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SIGNIFICANCE OF COEFFICIENT 13 IN THE LONG COUNT CALENDAR

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Introduction

Based on mathematics this note explains the significance of the number 13 in Long Count Calendar dates. Furthermore, it gives an explanation for the 360-day-duration of the *Tun*.

Significance of Coefficient 13 in Long Count Dates

It is known that some Long Count dates do not only show coefficients for the time periods of the *Bak'tun*, *K'atun*, *Tun*, *Winal* and *K'in* (e.g. 12.10.1.13.2, PAL T. XIX Hbh. S, B1-A4) but a number of further coefficients for the longer time periods of the Long Count Calendar (*Piktun*, *Kalabtun*, *K'inchiltun*, *Alawtun*, etc.). Examples for such dates are[1]

COB St. 1, M1-M13

13.13.13.13.13.13.13.13.13.13.13.13.13.13.13.13.13.13.13.13.0.0.0.0

YAX HS. 2 Step VII, I1-P2

13.13.13.13.13.13.13.13.9.15.13.6.9

In these dates we have – starting with the *Bak'tun* or *Piktun* position - between 8 and 20 coefficients that are all displaying the number 13. Mayanists assume that the Maya wrote down these dates representing extraordinary long periods of time to convey the infinity of time (Schele and Freidel 1999:512; Gronemeyer and MacLeod 2010:4). Use of the number 13 in such Long Count dates is explained with the mythic meaning this number had for the Maya (Gronemeyer and MacLeod 2010:4);

[1] after Gronemeyer and MacLeod 2010:4

the same applies to the 819-day-cycle that is the product of the numbers 7, 9 and 13 (Schele and Freidel 1999:69). A mathematical analysis of the Long Count Calendar system can alternatively explain why all these coefficients in such dates have stopped at the number 13. To understand this, we start with a look at the Calendar Round consisting of 18,980 days. The reason for this duration is clear: after 18,980 days the first day of the 365-day *Haab* and the first day of the 260-day *Tzolk'in* come together again for the first time. From a mathematical point of view, the number 18,980 is the lowest common multiple (LCM) of the numbers 365 and 260. To understand the significance of the number 13 for the Long Count Calendar it is important to know the mathematical procedure for calculating the LCM. For two given numbers one has to build by prime factorization the product of all the prime factors of the bigger number as well as of the additional prime factors of the smaller number (which are not already contained in the bigger number). Using the Calendar Round as an example it becomes evident that calculation of the LCM using this method is quite simple: prime factorization of the number 260 leads to 2 x 2 x 5 x 13 and prime factorization of the number 365 leads to 5 x 73. If we now take the prime factors of the bigger number 365 (5 x 73) and the prime factors of the smaller number 260 that are not part of the prime factorization of 365 (these are 2 x 2 x 13) and then build the aggregate product we obtain 2 x 2 x 5 x 13 x 73 = 18,980.

The day 13.0.0.0.0 4 *Ajaw* 8 *Kumk'u* (August 11/13, 3114 BC) is considered to be the starting point of the current 13 *Bak'tun* cycle and the beginning of the current creation (Thompson 1971:149; Wagner 2007:283; Gronemeyer and MacLeod 2010:4); the 13th *Bak'tun* of the current cycle ends with the Long Count date 13.0.0.0.0 4 *Ajaw* 3 *K'ank'in* (December 21/23, 2012). Regarding these two dates it is well known that the *Tzolk'in* date 4 *Ajaw* which is part of 13.0.0.0.0 4 *Ajaw* 8 *Kumk'u* is also part of the 13.0.0.0.0 4 *Ajaw* 3 *K'ank'in* (Gronemeyer and MacLeod 2010:5). Each *Bak'tun* closes with an *Ajaw* date; furthermore, on December 21/23, 2012 the *Tzolk'in* date 4 *Ajaw* comes for the first time since 13.0.0.0.0 4 *Ajaw* 8 *Kumk'u* together with the beginning of a *Bak'tun* (Thompson 1971:149; Gronemeyer/MacLeod 2010:6-7). The reason for this is that after 13 *Bak'tun* (1,872,000 days = 13 x 144,000 days) the LCM of 260 (number of days of the *Tzolk'in*) and 144,000 (number of days of a *Bak'tun*) is reached. If we confront the prime factorizations of the other Long Count time units with the prime factorization of the 260-day-period of the *Tzolk'in* we come to an interesting conclusion:

Long Count time units in days	**prime factorization of time units**	**prime factorization of number 260**	**LCM**
Tun = 360	2^3 x 3^2 x 5	2^2 x 5 x 13	2^3 x 3^2 x 5 **x 13**
K'atun = 7.200	2^5 x 3^2 x 5^2	2^2 x 5 x 13	2^5 x 3^2 x 5^2 **x 13**
Bak'tun = 144.000	2^7 x 3^2 x 5^3	2^2 x 5 x 13	2^7 x 3^2 x 5^3 **x 13**
Piktun = 2.880.000	2^9 x 3^2 x 5^4	2^2 x 5 x 13	2^9 x 3^2 x 5^4 **x 13**
Kalabtun = 57.600.000	2^{11} x 3^2 x 5^5	2^2 x 5 x 13	2^{11} x 3^2 x 5^5 **x 13**

The table reveals that each LCM – which is the product of the prime factors of the respective Long Count time unit and of the additional prime factor of 260 (*Tzolk'in*) – is built by adding the number 13 to the prime factors of the Long Count time unit. This means that the respective Long Count time unit has to repeat 13 times until the first day of the time unit comes together with the *Tzolk'in* date of day 1. This rule does not only apply for the time units until *Kalabtun* but also for any longer time unit as the higher time units are created by multiplication with 20 (2 x 2 x 5). Therefore, the prime factor 13 of the number 260 will always be needed to calculate the LCM with the respective Long Count time unit.

As demonstrated, this mathematical background of the Long Count Calendar system explains why the Maya stopped at the number 13 when they wrote down huge dates like in Monument 1 in Cobá: After 13 repetitions of each of the many time units (*Bak'tun*, *Piktun*, *Kalabtun*, etc.) the *Tzolk'in* date 4 *Ajaw* came back for the first time together with day one (or zero) of these time units. Thus, by using the coefficient 13 it was possible to add arbitrarily high time units in Long Count dates without shifting the important 4 *Ajaw* date. As Andreas Fuls points out, other Long Count dates indicate that the coefficient at the *Piktun* position was not numbered from 1 to 13 but from 0 to 19 (Morley 1975:107-114). It seems that the Maya used both modes of counting: As the re-entering cycles of 13 *Bak'tuns* were unsuitable for far reaching astronomical calculations, *Bak'tuns* were grouped for this purpose in 20's to form a higher unit in the vigesimal count, the *Piktun* (Thompson 1971:149).

Mathematical Explanation for 260-day Duration of the Tun

As Mayan mathematics is based on the number 20 (vigesimal system) 20 days (*K'in*) formed a "month" (*Winal*). Following the vigesimal system 20 *Winal* (= 400 *K'in*) should form a "year" (*Tun*). Instead, the Maya chose a duration of 360 days for the *Tun* by multiplying 20 *Kin* with 18 (and not with 20). They also did not apply a *Tun*-duration of 365 days which would have approximated the length of the solar year more exactly. Furthermore, the duration of both the *Tun* and the *Haab* calendar then would have been the same. A widespread explication is, that by choosing the number 360 the Maya tried to approximate the duration of the solar year (Morley 1975:63; Voß 2007:138). Thompson (1971:151) offered an alternative, more sophisticated explication: "I am inclined to think that the period of 360 days was chosen because the Maya desired a formal year which would invariably start with *Imix* and end with *Ahau*. To fulfill that condition, 360 days was the logical choice, for 380 days (it had to be a number divisible by 20) are nearly 15 days beyond the true length of the year. Furthermore, with an approximate year of 360 days the same lord of the night always governs the same nights in each *Tun*. Moreover, at the moment the sum of *Tuns* reaches the sacred figure of 13, 18 (twice the important number 9) sacred almanacs are completed, 4680 being the lowest common multiple of 360 and 260 (13 × 360 or 18 × 260 = 4680)."

The mathematical connection between the coefficient 13 in Long Count dates and the return of the 4 *Ajaw* date supports Thompson's explication. As shown before, the 4 *Ajaw* date returns after 13 repetitions of the *Bak'tun* as well as of any longer time period of the Long Count Calendar. The same applies to the *K'atun*: After 13 *K'atun* the *Tzolk'in* date 4 *Ajaw* returns (if the first *K'atun* started together with the date 4 *Ajaw* of the *Tzolk'in* calendar) which could explain why a cycle of 13 *K'atun* was one of the most holy calendar cycles for the Maya (Schele/Freidel 1999:230). By choosing the number 360 for a *Tun* the inner symmetry of the Long Count Calendar was perfect as the LCM of 360 and 260 (which is 4,680) is also reached after 13 repetitions of the *Tun*. This would not have worked with a *Tun* of 365 as the LCM of 365 and 260 is – as mentioned before – the number 18,980. In this case it would have taken 52 *Tun* (52 x 365 = 18,980) until the first day of the *Tun* falls together with the 4 *Ajaw* date. Nevertheless, the inner symmetry also could have been reached with a *Tun* of 400 days as the LCM of 400 and 260 is 5,200 (= 13 x 400); such a year of 400 days was used by the Cakchiquel (Thompson 1971:151). However, the number 360 was obviously the better choice to implement a mathematically consistent calendar system: 1) it is much closer to the length of the solar year than 400 and 2) it completes the inner symmetry of the Long Count Calendar as the 4 *Ajaw* date returns after 13 *Tun* of 360 days. Regarding this inner symmetry the number 13 and not the number 18 (which is also mentioned by Thompson) was the crucial factor and the reason for choosing a period of 360 days for the *Tun*.

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