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The Mayan Long Count Calendar

Thomas Chanier*

1 Introduction

The Maya had a very elaborate and accurate calendar. First, the Mayan Long Count Calendar (LCC) was used to point historical events from a selected "beginning of time". The Long Count Periods are given on Table 1. It is also characterized by the existence of a religious year Tzolk'in and a civil year Haab'. One Tzolk'in of 260 days (Kin) is composed of 13 months (numerrated from 1 to 13) of 20 named days (Imix, Ik, Akbal, Kan, Chicchan, Cimi, Manik, Lamat, Muluc, Oc, Chuen, Eb, Ben, Ix, Men, Cib, Caban, Eznab, Cauac, Ahau). One Haab' of 365 days is composed of 18 named months (Pop, Uo, Zip, Zotz, Tzec, Xul, Yaxkin, Mol, Chen, Yax, Zac, Ceh, Mac, Kankin, Muant, Pax, Kayab, Cumku) with 20 days (Uinal) plus one month of 5 nameless days called Uayeb. The LCC is supposed to begin on 11 August -3114 BC or 13(0).0.0.0.0, 4 Ahau 8 Cumku known as the Goodman-Martinez-Thompson (GMT) correlation to the Gregorian calendar based on historical facts and end on 21 December 2012 corresponding to a period of approximately 5125 years or 13 Baktun. We propose here to explain the origin the 13 Baktun cycle, the Long Count Periods and the religious year Tzolk'in.

Days	Long Count Period	Equivalent	Approx. solar year
1	1 Kin	-	-
20	20 Kin	= 1 Uinal	0.0547
260	13 Uinal	= 1 Tzolk'in	0.7118
360	18 Uinal	= 1 Tun	0.9856
7200	20 Tun	= 1 Katun	19.7125
144000	20 Katun	= 1 Baktun	394.2505

Table 1: Table of Long Count Unit.

Period	N [day]	Prime factorization
Mercury synodic period	116	$2^2 \times 29$
Venus synodic period	584	$2^3 \times 73$
Mars synodic period	780	$2^2 \times 3 \times 5 \times 13$
Jupiter synodic period	399	$3 \times 7 \times 19$
Saturn synodic period	378	$2 \times 3^3 \times 7$
5 Moon synodic periods	148	$2^2 \times 37$
6 Moon synodic periods	177	3×59
	178	2×89
	234	13×18
	338	2×13^2
Tzolk'in	260	$2^2 \times 5 \times 13$
Haab'	365	5×73
Tun	360	$2^3 \times 3^2 \times 5$
Katun	7200	$2^5 \times 3^2 \times 5^2$
Baktun	144000	$2^7 \times 3^2 \times 5^3$
Pictun	2880000	$2^9 \times 3^2 \times 5^4$
Calabtun	57600000	$2^{11} \times 3^2 \times 5^5$
Kinchiltun	1152000000	$2^{13} \times 3^2 \times 5^6$
Alautun	23040000000	$2^{15} \times 3^2 \times 5^7$

Table 2: Prime factorization of the periods.

2 The different Calendars

The Long Count Calendar (LCC) represents a date D as a set of coefficients $(C_0, C_1, C_2, C_3, \dots, C_i)$ such as: $D = C_0 + C_1 \times 20 + \sum_{i=2}^n C_i \times 18 \times 20^{i-1}$ with $C_0 = \text{mod}(D, 20)$, $C_1 = \text{int}(\text{mod}(D, 360)/20)$ and $C_i = \text{int}(\text{mod}(D, 18 \times 20^i)/(18 \times 20^{i-1}))$ for $i > 1$. The date usually stops at $C'_4 = \text{mod}(C_4, 13)$ such as the date is given as $C'_4.C_3.C_2.C_1.C_0$. There is 18 weeks (Uinal) of 20 days (Kin) in one Tun (360 days), 20 Tun in a Katun and 20 Katun in a Baktun (Table 1). Two other Calendars, the Tzolk'in and the Haab', coexist with the Long Count Calendar. The Tzolk'in and the Haab' coincide every 73 Tzolk'in or 52 Haab' or a Calendar Round: their least common multiple (LCM) is $73 \times 260 = 52 \times 365 = 18980$ days.

When we look at the LCM of the number of days D of a Long Count Period and a Haab' (365 days), we obtain $\text{LCM}(D, 365) = 73 \times D$ as seen on Table 3. 73 is not present in the prime factorizations of the Tzolk'in and the Long Count Periods (Table 2) which explains the results in Table 3.

When we look at the LCM of the number of days D of a Long Count Period and a Tzolk'in (260 days), we obtain $\text{LCM}(D, 260) = 13 \times D$ as seen on Table 4. 13 is not present in the prime factorizations of the Long Count

Periods (Table 2) which explains the results in Table 4. There is for example a 13 Katun cycle of 93600 days and a 13 Baktun cycle of 1872000 days corresponding respectively to 360 and 7200 Tzolk'in. This means that the Baktun cycle coincides with the Tzolk'in cycle every 13 Baktun corresponding approximately to 5125 years. That explain the origin of the 13 Baktun cycle.

LCP	D [day]	$N = \text{LCM}(D, 365)$	N/D	$N/365$
Tzolk'in	260	18980	73	52
Tun	360	26280	73	72
Katun	7200	525600	73	1440
Baktun	144000	10512000	73	28800
Pictun	2880000	210240000	73	576000
Calabtun	57600000	4204800000	73	11520000
Kinchiltun	1152000000	84096000000	73	230400000
Alautun	23040000000	1681920000000	73	4608000000

Table 3: Coincidence of the civil year Haab' with the Long Count Period (LCP).

LCP	D [day]	$N = \text{LCM}(D, 260)$	N/D	$N/260$
Tun	360	4680	13	18
Katun	7200	93600	13	360
Baktun	144000	1872000	13	7200
Pictun	2880000	37440000	13	144000
Calabtun	57600000	748800000	13	2880000
Kinchiltun	1152000000	14976000000	13	57600000
Alautun	23040000000	299520000000	13	1152000000

Table 4: Coincidence of the religious year Tzolk'in with the Long Count Period (LCP).

3 The Long Count Calendar and the Tzolk'in

The only planets of the Solar System visible to the naked eye in the sky are the Moon, Mercury, Venus, Earth (solar year), Mars, Jupiter and Saturn. Their respective mean synodic periods are given in Table 5. Mayan astronomers may have observed their periodic movements in the night sky. Some evidence has been found in different Maya Codices for Mercury, Venus and Mars whereas it is less clear for Jupiter and Saturn [2]. The periods relevant for the prediction of solar/lunar eclipses are the pentalunex of 148 days (5 Moon synodic periods of 29.53 days) and the lunar semesters of 177

Planet	P [day]	$\text{LCM}(P, 365)$	LCC date
Mercury	116	42340	0.5.17.11.0
Venus	584	2920	0.0.8.2.0
Earth	365	365	0.0.1.0.5
Mars	780	56940	0.7.18.3.0
Jupiter	399	145635	1.0.4.9.15
Saturn	378	137970	0.19.3.4.10
Pentalunex	148	54020	0.7.10.1.0
Lunar semester	177	64605	0.8.19.8.5
	178	64970	0.9.0.8.10

Table 5: Coincidence of the planet mean synodic periods [1] and the Haab' and their date in the Long Count Calendar (LCC) from the selected "beginning of time".

or 178 days (6 Moon synodic periods) which are the time intervals between subsequent eclipse warning stations present in the Dresden Codex Eclipse Table [3]. The LCM of these numbers is $N = 20757814426440$ days (including only the planet mean synodic periods and the two lunar semesters) or $N' = 768039133778280$ days (including also the pentahunex).

i	C_i [day]	Expression	Integer part
0	338	$N/13/73/\sum_0^6 C_i$	18
1	360	$N/13/73/\sum_0^5 C_i$	360
2	7200	$N/13/73/\sum_0^4 C_i$	7214
3	144000	$N/13/73/\sum_0^3 C_i$	144000
4	2880000	$N/13/73/\sum_0^2 C_i$	2769480
5	57600000	$N/13/73/\sum_0^1 C_i$	31337185
6	1152000000	$N/13/73/C_0$	64714069

Table 6: Divisibility of $N = 20757814426440$ days by a polynomial expression of the type $C_0 + \sum_n 18 \times 20^n$ where C_0 is an integer.

We note that $N/13/73/(338.3025 + 360 + 7200 + 144000) = 144000$ (Table 6). We obtain the same results with N' but divided by 13, 37 and 73. The $\text{LCM}(338, 360) = 169 \times 360 = 234 \times 260 = 60840$. 338 and 365 are relatively prime numbers: the $\text{LCM}(338, 365) = 338 \times 365 = 123370$. 234 and 365 are also relatively prime numbers: the $\text{LCM}(234, 365) = 234 \times 365 = 85410$. The $\text{LCM}(260, 365)$ is $73 \times 260 = 52 \times 365 = 18980$ days or a Calendar Round. That may define the Tzolkin. When we look at the LCM of the synodic periods and the Haab' (Table 5), we see that Jupiter has the highest LCM of 145635 days which corresponds to the LCC date 1.0.4.9.15, exceeding a Baktun. That may explain why the LCC stops at the Baktun.

LCP	D [day]	L [day]	M [day]	N [day]	$L/260$	$L/234$
Winal	20	3380	260	2340	13	14.44444
Tun	360	60840	4680	4680	234	260
Katun	7200	1216800	93600	93600	4680	5200
Baktun	144000	24336000	1872000	1872000	93600	104000

Table 7: Coincidence of the 234, 260 and 338 day period with the Long Count Period (LCP). $L = \text{LCM}(D, 338)$, $M = \text{LCM}(D, 260)$ and $N = \text{LCM}(D, 234)$.

Table 7 gives the coincidence of the 338 day period with the Long Count Periods as well as the Tzolk'in and the 234 day period. As seen earlier, the Tun (360 days) and the 338 day period coincide every 60840 days or 234 Tzolk'in. We see also that the 338 day period coincides with the Winal (20 days) every 3380 days corresponding to 13 Tzolk'in, a cycle that does not coincide with the 234 day period. The 234 day period coincides with the Winal every 2340 days or 9 Tzolk'in = $9 \times 260 = \text{LCM}(9, 13, 20)$. This 2340 day cycle is present in the Dresden Codex on pages D30c-D33c and has been attributed to a Venus-Mercury almanac because $2340 = 20 \times 117 = 5 \times 585$, an integer multiple of Mercury and Venus mean synodic periods plus one day [4]. Another explanation may be of divination origin because $117 = 9 \times 13$. In Mesoamerican mythology, there are a set of 9 Gods called the Lords of the Night [5, 6, 7] and a set of 13 Gods called the Lords of the Day [8]. Each day is linked with one of the 13 Lords of the Day and one of the 9 Lords of the Night in a repeating 117 day cycle. This cycle coincides with the Winal every 2340 days.

4 The Tzolk'in and the Planet cycles

Various religious cycles can be constructed by taking the LCM of 260 and the planet synodic periods (Table 8). The most important one in Maya religion is the Calendar Round which is the $\text{LCM}(260, 365) = 73 \times 260 = 52 \times 365 = 18980$ days. There is a coincidence between Venus synodic period and the Tzolk'in: the $\text{LCM}(260, 584) = 65 \times 584 = 146 \times 260 = 104 \times 365 = 37960$ days (2 Calendar Rounds). There is a coincidence between Mars synodic period and the Haab': the $\text{LCM}(780, 365) = 73 \times 780 = 219 \times 260 = 156 \times 365 = 56940$ days (3 Calendar Rounds). Venus and Mars cycles are of particular importance in Maya religion. There is another cycle of $46 \times 260 = 11960$ days corresponding to 405 Moon synodic periods used for the prediction of solar/lunar eclipses in the Dresden Codex [3]. Two other cycles are not based on the planet cycles but on the coincidence of the Tzolk'in and the 234 and 338 day period: the $\text{LCM}(260, 234) = 9 \times 260 = 2340$ days and the $\text{LCM}(260, 338) = 13 \times 260 = 3380$ days. On page 24 of the Dresden

Codex, there is a period called Long Round noted 9.9.16.0.0 or 1366560 days
 $= 2340 \times 584 = 3744 \times 365 = 1752 \times 780 = 72 \times 18980 = 3796 \times 360$
 $= 5256 \times 260$. This shows the importance of astronomical observations in
Maya religion.

Planet	P [day]	$N = \text{LCM}(P, 260)$	$N/260$	N/P
Mercury	116	7540	29	65
Venus	584	37960	146	65
Earth	365	18980	73	52
Mars	780	780	3	1
Jupiter	399	103740	399	260
Saturn	378	49140	189	130
Pentalunex	148	9620	37	65
Lunar semester	177	46020	177	260
	178	23140	89	130

Table 8: Coincidence of the planet mean synodic periods [1] and the Tzolk'in.

5 Conclusion

We propose here an explanation of the origin of the Long Count Calendar and its connection with the Tzolk'in and Haab' calendars. The Haab' and the Long Count Periods give rise to 73 Long Count Period cycles. The 13 Baktun cycle originates from the coincidence between the Baktun and the Tzolk'in. Based on astronomical observations of the Solar System, the Long Count Calendar gives rise to three different periods: 234 day, 260 day (Tzolk'in) and 338 day periods. The coincidence of the 234 day period and the Tzolk'in, a 2340 day cycle identified in the Dresden Codex, was certainly used for divination purposes. The coincidence of the 338 day period and the Tzolk'in gives rise to a 13 Tzolk'in cycle which has not yet been identified in the Codices. The results suggest that Mayan astronomers knew the synodic periods of all the planets of the Solar System visible to the naked eye and the basic cycles for solar/lunar eclipse prediction, the pentalunex and the lunar semesters. Various religious cycles may have been in use by the Mayans based on the coincidence of the planet cycles and the Tzolk'in. Among them, Venus and Mars cycles are of primary importance.

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