7 and 2017/8/21 eclipses. Why do the gravitational waves coming from millions of light years away arrive to Earth so close to these lunar events? The question is investigated in more detail.

Key words: gravitational waves, lunar motion, earthquakes.

Patterns in gravitational waves detections. Table 1 shows LIGO's confirmed gravitational waves detections up to December 26, 2019, the first five were within 2 days of New/Full Moon or perihelion. Of the other six, two were within 36 hours of New/Full Moon, three were sandwiched between the 2017/8/7-8 lunar eclipse and 2017/8/21 solar eclipse, and one was not close to any lunar-solar event. How do the gravitational waves from millions of light years away manage to arrive to Earth to fit so well with lunar/solar events? To understand the pattern of Table 1 let us look at the patterns exhibited by earthquakes.

Similar patterns in earthquakes. Recall that lunar perigee recurs every ≈ 27.55 days, while the New/Full Moon recurs every ≈ 29.53 days; and, since $29.53 \times 14 \approx 27.55 \times 15 \approx 413$ days, the spread between perigee and the nearest New/Full Moon is almost the same after ≈ 413 days. A "full lunar cycle" is an ≈ 413 -day period that starts and ends with the same lunar phase and contains 14 New/Full Moons and 15 perigees. The closest and 2nd closest perigees of a full lunar cycle always occur within 11 hours of New/Full Moon resulting in spring tides.

On 2011/3/19, 2012/5/6, 2013/6/23, 2014/8/10, and 2015/9/28, perigee and Full Moon came within, correspondingly, 59, 2, 23, 27, and 65 minutes of each other creating an extremely rare case of five-year synchronization of perigee and Full Moon. The period was marked by elevated earthquake activity, e.g. 1) 2010 – 2015 had thirty five $M \geqslant 7.5$ earthquakes averaging 5.83 earthquakes per year, for comparison 1910 – 2009 had 381 $M \geqslant 7.5$ earthquakes averaging ≈ 3.61 earthquakes per year; 2) 2010 – 2014 had five $M \geqslant 8.2$ earthquakes averaging 1 earthquake per year, for comparison 1910 – 2009 had thirty one $M \geqslant 8.2$ earthquakes averaging ≈ 0.31 earthquakes

LIGO's confident detections	hours	lunar/solar events within 51 hours of the detection	days	lunar/solar events within 52 days of the detection
First observing run 2015/9/12 – 2016/1/19, 129 days				
2015/9/14 9:51	27	**2015/9/13** 6:41 New Moon	13 - 14	2015/9/28 Full Moon
	27	**2015/9/13** 6:54 solar eclipse		2015/9/27 lunar node
	5	**2015/9/14** 4:38 lunar node		2015/9/28 perigee,
2015/10/12 9:55	14	**2015/10/13** 0:07 New Moon	14 - 15	the closest perigee of
	23	**2015/10/11** 10:54 lunar node		2012 – 2015
2015/12/26 3:39	17	**2015/12/25** 11:12 Full Moon	7	2006/1/2 perihelion
Second observing run 2016/11/30 – 2017/8/25, 268 days				
2017/1/4 10:12	4	**2017/1/4** 14:18 perihelion	52	2016/11/14 Full Moon
			52	2016/11/14 perigee,
			the closest perigeeof 1949 - 2033	
2017/6/8 2:01	36	**2017/6/9** 13:10 New Moon	14	2017/5/26 New Moon
				2017/5/26 perigee,
			the 2nd closest perigee of 2017	
2017/7/29 18:56	23	The only detection with no relation to the Moon; 23 hours after the 2017/7/28 20:15 Jupiter-Moon-Earth alignment		
2017/8/9 8:28	39	**2017/8/7** 18:13 Full Moon		
	22	**2017/8/7** 18:20 lunar eclipse		
	22	**2017/8/8** 10:56 lunar node		
2017/8/14 10:31		these three detections were sandwiched between the two eclipses		
2017/8/17 12:41				
2017/8/18 2:25				
2017/8/23 13:14	43	**2017/8/21** 18:30 New Moon		
	51	**2017/8/21** 10:34 lunar node		
	51	**2017/8/21** 10:26 solar eclipse		

Table 1: LIGO's confirmed gravitational waves detections, LIGO (2019), Lunar Calculator (2019). The 2nd/4th column shows the number of hours/days between a gravitational wave detection and the event(s) in the 3rd/5th column.

per year; 3) of the 12 M $\geqslant$ 8.6 earthquakes in 1910 – 2012, three struck in 2010 – 2012 averaging one per year, seven struck in 1946 – 1965 laden with 1949/3/14, 1950/5/2, 1951/6/19, 1952/8/5, 1953/9/23, 1954/11/10, 1962/3/6, 1963/4/23, 1965/7/28, 1966/914 perigees within 3 hours of New/Full Moon, two struck in 1966 – 2008, no M $\geqslant$ 8.6 struck in 1910 – 1945.

Even more remarkable is the correlation between earthquakes and lunar/solar events. Table 2 shows 7 full lunar cycles. In 6 out of 7 full lunar cycles the strongest earthquake struck within 34 days of the closest perigee. Since 2009/7/5 – 20017/6/8 comprised 2885 days and contained 7 closest perigees, the number of strongest earthquakes within 34 days of the closest perigees is expected to be $\approx \frac{7 \times 68}{2885} \times 7 \approx 1.2$ not 6. The 2014/4/1 earthquake was the only one more than 34 days away from the closest perigee; but it struck right after the 2014/3/30 New Moon and 2014/3/29 X1 solar flare. Also in 5 out of 7 full lunar cycles the strongest earthquake struck within 88 hours ($\approx$ 3.7 days) of New/Full Moon. The 2011/3/11 earthquake was one of the

full lunar cycle	the strongest earthquake(s) of the full lunar cycle	d a ys	lunar/solar events within 47 days of of the earthquake	h ou rs	lunar/solar events within 88 hours of the earthquake
2009/7/5 - 2010/8/22	**2010/2/27** 6:34 M=8.8	28	2010/1/30 9:04 closest perigee 6:19 Full Moon,	34 45	**2010/2/28** 16:39 Full Moon, **2010/2/25** 9:11 lunar node
		29	2010/1/29 lunar node		
2010/8/22 - 2011/10/10	**2011/3/11** 5:46 M=9.1, aftershock M=7.9	8	2011/3/19 19:10 closest perigee 18:11 Full Moon	<54 24	**2011/3/9** X1.5 solar flare, **2011/3/10** 6:30 CME reached Earth
2nd strongest	**2010/10/25** 4:42 M=7.8	47	2010/9/8 4:02 2nd closest perigee 10:30 New Moon	3	**2010/10/23** 1:38 Full Moon
2011/10/10 - 2012/11/26	2012/4/11 8:39 M=8.6, aftershock M=8.2	26	2012/5/6 3:34 closest perigee and 3:36 Full Moon,		
		27	2012/5/7 lunar node,		
		35	2012/3/7 X5.4 solar flare and 2012/3/8 9:42 Full Moon		
2nd strongest	2012/10/28 3:04 M=7.8	45	2012/12/12 23:15 2nd closest perigee	2	**2012/10/29** 19:51 Full Moon
		46	2012/12/13 10:32 New Moon		
2012/11/26 - 2014/1/14	**2013/5/24** 5:45 M=8.3	31	2013/6/23 11:11 closest perigee 11:34 Full Moon	24 5	**2013/5/25** 4:27 Full Moon, **2013/5/24** 0:40 lunar node
2014/1/14 - 2015/3/1	**2014/4/1** 23:47 M=8.2	35	2014/2/25 X4.9 solar lfare	29 22	**2014/3/30** 18:48 New Moon, **2014/4/1** 2:30 lunar node **2014/3/29** X1 solar flare
2015/3/1 - 2016/4/20	**2015/9/16** 22:55 M=8.3	12	2015/9/28 1:47 closest perigee 2:52 Full Moon,	88 66	**2015/9/13** 6:43 New Moon, **2015/9/14** 4:38 lunar node
		11	2015/9/27 lunar node		
2016/4/20 - 2017/6/8	**2016/12/17** 10:51 M=7.9, 2017/1/22 M=7.9 aftershock	34	2016/11/14 11:24 closest perigee 13:54 Full Moon,	83	**2016/12/14** 0:07 Full Moon
			the closest perigee of 1949 - 2033		

Table 2: Correlation of the strongest earthquakes of full lunar cycles and lunar/solar events in 2009/6/8 – 2017/5/11, USGS & NOAA (2019), Lunar Calculator (2019), Flares (2017). The 3rd/5th column shows the number of days/hours between the strongest earthquake of the full lunar cycle and the event in the, correspondingly, 4th/6th column. The closest perigee of each full lunar cycle is less than 3 hours away from Full Moon. The date of 2009/7/5 as the beginning of the first full lunar cycle was chosen rather arbitrarily and may be moved to an earlier or later date; once the first date of the first cycle is selected, the beginning and end of all other cycles are determined. Changing the first days of the first full lunar cycle will not change the earthquakes in this Table but may change the strongest and 2nd strongest earthquakes in Table 3.

two earthquakes more than 88 hours away from New/Full Moon; but it struck right after the 2011/3/9 X1.5 solar flare and merely 8 days after the 2011/3/19 closest perigee. In the two full lunar cycles when the strongest earthquakes was more than 88 hours away from New/Full Moon, the 2nd strongest earthquake struck within 2.2 hours of Full Moon and within 1.5 months of the 2nd closest perigee.

full lunar cycle	the strongest earthquake(s) of the full lunar cycle	d a ys	lunar/solar events within 44 days of the earthquake	h ou rs	lunar/solar events within 48 hours of the earthquake
two most powerful earthquakes of 2007/3/31 - 2008/5/18	**2007/9/12** 11:10 M=8.4	44	2007/10/26 11:52 closest perigee 4:53 Full Moon	23 43	**2007/9/11** 12:45 New Moon, **2007/9/10** 14:49 lunar node
	2007/4/1 20:40 M=8.1	17	2007/4/17 5:56 2nd closest perigee 11:38 New Moon	22	**2007/4/2** 17:16 Full Moon **2007/3/31** 11:41 lunar node
two most powerful earthquakes of 2008/5/18 - 2009/7/5	**2009/1/3** 19:44 M=7.7	23	2008/12/12 21:38 closest perigee 16:39 Full Moon	21	**2009/1/4** 15:30 perihelion
	2008/7/5 2:12 M=7.7	33	2008/6/3 13:09 2nd closest perigee 19:24 New Moon	48 1	**2008/7/3** 2:20 New Moon, **2009/7/5** 1:39 lunar node
2009/7/5 – 2017/6/8 period of Table 2					
two most powerful earthquakes of 2017/6/8 - 2018/7/25	**2017/9/8** 4:49 M=8.2			46	**2017/9/6** 7:05 Full Moon, **2017/9/7** X9.3 solar flare
	2018/1/23 9:32 M=7.9	23 22 21	2018/1/1 21:56 closest perigee 2018/1/2 2:56 Full Moon 2018/1/3 perihelion		
two most powerful earthquakes of 2018/7/25 - 2019/9/12	**2018/8/19** 0:20 M=8.2	37	2018/7/13 8:30 2nd closest perigee 2:50 New Moon 2018/7/14 lunar node	<48	**2019/8/20** powerful CME
	2019/5/26 7:41 M=8.0				

Table 3: Correlation of earthquakes of the two full lunar cycles before and after the period of Table 2 with lunar/solar events, USGS & NOAA (2019), Lunar Calculator (2019), Flares (2017). The 3rd/5th column shows the number of days/hours between the strongest earthquake of the full lunar cycle and the event in the, correspondingly, 4th/6th. The closest perigee of each full lunar cycle is more than 3 hours away from Full Moon.

Table 3 shows the strongest and 2nd strongest earthquakes of the two full lunar cycles before and after the 2009/7/5 – 20017/6/8 period of Table 2. Although the influence of the lunar motion and solar flares on earthquakes is still observed, it is not as sharp as in Table 2, it is "smudged" between the strongest and 2nd strongest earthquakes. Table 4, showing all $M \geqslant 8.4$ earthquakes in 1935/1/1 – 2019/12/31, reveals that all $M \geqslant 8.4$ earthquakes in 1935 – 2019 struck either within 47 days of the closest perigee or within 3 days of New/Full Moon. The number of days in a full lunar cycle within 47 days of the closest perigee or within 3 days of New/Full Moon is $\approx 47 \times 2 + 11 \times 3 \times 2 = 160$, thus we would expect the number of $M \geqslant 8.4$ earthquakes within 47 days of the closest perigee or within 3 days of New/Full Moon to be only $\approx \frac{160}{413} \approx 39\%$ of the total. Of course, New/Full Moon and closest perigees do not affect only $M \geqslant 8.4$ earthquakes, they must also affect earthquakes of lower magnitudes only to a lesser degree and less explicitly.

Date, time, magnitude	likely relevant celestial events	time between
2012/4/11 8:39 M=8.6	2012/5/6 Full Moon-closest perigee	26 days
2011/3/11 5:46 M-9.1	2011/3/19 Full Moon-closest perigee	8 days
2010/2/27 6:34 M=8.8	**2010/2/28** 16:39 Full Moon	34 hours
	2010/2/25 9:11 lunar node	45 hours
	2010/1/20 Full Moon-closest perigee	28 days
2007/9/12 11:10 M=8.4	2007/9/11 12:45 New Moon	23 hours
	2007/9/10 14:49 lunar node	43 hours
	2007/10/26 Full Moon-closest perigee	44 days
2005/3/28 16:10 M=8.6	**2005/3/25** 21:01 Full Moon,	67 hours
	2005/3/27 5:15 lunar node	35 hours
	2005/01/17 X3.8 solar flare	
2004/12/26 0:59 M=9.1	**2004/12/26** 21:31 Full Moon,	21 hours
	2005/1/2 perihelion,	7 days
	2005/1/10 New Moon-closest perigee	15 days
	2004/5/15 - 2006/1/20 numerous X1 - X7.1 solar flares	
2001/6/23 20:33 M=8.4	**2001/6/21** 11:59 New Moon,	59 hours
	2001/6/21 22:11 lunar node	
	2001/4/2 - 2001/4/30 numerous X1.1 - X20 solar flares	
1965/2/4 5:01 M=8.7	1964/12/19 Full Moon-closest perigee,	47 days
	1964/12/18 lunar node	
	1965/2/1 16:37 New Moon	60 hours
1964/3/28 3:36 M=9.2	**1964/3/28** 2:49 Full Moon	1 hour
1963/10/13 5:18 M=8.5	1963/11/2 Full Moon-closest perigee	20 days
1960/5/22 19:11 M=9.5	**1960/5/25** 12:27 New Moon,	68 hours
1957/3/9 M=8.6	1957/2/14 Full Moon-closest perigee	23 days
1952/11/4 16:58 M=9.0	**1952/11/1** 23:09 Full Moon	64 hours
1950/8/15 14:10 M=8.6	**1950/8/13** 16:47 New Moon	46 hours
	1950/8/16 12:16 lunar node	20 hours
1946/4/1 12:29 M=8.6	**1946/4/2** 4:39 New Moon	16 hours
1938/2/1 19:04 M=8.5	**1938/1/31** 13:35 New Moon	30 hours

Table 4: Correlation of M $\geqslant$ 8.4 earthquakes in 1935 - 2019 with lunar/solar events, USGS & NOAA (2019), Lunar Calculator (2019), Flares (2017). "Closest perigee" means that all perigees within 210 days are farther away. The table starts at 1935 as it was the year the Richer scale was introduced, the table covers M $\geqslant$ 8.4 earthquakes as NOAA and USGS catalogs of USGS & NOAA (2019) unequivocally agree only for M $\geqslant$ 8.4 earthquakes.

We are compelled to conclude that the correlation between earthquakes and New/Full Moon is due to tidal forces as New/Full Moon amplifies tidal forces, proximity of New/Full Moon to perigees or lunar nodes increases tidal forces even more. The 2011/3/11, 2014/4/1, 2017/9/8, and 2018/8/18 earthquakes struck within two days of powerful solar flares or CME, suggesting that the latter also contribute to powerful earthquakes. Since the only part of the Earth affected by both the tidal forces and the magnetic forces produced by solar flares/CMEs is the liquid core, we may hypothesize that powerful earthquakes have their power amplified by movements inside the liquid core; the movements themselves are caused/augmented by proximity to the closest/2nd closest

perigee of a lunar cycle, New/Full Moon, or a solar flare/CME. The earthquakes in Table 2 specifically had their power amplified by 1) 34-day proximity to the closest perigee of the full lunar cycle practically coinciding with Full Moon; 2) 3-day proximity to New/Full Moon; 3) proximity of the New/Full Moon in 1) or 2) to a lunar node; 4) unusually short time between perigee and Full Moon on 2012/5/6; 5) unusual closeness of the Moon to Earth on 2016/11/14; 6) proximity to perihelion on 2017/1/4; 7) 3-day proximity to an X-level solar flare.

Discussion of patterns in gravitational waves detections. The first five gravitational waves detections occurred in the 2009/7/5 – 2017/6/8 period of Table 2 and followed a pattern similar to that of the earthquakes in Table 2: 1) all five detections are within 2 days of new/full Moon or perihelion; 2) four of the five detections are within 14 days of a perihelion or the closest/2nd closest perigee of a full lunar cycle with the perigee almost coinciding with Full Moon. Since an average year contains $\approx \frac{365.25}{29.53 \times 0.5} \approx 24.74$ New/Full Moons and one perihelion, the number of days within 1.5 days of New/Full Moon or perihelion is $\approx \frac{(24.74+1) \times 3}{365.25} \approx 0.2$; we would expect the number of gravitational waves detections within 1.5 days of New/Full Moon or perihelion to be close to $\approx 0.2 \times 7 \approx 1.5$.

Table 5 reveals that the first six detections satisfy a certain pattern: the larger is the "amplitude" of a detection the larger is the magnitude of the corresponding earthquake. The probability that the "amplitudes" of the first six detections correlate with the magnitudes of the corresponding earthquakes is $\frac{1}{6!} = \frac{1}{720} < 0.0014$. The post-2017/7/29 detections do not follow the same pattern.

We hypothesised earlier that the movements within the liquid core caused by New/Full Moon, perigees, lunar nodes, solar flares/CMEs, etc. amplify the earthquakes' power. Such movements would produce seismic activity and minute changes in the gravitational field. The LIGO team claims they have eliminated seismic signal from that of the gravitational waves, whether it is so is not clear. But there are presently no mechanical instrumentation capable of shielding from the minute changes of the gravitational field, nor are there any theories capable of calculating the effects of these minute changes.

Could the signals interpreted as gravitational waves be in fact caused by other phenomena like movements in the liquid core or minute changes in the gravitational field? Is the similarity in the pattern of gravitational wave detections and the pattern of earthquakes merely coincidental or an indication that the detections of gravitational waves were in fact detections of something else?

gravitational waves detections	days	most powerful earthquakes of 2015/9/1 – 2016/2/1 and 2016/12/1 – 2017/9/7
2015/9/14 9:51	1.5	M=8.3 2015/9/16 22:55 22 km-deep Chile; near 2015/9/13 New Moon
2015/10/12 9:55	14	M=7.5 2015/10/26 231 km-deep Afghanistan; near 2015/10/27 Full Moon 2015/12/25 M=6.3 aftershock 8 hours before next detection
2015/12/26 3:39	32	two M=7.6 2015/11/24 606 - 621 km-deep near Brazil-Peru border; near 2015/11/25 Full Moon
2017/1/4 10:12	18, 19	two M=7.9 quakes on 2016/12/17 10:51 and 2017/1/22 04:30 38 - 135 km -deep Papua New Guinea; the first one near 2016/12/14 Full Moon
2017/6/8 2:01	40	M=7.7 2017/7/17 23:34 10 km-deep Kamchatka
2017/7/29 18:56	12	

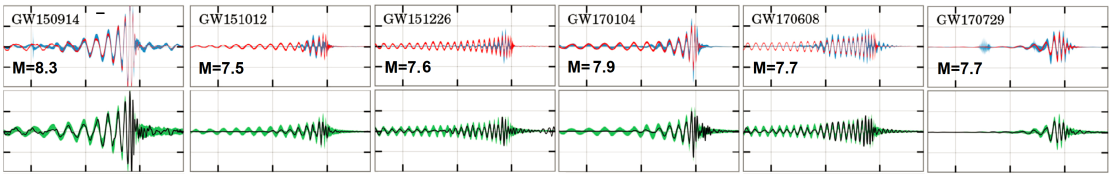

Table 5: Detections and the most powerful earthquakes, LIGO (2019), USGS & NOAA (2019). The 2nd column shows the number of days between a detection and the corresponding earthquake in the 3rd column. The picture shows time-frequency maps and reconstructed signal waveforms for the first six detections, LIGO's https://www.ligo.org/news.php and https://arxiv.org/ftp/arxiv/papers/1811/1811.12907.pdf, see details there. The magnitudes of the earthquakes and the "amplitudes" of the signals of GW150914 – GW170609 follow the pattern: the larger is the magnitude of the earthquake the larger is the "amplitude" of the wave.

Our doubts are echoed by Creswell, et al (2017).

References and data sources (all web sites cited were sighted on 2019/10/31)

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