Glyph Dwellers

Report 70 May 2021

The Great Year of the Maya:

U Kokan Chan, K'uk' Bahlam I, and Contrived Intervals of the Sidereal Year and the Tropical Year in the Tablet of the Cross, Palenque

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The Temple of the Cross Sanctuary Text at Palenque contains a well-known series of mythological dates within the west panel that are spatially and thematically distinguished from the historical dates found in the east panel. The mythological text in the west panel recounts events both prior to and following the Era base of the Long Count in 3114 BC, and it ends with the birth of a mythological king, U Kokan Chan,[1] in 993 BC. This one king serves as a bridge to connect the mythological and historical texts, with his accession date on the Haab New Year 0 Pop in 967 BC, stated at the beginning of the east panel. The text then jumps forward precisely 1,398 sidereal years from the birth of U Kokan Chan to the birth of the historical King K’uk’ Bahlam I in 393 AD, and then to his accession in 431 AD, which itself is precisely 1,423 tropical years from the birth of U Kokan Chan. The east panel continues through a list of kings up to K'inich Kan Bahlam I, the namesake of Kan Bahlam II who commissioned the monument in 690 AD. Upon closer analysis, the intervals between the births and accessions of U Kokan Chan and K'uk' Bahlam I reveal intentionally contrived calculations of both the sidereal year (365.25636 days) and the tropical year (365.24219 days) that also utilize whole multiples of the 365 day Haab and the 260-day Tzolk’in. This is the most direct statement that Maya astronomers understood precisely how the tropical year slowly drifts backward from the sidereal year through time, and it provides an important key to

[1] The correct phonetic rendering of the name of this legendary king, also nicknamed “Uk’ix Chan” (Schele 1992; Stuart 2005:115) is uncertain (see Davletshin 2002; Stone and Zender 2011:78–79; Zender 2002).

understand the intended positions of all of the back-calculated mythological dates throughout the Cross Group in Palenque, which I will be exploring in a forthcoming publication.

The Sidereal Year and the Tropical Year

The measurement of the length of the year may at first seem straightforward, as we take for granted the way in which our current calendar reliably revolves in a cycle of 365 days that reflects the time it takes for the Earth to make one revolution around the sun. However, the actual dynamics of this movement are much more complex. For agricultural purposes, ancient peoples throughout the world needed to be able to coordinate their calendars with seasonal occurrences such as rainfall or annual flooding, and there are a couple of different ways to do this.

Diligent observers who compared their observations to either oral or written records would notice that seasonal events coincide with the first heliacal reappearance of the same star on the horizon following its disappearance from being obscured by the light of the sun. Babylonian astronomers used such sidereal observations of the stars to record the length of their year (Neugebauer 1969:140; North 2008:51). Similarly, Ancient Egyptian astronomers are known to have recorded the heliacal rising of the brightest star *Spdt* (Sothis/Sirius) in anticipation of the annual flood of the Nile. Conceivably from these observations, they derived their Civil Calendar of 365 days, which was nevertheless allowed to drift rapidly backwards from its original seasonal position by approximately one day every four years (Clagett 1995:1–6, 12, 62; Spalinger 2018:1–6). Because of this drift, the Egyptian Civil Calendar has been called the *annus vagus*, the 'vague year' or 'wandering year' (Depuydt 1995:44).

The apparent return of the sun to its position relative to the fixed stars on the ecliptic is known as the **sidereal year**, which is highly stable over periods of thousands of years, as it reflects the true orbital period of the Earth around the sun. The sidereal year is currently measured as 365.25636 days, over a quarter of a day in excess of 365 days (Capitaine, Wallace, and Chapront 2003). However, this measurement is slightly *longer* than the **tropical year**, which corresponds with the actual seasonal return of the sun to the same fixed position on the horizon, as measured from a specific time of year. The reason for this discrepancy is due to the wobbling of the Earth's axis that causes the seasonal positions such as the solstices and equinoxes to return slightly earlier than the sidereal year. The Greek astronomer Hipparchus is recognized by Ptolemy in his *Almagest* as having first attempted to calculate the slippage between the sidereal and tropical years caused by what was much later named as the 'precession of the equinoxes', which Hipparchus first discovered in the Second Century BC (Evans 1998:259–261). According to Ptolemy, Hipparchus first suspected that the stars along the ecliptic in the zodiac were moving relative to the tropical year. However, in his later work *On the Displacement of the Solstitial and Equinoctial Points,* which survives only in part in the *Almagest*, Hipparchus described the positions of the tropical year as moving backwards relative to all of the fixed stars (Toomer 1984:321–322).

The tropical year is actually far less stable than the sidereal year in that the variable speed of the Earth in its elliptical orbit around the sun will result in slightly different lengths of the year based on what time of year the measurement is taken and how close or how far the Earth is to the perihelion. In addition, the measurement of the tropical year can differ significantly from year to year, and the length of the tropical year is progressively getting shorter through the centuries due to the increasing rate of axial precession. We currently take an average measurement of the tropical year as derived from the points of the two solstices and two equinoxes over multiple years as the *mean tropical year* of 365.24219 days in the epoch J2000 (Meeus and Savoie 1992:42).

Because the length of the mean tropical year is just under one quarter of a day longer than 365 current Earth days, we insert an intercalary leap day approximately every four years, which alone would provide for a year of 365.25 days. This is essentially the Julian Calendar Year, first officially instituted in 46 BC by Julius Caesar to keep pace with the tropical year, though this quarter-day addition was certainly known about much earlier (Samuel 1972:155). By 1582, the Julian calendar had fallen out of step with the tropical year by 10 days, requiring the removal of these days with the Gregorian Calendar reform, instituted by Pope Gregory XIII. The Gregorian year of 365.2425 days more closely approximates the mean tropical year by adding a leap year of 366 days every four years, except in years divisible by 100 unless they are also divisible by 400 (Doggett 2006:583).

While their observations were apparently based on the sidereal year, the Egyptians similarly noticed the quarter-day shortfall of their 365-day Civil Calendar when compared with the heliacal rising of Sirius, which was continuously recorded and used to predict the annual flooding of the Nile. Curiously, this Sothic Year, or the interval between heliacal risings of Sirius, happened to remain very nearly 365.25 days during most of Egyptian history, due to the way in which stars far south of the ecliptic appear to behave slightly differently than those nearer to the ecliptic, which more closely follow the slightly longer sidereal year (Clagett 1995:132).

The New Year in the Egyptian Civil Calendar fell on the first day of the month of Thoth, but this only aligned with the heliacal rise of Sothis every 1,461 cycles of 365 days, which were equivalent to 1,460 Sothic Years of 365.25 days. In his work *De Die Natalie* from 238 AD, the Roman scholar Censorinus records various names of this 1,460-year cycle as the *Annus Magnus*—the 'Great Year', the *Kunikon* or *Canicular* 'Year of the Dog Star/Sirius', the Heliakos 'Heliacal Year', and *Anno Deus* 'The Year of God'. Censorinus recorded the rare commemoration of the Great Year when the first day of Thoth in the Egyptian Civil Calendar returned to the heliacal rising of Sothis on 20 July, 139 AD (Clagett 1995:5, 333-35).

The Maya Measurement of the Year

Like the Egyptians, the Maya and their counterparts in Mesoamerica employed a similar 365-day 'vague year', which also drifted from its seasonal position without any intercalary addition of leap year days that interrupted its rotation. As among the Egyptians, Mesoamerican observers were certainly aware of the relatively rapid drift of their 365-day cycle from the actual tropical year, given the importance of timing agricultural planting with the seasonal rains. So-called "E-Group" monuments[2] and multiple

[2] Alignments to solstice and equinox positions are relatively rare in Maya architecture. While Late Preclassic "E-Group" monuments are common, few of them actually align to the solstices, and many align to the quarter-days at the midpoint between the solstices (23 March and 21 September) rather than to the true equinoxes (Aveni, Dowd, and Vining 2003; Aveni and Hartung 1989; Šprajc 2001). The earliest known examples of E-Group architectural assemblages have recently been identified in the Maya Lowlands at the sites of Aguada Fénix and Ceibal, dating to approximately 1000 BC (Inomata et al. 2020; Inomata et al. 2013), suggesting that solar measurements were an

architectural alignments throughout Mesoamerica commemorate specific positions of the sun on the horizon at significant times of the year, particularly using an idealized agricultural year that extends from February to November.[3] The attested Yucatec name for this 365-day cycle, *ha'ab* is derived from *ha'* 'water' and the seasonal 'rains' (Thompson 1950:122; Brown 1987), so this repeating cycle was ritually useful for agricultural purposes, despite the way in which it drifted from a fixed seasonal position.

The question of whether the Maya recorded the slippage of their 365-day Haab against the tropical year has been explored in some detail, though less attention has been given to whether the Maya were capable of noticing or recording the slippage of the Haab against the sidereal year, or whether the Maya observed or even understood the difference between the sidereal and tropical years. Maya farmers in both the Lowlands and the Highlands are known to use the disappearance and heliacal reappearance of the Pleiades to time the planting of maize in late April and early May, and this is likewise coordinated with the first solar zenith passage, thereby relating current events in both the sidereal and tropical year.[4] But did their predecessors make note of their observations of these cycles through the centuries of their recorded history?

Observers in the Mesoamerican tropics have the added advantage of experiencing two zenith passages of the sun. The northward and southward zenith passages continue to provide Mesoamericans with a useful way to predict the seasonal rains that follow the solar zeniths through the movement of the inter-tropical convergence zone, and these observations may have enabled Mesoamerican astronomers a precise means by which to calculate the length of the tropical year.[5]

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important component in the formation of Mesoamerican calendars prior to the earliest written calendrical records from several hundred years later in Oaxaca (Marcus 1992:41; Milbrath 2017:88, 93).

[3] The Teotihuacan alignments of 15º 28' north of west and 16º 26' south of east are part of a pattern of similar orientations found in archaeological sites throughout Mesoamerica known as the 17º family of orientations (Aveni 1991:269; Aveni and Gibbs 1976:510; Šprajc 2000:404; 2001). Taken together, these repeated alignments appear to commemorate four significant moments in an idealized maize cultivation cycle. Based on the work of Stanislaw Iwaniszewski (1991; 1993) and Johanna Broda (1993), Šprajc proposes that these four dates correspond with a canonical agricultural cycle, beginning with the preparation of the milpa in February, the onset of the rainy season in early May, the ripening of the first maize in mid-August (at lower latitudes), and the end of the rainy season and the beginning of the harvest in early November (Šprajc 2000; 2001). Furthermore, Šprajc notes that the specific Teotihuacan dates of 13 August, 1 November, 9 February, and 30 April are separated by multiples of the known Mesoamerican period of 20 days (Šprajc 2000:408).

[4] Milbrath (1999:38) reviews the ethnographic evidence compiled by several scholars concerning observations of the Pleiades to coordinate the planting season: Thompson (1974:93) notes that the contemporary Lacandón prepare their milpas by burning them when the Pleiades are first visible at the level of the treetops at dawn; Girard (1948:453; 1962:78) observes that the Ch'orti' use the heliacal setting of the Pleiades to predict the April 30/May 1 solar zenith as a herald of planting season; among the K'iche', Dennis Tedlock (1985:343) describes how the disappearance of the Pleiades in conjunction with the sun in May is used to time the planting of low-altitude maize; and Barbara Tedlock (1982:189) notes that this is timed to coincide with the first solar zenith and the beginning of the rainy season.

[5] The importance of the solar zenith passage in Mesoamerica and its relationship to the 260-day calendar and the calculation of the tropical year were first proposed by Zelia Nuttall (1928), Ola Apenes (1936), and Rafael Girard (1948). Robert Merrill (1945) and Vincent Malmström (1973; 1978; 1997) independently proposed that the zenith passage at 14.8° N latitude corresponds to the Era base in the Long Count, using the 584285 GMT correlation, which places this date on 13 August, 3114 BC (Gregorian proleptic) where the two zenith passages are 260 days

In addition to their using an uncorrected 365-day cycle, Mesoamericans recorded dates using the 260-day cycle, conventionally known as the Tzolk'in when describing the Maya use of the cycle.[6] However, the Maya additionally used the Long Count, which served as a continuous count of individual days from a back-calculated, mythological Era base date on 13.0.0.0.0, 4 Ajaw 8 Kumk'u, several thousand years prior to the Classic Period and long before the historical development of state societies or writing in Mesoamerica. As an exact count of days from a remote era base, the Long Count closely resembles the Julian Day Number system devised by Joseph Scaliger in 1583, which is useful for precise astronomical calculations in that it does not rely on the fallibility of calendars that have been corrected through the centuries (Moyer 1981).

The earliest confirmed usage of the Long Count dates to 7.16.6.16.18 from the Late Preclassic Tres Zapotes Stela C (Coe 1996:76), and the latest uncorrected date appears in the Postclassic Dresden Codex Lunar Table as 10.19.6.1.8. Given the remarkable usage of the Long Count for over a thousand years, it becomes increasingly more likely that the Maya recorded measurements of the year using multiples of whole days, thereby enabling them to calculate and predict solar positions in the remote mythological past using deep time calculations, perhaps including the Era base itself. Might we then expect to find a Great Year among the Maya that describes one full cycle of the 365-day Haab through the tropical year and/or the sidereal year, analogous to the Egyptian *Annus Magnus*? This is precisely what this paper will address in a specific record from the Tablet of the Cross in Palenque.

The Astronomical Approach

Eric Thompson (1927:12) originally suggested that the creators of the Long Count utilized the equation of 1,507 tropical years with 1,508 x 365 days, giving a tropical year value equivalent to the current mean measurement of 365.2422 days.[7] However, Thompson later retracted his proposal, stating that he was "crediting the Maya with too great accuracy for such an early period in their history" (1932:370-371). Nevertheless, in the same publication he cited a later, deep-time example from the Palenque Tablet of the Foliated Cross that demonstrates a possible use of precisely half of this cycle as 754 x 365 days between the Era base and what we now know to be the year of the birth of the Palenque Triad (Thompson 1932:402).

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apart. Measurements of the zenith passage in Mesoamerica are discussed by Franz Tichy (1981), Anthony Aveni and Horst Hartung (1981), Clemency Coggins (1982), and Johanna Broda (2000; 2006). So-called zenith-sighting tubes have been identified outside the Maya area in Teotihuacan, Monte Albán, and Xochicalco, though these often allow in light for multiple days in addition to the zenith, some fixing a period of 260 days. Šprajc (2018) concludes that the local zenith passages were not commonly commemorated on the horizon, and that they may not have been as important as the predominant Teotihuacan family of alignments that fix these canonical intervals of 260 days, one of which is 13 August (see note 3).

[6] *Tzolk'in* is a Yucatec neologism meaning 'the counting in order of the days' first suggested by William Gates in 1921 (Thompson 1950:97). The original name of this cycle among the Classic Maya is unknown.

[7] In his foundational paper on the Maya calendar correlation, Thompson (1927:12) first proposes that the originators of the Long Count derived the Era base date through the equation where 3,016 Haabs of 365 days are equivalent to 3,014 tropical years; this can be reduced to 1,508 Haabs = 1,507 tropical years, or 29 Calendar Rounds of 52 Haabs each, also noted in Teeple (1931:38–40), though Teeple did not provide evidence that the Maya were specifically aware of this interval.

John Teeple (1931:70-4) first proposed that the Maya utilized what he called 'determinant' dates, which reconciled the drift of the 365-day Haab with the tropical year when compared with the original astronomical position of the Haab on the Era base. Analyzing dates on Copan Stela A, Teeple concluded that the Copan astronomers had calculated a tropical year using the equation 1,403,990 days = 3,844 years. If taken as a whole multiple, this yields a tropical year of 365.2419355 days, slightly more accurate than the Gregorian year of 365.2425 days. I have since identified additional, productive examples of the use of Teeple's Copan tropical year elsewhere (Grofe 2007:74–85; 2011b:60).

Both Teeple and Thompson enthusiastically explored many other possible determinants throughout the inscriptions. However, they were operating prior to any understanding of the historical content of the hieroglyphic script. In their view, nearly *all* of the texts on the monuments were concerned with time and astronomy, and they considered a great many recorded dates as potentially involved in determinant calculations. When it was later realized that, in fact, *most* of the dates cited in the monumental inscriptions are actually historical records of events in the lives of dynastic rulers, the foundations of determinant theory were criticized and largely abandoned (Aveni 2001:165). Nevertheless, the question remains whether some Maya historical dates could have been timed to coincide with significant positions of the tropical year and the calendar, and this becomes a more likely possibility when we consider the multiple, intentionally back-calculated deep-time intervals recorded in Maya inscriptions. Given our current understanding of the script, a reevaluation of determinant theory is warranted, as I will be exploring in a future publication.

Hans Ludendorff (1933)[8] originally proposed that Maya dates recorded multiple astronomical events, including the sidereal and synodic positions of the visible planets. Ludendorff used the earlier correlation between the Maya and Christian calendars proposed by Herbert Spinden (1924), as well as many inaccurate dates, and Thompson (1935:83–89) demonstrated that most if not all of Ludendorff's astronomical conclusions about intentional recordings of planetary cycles were due to chance, particularly in that many of these dates rely on the Spinden correlation that places all Maya dates five Calendar Rounds prior to the Goodman-Martinez-Thompson (GMT) correlation that Thompson promoted and used.[9]

In addition to his planetary proposals, Ludendorff (1935; 1938) also was the *first* to propose that the Maya recorded calculations of whole multiples of the sidereal year between associated dates within the Palenque inscriptions, as well as recording multiples of the tropical year, and these observations do not rely on any specific correlation. To my knowledge, Thompson did not critique these later proposals. Indeed, Thompson himself was broadly applying Teeple's determinant theory to Maya dates to derive calculations of the tropical year, yet he otherwise discounted Ludendorff's astronomical conclusions for some of the very same reasons for which determinant theory was later criticized.

In a statistical analysis of 29 dates taken from the Cross Group in Palenque, G. Rosenfeldt (1982) further

[8] I am extremely grateful to Carlos Barrera Atuesta for introducing me to the works of Ludendorff (1935, 1938) and Rosenfeldt (1982). Without knowing them, I was unaware that I was recreating the sidereal wheel.

[9] Spinden's correlation equates the Era base 4 Ajaw 8 Kumk'u with JDN 489384, while the GMT family of correlations equates the Era base with JDN 584280 to 584285, five Calendar Rounds later. Thompson (1927) originally supported the 584285 correlation, placing the Era base on 13 August 3114 BC in the Gregorian proleptic Calendar (8 September, 3114 BC Julian). Thompson (1974:85) later settled on the modified-Thompson correlation of JDN 584283, which equates with the Highland Maya and Central Mexican 260-day counts.

demonstrated how Ludendorff's original astronomical proposal about the sidereal year could simply be due to random chance. In his correlation-free analysis, Rosenfeldt (1982:50-52) finds that five pairs of dates from the Cross Group provide multiples of the sidereal year within a tolerance of ± 1.25 days, but he concludes that such a result could be statistically expected in any random sample. However, it should be noted that 7 out of the 29 dates Rosenfeldt selects are incorrectly derived from earlier misinterpretations, and he leaves out 12 important additional dates from the Cross Group texts that have since been corroborated, comprising several other sidereal parallel dates that I have identified, including those that are the primary focus of this investigation.[10] I will be providing an updated analysis of the sidereal parallels in Palenque in a follow-up to this article that incorporates a more analytical approach to deep time intervals that differs from Rosenfeldt's approach, which treats historical and contrived, mythological dates equally.

In my previous work, I identified multiple sidereal parallel dates throughout the inscriptions, and I proposed that the Maya were capable of measuring and calculating both the sidereal year and the tropical year in their deep time intervals (Grofe 2007; 2011a; 2011b). In particular, I proposed that both measurements would have likely utilized the 365-day Haab by adding a corrective number of days to this cycle in order to predict positions in both the sidereal and tropical years. Likewise, I established a methodology that attempts to target intentionally back-calculated dates by prioritizing the analysis of direct distance numbers and non-period ending dates within the same texts, and intervals that otherwise cannot be explained through whole multiples of non-astronomical cycles (Grofe 2011b:58).

Unaware of the earlier work of Ludendorff, I began by analyzing some otherwise unexplained longer intervals of many thousands of years from the Serpent Series in the Dresden Codex, and I was able to find evidence for the repeated usage of constant values of a sidereal year of 365.25651 days in the preface to the Serpent Series, beginning with an interval of 5,482,135 days as 15,009 sidereal years, as well as a longer interval of 1,2438,810 days as 34,055 sidereal years in Serpent 3a (Grofe 2007:75, 213). In addition, I identified the repeated use of the Copan tropical year that Teeple derived of 365.2419355 days (Grofe 2007:74-85; 2011b:60).

I have since found it to be more productive to look for shorter, secure intervals on the order of hundreds of years that represent whole multiples of the sidereal year, and thus to attempt to determine and test constant values for both the sidereal year and the tropical year that could be used within longer distance numbers at specific sites. One such interval of 304,623 days from Naranjo Altar 1 demonstrates a close whole multiple of the sidereal year in a directly stated distance number of 2.2.6.3.3 between the dates 9.4.10.8.17 and 7.2.4.5.14 (Grofe 2011a:24-27). This represents 834 revolutions of the current sidereal year, within -0.8 day. Using these types of "shorter" intervals, I had some success demonstrating the repeated usage of a sidereal year of 365.25556 days in Palenque, Naranjo, and

[10] As part of my dissertation research in 2006, I first analyzed all of the Palenque dates from the Cross Group and determined sidereal year and tropical year parallels using the Maya Hieroglyphic Database and dates derived by David Stuart (2006) in the *Sourcebook for the 30th Maya Meetings at the University of Texas, Austin*. Unaware of the work of either Ludendorff or Rosenfeldt at that time, I compiled extensive notes of all of the sidereal parallel dates I found, including the 5 pairs identified by Rosenfeldt, adding 3 more. Several others have since been determined by Kinsman (2016), who also independently reproduced 2 of Rosenfeldt's pairs, and 2 that I had found, including the pair that is the focus of this paper. I included some of my analysis in a later unpublished manuscript (Grofe 2008), but I felt that more evidence was needed to corroborate the Maya understanding of the sidereal year, which led me to exclusively study the Serpent Series for my dissertation (Grofe 2007).

Copan, which could be calculated by adding 23 days to an interval of 90 Haabs of 365 days, giving a sidereal year of 365.25556 days (Grofe 2011b:85).

Following the proposals of Robert Haliburton (1920) and Carlos Trenary (1987-88), Hutch Kinsman (2014; 2015; 2016; 2017a; 2017b) has sought to identify whether the Maya recorded and predicted meteor outbursts by systematically plotting the solar longitudes of multiple Maya dates. In so doing, he has identified many sidereal pairs, and he has arrived at identifying Maya calculations of the sidereal year through asking different questions, which have nevertheless produced similar results. Significantly, he has found that many Maya sidereal intervals throughout the inscriptions appear to be multiples of 39 years, which suggested to him a possible corrective equation to derive the sidereal year by adding 10 days to 39 Haabs of 365 days to give the following equation (Kinsman 2017a):

39 x 365 days + 10 days = 14,245 days = 39 sidereal years of 365.2564103 days

I would like to acknowledge Kinsman for this interval, as I have found it to be highly productive and consistent in analyzing multiple deep time intervals in the inscriptions at several sites. Significantly, Barrera (2015:45) also derived this same sidereal year value, albeit through different means.

The Tablet of the Cross in Palenque: Contrived Numbers

The Initial Series date from the west panel of the Temple of the Cross Sanctuary Text in Palenque reads as a Long Count date just 6.14.0, or 2,440 days before the beginning of the current era on 4 Ajaw 8 Kumk'u, given as 12.19.13.4.0, 8 Ajaw 18 Sek (**Fig. 1:A1-B9**). The event associated with this Long Count position is the birth of what Floyd Lounsbury believed to be an ancestral goddess of the Palenque royal line, and the mother of the Palenque Triad (Lounsbury 1976:218; 1978:807). More recently, David Stuart refers to this deity as the Triad Progenitor, or Muwan Mat, in part, and he proposes that this deity is not female, but rather an aspect of the Classic Maize God (Stuart 2005:180-183).

Following similarly constructed Ring Numbers from the Postclassic Dresden Codex, Lounsbury (1978: 806) noticed that the birth date of Muwan Mat is most likely associated with the birth date of the late Classic Palenque ruler Janahb Pakal, well known as the father of Kan Bahlam II who commissioned the construction of the Cross Group. Lounsbury found that this interval is not only a whole multiple of the 260-day Tzolk'in, but also a multiple of the cycle of 9 days, the computing year of 364 days, the Mars synodic cycle of 780 days, the 819-day cycle, and the 1,820-day cycle, all of which are factors in the lowest common multiple of 16,380 days, or 20 x 819 days. He concluded that this immense interval must be a **contrived number**, and that it serves to relate Pakal to this ancestral deity, thereby legitimizing Pakal through "a calendrical and numerological charter" (Lounsbury 1978: 807).

Setting aside arguments for the rationale for the birth of Muwan Mat, the mythological text describes various dates involving the first born of the Palenque Triad deities, dubbed "God One" or "GI" (Berlin 1963). The text then counts forward by a large distance number given as 2.1.7.11.2 (**Fig. 1:E5–F6**). Hans Ludendorff (1935:7; 1938:32), Heinrich Berlin (1965:330–331), and Linda Schele and Mary Miller (1986:59) concluded that this distance number counts from the 819-day count station at the beginning of the text. This is given as 1 Ajaw 18 Sotz' (**Fig.1:A16–B16**), precisely 20 days prior to the birth of Muwan Mat, which is stated at the bottom of the first two columns (**Fig. 1:A17-B17**), immediately following the Calendar Round date for the 819-day count. This distance number of 2.1.7.11.2 leads to the implied date 2.1.0.14.2, 9 Ik' 0 Yax:

12.19.13.03.00	**1 Ajaw 18 Sotz'**	**819-day count position**
+2.01.07.11.02	**(Distance Number)**	
2.01.00.14.02	**9 Ik' 0 Yax [implied]**	

The text references the accession date of Muwan Mat, given as 9 Ik' 0 Sak (**Fig. 1:E9-F9**), which has been subsequently confirmed in the text from Temple XIX as 2.0.0.10.2, 9 Ik' 0 Sak (Stuart 2005:81-86). However, Berlin noted that that the implied date 2.1.0.14.2, 9 Ik' 0 Yax is subsequently used as a base from which the next distance number of 3.6.10.12.2 (**Fig. 1:E10–F11**) then counts forward to the birth of the legendary ruler U Kokan Chan at the end of the west panel. Though the Calendar Round of his birth date is suppressed, it is directly implied as it is followed by yet another distance number of 1.6.7.13 (**Fig. 1:F15–F16**) at the end of the text on the west panel, which correctly counts to the accession date of U Kokan Chan as 11 Kaban 0 Pop, given at the very beginning of the text on the east panel (**Fig. 2:H2–G3**):

2.01.00.14.02	**9 Ik' 0 Yax [implied]**	
+ 3.06.10.12.02	**(Distance Number)**	
5.07.11.08.04	**1 K'an 2 Kumk'u**	**U Kokan Chan birth [implied]**
+ 1.06.07.13	**(Distance Number)**	
5.08.17.15.17	**11 Kaban 0 Pop**	**U Kokan Chan accession**

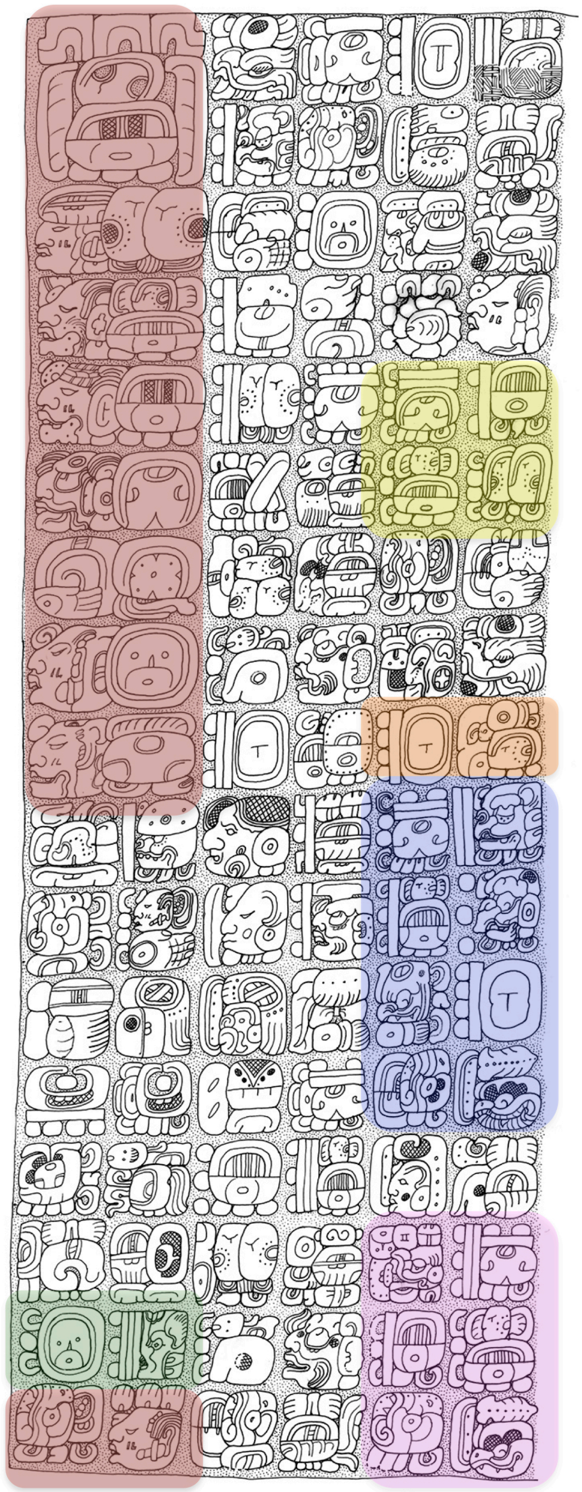

Fig. 1. West Tablet of the Cross, Palenque.
Drawing by Linda Schele © David Schele.
Photo courtesy Ancient Americas at LACMA.
(ancientamericas.org)

A1-B9: Initial Series
12.19.13.4.0, 8 Ajaw 18 Sek

A16-B16: 819-day count
12.19.13.3.0, 1 Ajaw 18 Sotz'

A17-B17: Birth of Muwan Mat

E5-F6: Distance Number
2.1.7.11.2 from 819-day count to
[2.1.0.14.2, 9 Ik' 0 Yax]

E9-F9: Accession of Muwan Mat
[2.0.0.10.2] 9 Ik' 0 Sak

E10-F13: Distance Number
3.6.10.12.2 from 9 Ik 0 Yax to
birth of U Kokan Chan
[**5.7.11.8.4, 1 K'an 2 Kumk'u**]

F15-F17: Distance Number
1.6.7.13 from birth of U Kokan Chan
to his accession [**5.8.17.15.17**]
11 Kaban 0 Pop on east tablet (Fig.2)

Upon further analysis, we can see that the implied date of 2.1.0.14.2, 9 Ik’ 0 Yax is just 1 day in excess of a whole multiple of the current measurement of the mean tropical year when reckoned from the Era base:

2.1.0.14.2 = 295,482 days = 809 (365.24219 days) + 1.07 d[11]

This reference to 0 Yax similarly evokes an intentional calculation as a convenient marker for the Haab half-year. Victoria Bricker and Anthony Aveni (2014:13–16) note that the Haab position of 0 Yax is commonly referenced together with 0 Pop as a means to track the movement of the tropical year within the Dresden Codex Seasonal Table. Therefore, it remains quite possible that this implied date of 2.1.0.14.2, 9 Ik’ 0 Yax was utilized as a stepping stone within this larger calculation, and that it was intentionally positioned within the text of the Tablet of the Cross, reckoning the tropical year with the Haab, which becomes apparent in the subsequent calculations.

U Kokan Chan and K’uk’ Bahlam I: The Maya Great Year

The Tablet of the Cross effectively and visibly divides mythological and historical time, placing mythological dates in the left panel, while the right panel contains a continuous count of kings in historical time. Yet it is the legendary figure of U Kokan Chan that ties together the two panels through the reference to his birth at the end of the left panel and his accession on 0 Pop, which begins the text on the right panel. The appearance of this 0 Pop Haab New Year in a back-calculated date of the mythological accession of U Kokan Chan is certainly notable, and it raises the question of whether this date contains an intentionally contrived calculation of the year. When comparing the mythological dates for the birth and accession of U Kokan Chan with the subsequent historical dates for the birth and accession of K’uk’ Bahlam I, such an intentional calculation becomes immediately apparent.

Following the reference to the 0 Pop accession of U Kokan Chan, K’uk’ Bahlam’s birth is given as [8.18.0.13.6] 5 Kimi 14 K’ayab (**Fig. 2: G4–H4**), and this is corroborated by the historical chronology found in the right panel. This birth date is immediately followed by K’uk’ Bahlam’s accession, given as [8.19.15.3.4] 1 K’an 2 K’ayab (**Fig.2:H8–G9**), though there is another distance number here between the birth and accession dates, which I will return to discuss.

The dates are as follows, given with their tropical year equivalents in Gregorian proleptic and Julian proleptic calendars, using the 584285 GMT[12] calendar correlation for reference. Note that this **tropical**

[11] Hans Ludendorff (1935:12) was the first to notice the tropical year correspondence between this 2.1.0.14.2, 9 Ik’ 0 Yax date and the Era base. I reproduced this finding independently, only later realizing that Ludendorff had preceded me by many decades.

[12] I prefer to use the 584285 GMT correlation together with the 584286 Martin/Skidmore correlation (Martin and Skidmore 2012), which relies on the single solar eclipse record from Santa Elena Poco Uinic Stela 1. Given that we do not know when the Maya day began, and that the Tzolk’in is occasionally given out of synch with the Haab, I contend that it is quite likely that these cycles had different starting positions in the day, and that the Era may have begun at 6pm Central Time, JDN 584285.5 and extended until JDN 584286.5. While specific arguments for one correlation over another are important, we can solidly rely on stated intervals that are correlation free.

year parallel persists in a correlation-free environment (the green color-coded highlighting notes the tropical year parallel):

5.07.11.08.04	**1 K'an 2 Kumk'u, U Kokan Chan birth**	**11 March, 993 BC (20 March J)**
+ 1.06.07.13	**(Distance Number)**	
5.08.17.15.17	**11 Kaban 0 Pop, U Kokan Chan accession**	**28 March, 967 BC (6 April J)**
8.18.00.13.06,	**5 Kimi 14 K'ayab, K'uk' Bahlam I birth**	**31 March, 397 AD (30 March J)**
+ 1.14.09.18	**(Distance Number *required*)**	
8.19.15.03.04,	**1 K'an 2 K'ayab, K'uk' Bahlam I accession**	**11 March, 431 AD (10 March J)**

What is remarkable is that the birth date of U Kokan Chan and the accession date of K'uk' Bahlam I occur on the same date in the tropical year. Both Carlos Barrera Atuesta (2015:17-20) and I independently determined this equivalence,[13] and we note that these two dates both occur on a day 1 K'an, in that they are separated by precisely 1,999 Tzolk'ins, which is a highly accurate calculation of 1,423 tropical years, yielding the following equation:

[13] In 2006 when preparing my dissertation proposal on sidereal parallel dates in the Palenque inscriptions, I first noticed the tropical year equivalence of the birth of U Kokan Chan and the accession of K'uk' Bahlam, as well as the sidereal equivalence of the births of both. Following my participation in the annual Maya Meeting at the University of Texas at Austin in 2006, I noted these patterns of the tropical and sidereal years in my notebook, among several other sidereal and tropical year intervals. Later examining the use of 0 Pop dates in calculations of the year, I wrote in an email to Barb MacLeod, dated 13 August, 2016, that, in addition to the interval between the births of Uk'ix Chan (U Kokan Chan) and K'uk' Bahlam I being a whole multiple of the sidereal year, the interval between the birth of U Kokan Chan and the accession of K'uk' Bahlam I is also 1,999 Tzolk'ins, and that this is just 20 days short of 1,424 Haabs and 1,423 sidereal years, thereby returning the Haab to the same sidereal position of the sun. A year later, in a group email to Carlos Barrera Atuesta, Barb MacLeod, Hutch Kinsman, Carl Callaway, and Mark Van Stone, dated to 2 October, 2017, I was surprised, frustrated, and delighted to find that Barrera (2015) had already identified the same Tzolk'in and Haab pattern that I had found in a self-published paper dated to 9 January, 2015, in which he kindly cites inspiration from my prior work on the sidereal year (Barrera 2015:36). Barrera (2012; 2016; 2019) has been studying the sidereal and tropical years in previous papers. In addition, in a table published in October of 2016, Hutch Kinsman (2016) plotted the solar longitudes of multiple pairs of dates in Palenque, likewise independently determining the sidereal year equivalence between the birth of U Kokan Chan and the birth of K'uk' Bahlam I, among several others. This convergence of independent, intersubjective analyses further serves to underscore the validity and significance of these findings from separate researchers analyzing the same dates, albeit making claims of being the first to realize these findings more problematic! While I had been analyzing patterns of sidereal and tropical year parallel dates prior to my dissertation in 2007, I humbly concede that Barrera was the first to articulate these potential equations in 2015 prior to my deriving them a year later. Barrera (2015:17) notes that he first identified the 1,999 Tzolk'in tropical year equivalence from this inscription in 2011, which I had known about and apparently overlooked, but I was unaware of his 2015 work on the equivalence of 1,424 Haabs as a whole multiple of sidereal years. I especially feel that this important finding needs to be acknowledged, validated, and highlighted in combination with the sidereal year interval between the birth dates that I and Kinsman independently identified.

8.19.15.03.04, 1 K'an 2 K'ayab, K'uk' Bahlam I accession 11 March, 431 AD (10 March J)

- 5.07.11.08.04 1 K'an 2 Kumk'u, U Kokan Chan birth 11 March, 993 BC (20 March J)

3.12.03.13.00 = 519,740 days = 1,999 (260 days) = 1,423 (365.2424455 days)

While recognizing that the length of the mean tropical year in the past would have been slightly longer, this is still a highly accurate equivalence in terms of either the current and past mean tropical year:

519,740 days = 1,999 (260 days) = 1,423 (365.24219 days) + 0.36 d

Furthermore, as Barrera (2015: 17-20) and I additionally determined, the Haab dates of K'uk' Bahlam's accession on 2 K'ayab and U Kokan Chan's birth on 2 Kumk'u are separated by 20 days, and it also becomes apparent that this interval of 1,423 tropical years is just 20 days short of exactly 1,424 Haabs, which happens to be precisely 1,423 sidereal years, effectively returning the *entire* Haab to the same position of the sun relative to the stars for the first time, and providing an effective equation:

519,740 days = 1,999 (260 days) = 1,423 tropical years

+ 20 days

519,760 days = 1,424 Haabs = 1,423 sidereal years of 365.2565004 days

The Haab makes *one complete revolution* through the sidereal year and first returns to the same sidereal position in 1,424 Haabs, strongly suggesting an intentionally contrived interval between the birth of U Kokan Chan and the accession of K'uk Bahlam I that uses the drift of the Haab against both the tropical year and the sidereal year. This would then appear to be analogous to the Egyptian *Annus Magnus* as a **Maya Great Year**, albeit as a far more accurate measurement of the actual sidereal year that also incorporates a highly accurate measurement of the tropical year. While the Egyptian Great year follows the more southerly heliacal rise of Sothis, which regularly rose every 365.25 days throughout much of Egyptian history, the Maya Great Year more closely tracks the actual sidereal year.

While this latter equivalence between 1,424 Haabs and 1,423 sidereal years is not explicitly stated in the text, I discovered that the interval between the birth of U Kokan Chan and the birth of K'uk' Bahlam I is also a near whole multiple of 1,389 sidereal years, placing the sun in the same position relative to the stars and thereby indicating a potentially intentional **sidereal parallel** date, and a highly accurate understanding of the sidereal year (the purple color-coded highlighting notes the sidereal year parallel):

8.18.00.13.06,	**5 Kimi 14 K'ayab, K'uk' Bahlam I birth**	**31 March, 397 AD (30 March J)**
-5.07.11.08.04	**1 K'an 2 Kumk'u, U Kokan Chan birth**	**11 March, 993 BC (20 March J)**
3.10.09.05.02 =	**507,342 days = 1,389 sidereal years of 365.2570194 days**	

This can be expressed in terms of the current sidereal year of 365.25636 days, with an error of -0.92 day:

3.10.09.05.02 = 507,342 days = 1,389 x 365.25636 days – 0.92d

Hutch Kinsman (2016, 2017a, 2021) independently arrived at this same calculation amid several other sidereal intervals at Palenque.

While observers on Earth would not be able to see the sun directly against the background of fixed stars, except in the exceedingly rare instance of a total lunar eclipse, I find it helpful to *visualize* the physical sidereal position of the sun using reliable astronomy software when comparing sidereal parallel dates. However, I would like to emphasize that this is ***not*** how the Maya would have observed the sidereal year; they would have conceivably used heliacal star risings and settings, as well as oppositions, as are evident in the ethnographic record. Likewise, the constellations and celestial grid and the line of the ecliptic are drawn for our reference, and these are not to suggest that the Maya would have looked at or imagined these sidereal positions in the same way. While inputting dates requires using a specific calendar correlation, the sidereal parallel with an equivalent solar longitude persists regardless of what correlation is used. In this case, I provide the solar longitudes (equinox J2000) using the 584285.5 GMT correlation as a reference to establish the equivalent position of the Earth in space, relative to the sun.[14]

[14] I am grateful to Hutch Kinsman for directing me to NASA's JPL HORIZONS Web Interface to easily determine fixed J2000 solar longitudes for any given date (Giorgini 2021).

Fig. 2. East Tablet of the Cross, Palenque.
Drawing by Linda Schele © David Schele.
Photo courtesy Ancient Americas at LACMA.
(ancientamericas.org)

G1-H3: Accession of U Kokan Chan
5.8.17.15.17, 11 Kaban 0 Pop

G4-H5: Birth of K'uk' Bahlam I
8.18.0.13.6, 5 Kimi 14 K'ayab

G6-H6: Distance Number
1.2.5.14 from birth of K'uk' Bahlam I
to implied date:
[8.19.3.1.0, 5 Ajaw 18 K'ayab]

G7-H9:
Accession of K'uk' Bahlam I
8.19.15.3.4, 1 K'an 2 K'ayab

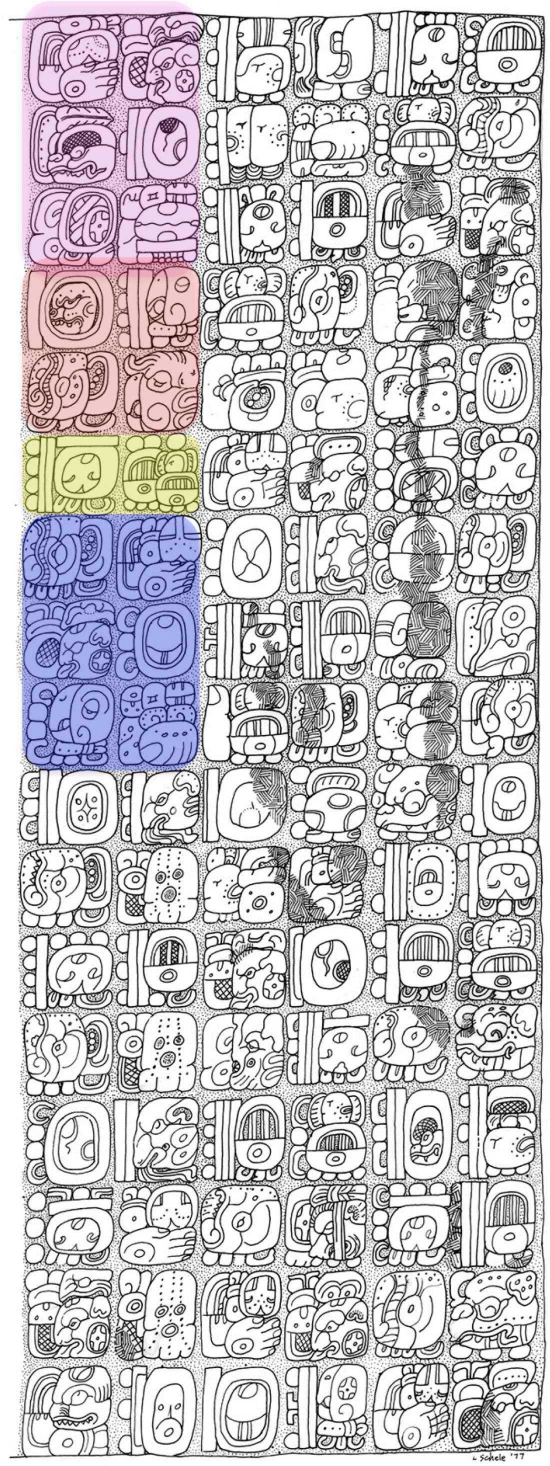

Figure 3 compares the sidereal position of the sun on (**a**) the birth of K'uk' Bahlam I on 31 March, 397 AD (30 March J), at a solar longitude of 32.2º - 33.2º; with (**b**) the birth of U Kokan Chan 1,398 sidereal years earlier on 11 March, 993 BC (20 March J), at a solar longitude of 31.5º - 32.5º, Note the shifting position of the Vernal Equinox. In both of these images, the sun can be seen in close conjunction with the faint star HIP9517.

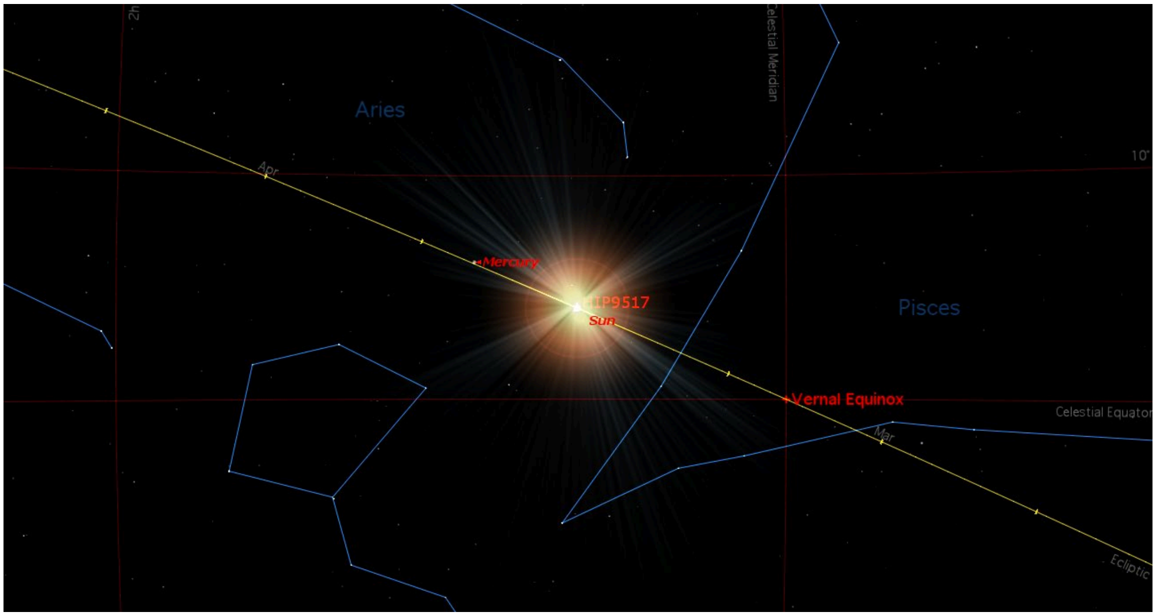

Fig. 3a. 8.18.00.13.06, 5 Kimi 14 K'ayab, K'uk' Bahlam I birth on 31 March, 397 AD (30 March J). Image by the author courtesy of Starry Night Pro Plus 6.4.3: Simulation Curriculum (2009).

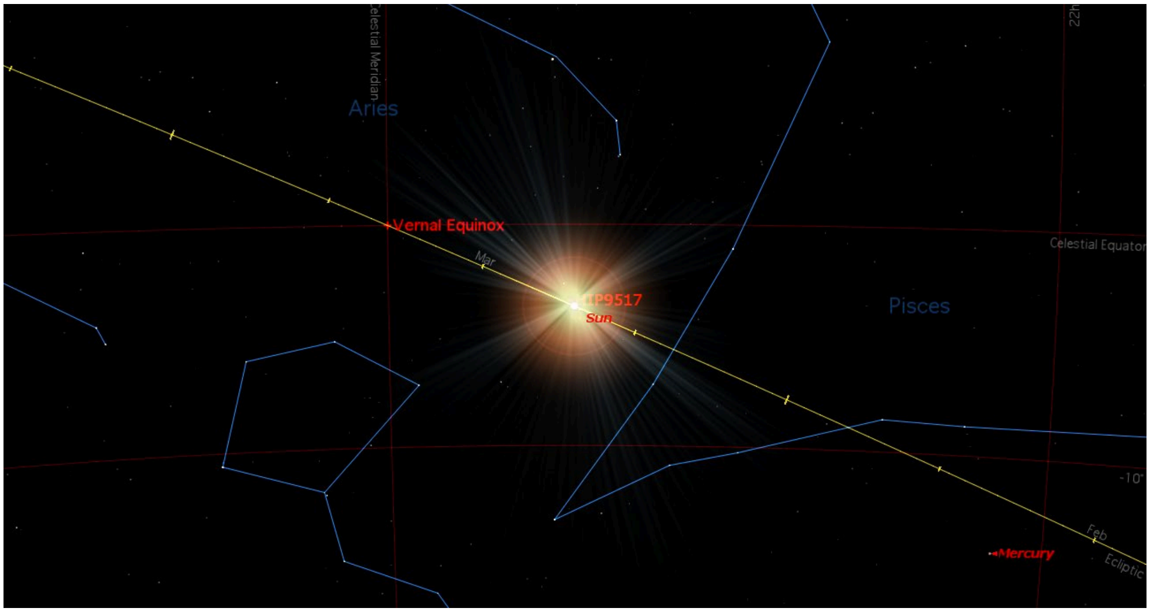

Fig. 3b. 5.07.11.08.04, 1 K'an 2 Kumk'u, U Kokan Chan birth on 11 March, 993 BC (20 March J). Image by the author courtesy of Starry Night Pro Plus 6.4.3: Simulation Curriculum (2009).

If Kan Bahlam II and the Maya astronomers who contrived these dates understood that the birth dates of K'uk' Bahlam I and the legendary U Kokan Chan were to be on the *same day* in the sidereal year, then they would also have easily understood that 20 days after the tropical year and Tzolk'in anniversary of U Kokan Chan's birth, the sun would return to the sidereal year position of both birth dates on the same *Haab* anniversary date, one full Maya Great Year after the mythologically contrived birth of U Kokan Chan.

What this strongly suggests is that the birth date of U Kokan Chan was specifically contrived to correspond with both the **sidereal year** position of K'uk' Bahlam I's birth as well as with the **tropical year** position of K'uk' Bahlam's accession. This is the single most direct statement that Maya astronomers quite accurately understood and recorded precise measurements of both the sidereal and tropical years.

Here are demonstrated not only Lounsbury's contrived cycles of 260 days and 365 days, but also the astonishing commensuration of the Tzolk'in with the tropical year 20 days prior to the commensuration of the Haab with the sidereal year in one Maya Great Year of 1,424 Haabs.

Given that the Tablet of the Cross is the only text to record the dates for K'uk' Bahlam I, it is likely that even these early historical dates were contrived by the author of the Cross Group text in order to circumscribe the interval of the Maya Great Year when taken together with the birth date of U Kokan Chan. The physical placement of these individuals in the east and west panels further supports this contrivance.

The astronomically motivated author of this contrived interval that connects the lineage of mythological rulers in the west panel with the earliest historical rulers in the east panel deftly and intentionally positioned the birth of U Kokan Chan on the same date in the tropical year and the same day in the Tzolk'in as the accession date of K'uk' Bahlam I, while also placing it in a year when the birth of U Kokan Chan would fall on the same date in the sidereal year as on K'uk' Bahlam I's birth. This necessitates that that the birth and accession dates of K'uk' Bahlam I be precisely 20 days apart in the year, given that this is the accumulated difference between the sidereal and tropical years after one complete Maya Great Year of 1,424 Haabs.

The Lyrid Meteor Shower

Through plotting solar longitudes using the 584286 Martin and Skidmore (2012) calendar correlation, Hutch Kinsman and David Asher (2017:7) originally tabulated the correspondence of various historical Maya events and accession dates with the Eta Aquariid meteor shower, noting that the accession date of U Kokan Chan corresponds with this event, and that U Kokan Chan is likely a mythological ruler. However, Kinsman (2017a; 2021) has additionally proposed that the *birth* dates of U Kokan Chan and K'uk' Bahlam I were intentionally positioned to coincide with the peak of the Lyrid meteor shower. While this correspondence provides a plausible and interesting rationale for this particular sidereal parallel, Kinsman proposes that U Kokan Chan may have been an actual historical king, and that his birth would therefore be the earliest recorded record of a Lyrid meteor shower outburst in 993 BC, predating a major outburst recorded in China in 687 BC (Kinsman 2021:7).

Kinsman has determined that the major planetary positions that influence Lyrid outbursts were in a similar position in 993 BC as they appeared during the 687 BC major outburst. However, to suggest that such a remote date was precisely recorded and tracked some 400 years prior to the earliest attested usage of the Mesoamerican Calendar Round, and over 800 years prior to the first evidence of the Long Count, stretches credulity.

Given the evidence presented for the Maya Great Year as the basis for the contrived interval counting between the birth of U Kokan Chan and the accession of K'uk' Bahlam I, I find it far more likely that an intentional sidereal parallel was back-calculated, rather than that this remote date was an historically recorded observation. One must also admit that having two *birth* dates fall on a sidereal parallel that is also on a meteor shower maximum must be a contrivance, even were these both historical people. While positive correspondences with meteor showers provide a tempting and observable rationale for calculating the sidereal year, the chances of finding false positives greatly increase with some 37 meteor showers occurring per year (Rendtel 2019). While I applaud the intriguing possibility that the Maya used the sidereal year to predict meteor outbursts, it is unlikely that the sidereal year was primarily or exclusively used to track and predict meteor showers alone. As Kinsman (2015:2016) himself demonstrates, many of the intentionally calculated sidereal year intervals in the inscriptions do not target meteor showers in the 584286 correlation, and several deep time mythological intervals parallel the historical accession dates of kings, only some of which fall on meteor shower dates. For example, Ludendorff (1938:12, 55) first identified a 3,803 sidereal year interval between the 819-day count date 12.19.13.3.0, 1 Ajaw 18 Sotz' on the Tablet of the Cross and what we now know to be the accession date of Kan Bahlam I on 9.12.11.12.10, 8 Ok 3 K'ayab, which both I and Kinsman (2016) later independently identified, but these dates do not correspond with any major meteor shower in the 584286 correlation.

Citing my prior work on Maya measurements of the sidereal year (Grofe 2011b:85), Kinsman (2014:119-120) first proposed that the Maya were tracking the 4330.89-day sidereal cycle of Jupiter in association with the solar sidereal year, and that they may have cleverly noticed that the position of Jupiter influences major meteor shower outbursts, since Jupiter gravitationally influences the dust trails of comets that cause meteor showers at specific positions in the sidereal year. Kinsman (2021:3) more recently cites Aveni (2001:87-88) for the proposal that the Maya could have noted the sidereal position of Jupiter as it returned to the same star in just over 4,330 days. Jupiter then returns to the same star and the same time of year after 7 of these sidereal cycles of Jupiter, equating to 30,316 days. Though Aveni does not mention the sidereal year, Kinsman (2021:3) insightfully points out that 30,316 days is just 0.27 of a day short of 83 solar *sidereal* years. Meteor showers aside, it is possible that the Maya were using the sidereal and synodic cycles of Jupiter to calculate the sidereal year, though this interval would require a correction over time. In fact, Ludendorff originally proposed that the Palenque astronomers were calculating the synodic and sidereal cycles of Jupiter together with the sidereal year, and he demonstrates that the 1,096,134-day interval in the Tablet of the Sun between the Initial Series 1.18.5.3.6 and the last date in the text, 9.10.10.0.0, is a whole multiple of 3,001 sidereal years, 2,748 synodic cycles of Jupiter, and 253 sidereal cycles of Jupiter of 4,332.55 days, very close to the astronomically correct measurement of 4,332.59 days (Ludendorff 1938:8-12, 55).

Regarding the mysterious distance number that follows the birth of K'uk' Bahlam I as 1.2.5.14 (**Fig. 2:G6–H6**), the correct distance number to his accession is 1.14.7.18. Kinsman (2021:7) adds this unusual number to the underlying but unstated distance number of 3.10.9.5.2 between the birth of U Kokan Chan and the birth of K'uk' Bahlam I to reach an interval of 3.11.11.10.16, or 515,376 days, which is both

1,411 sidereal years as well as approximately 119 sidereal cycles of Jupiter. This interval is just 4 days longer than 17 of Aveni's uncorrected intervals of 30,316 days, though it would be some 202 days short of a whole multiple of the actual sidereal cycle of Jupiter. Kinsman contends that these dates could have represented major outbursts of the Lyrids. If accurate, his observations concerning the interplay between the sidereal cycle of Jupiter and calculations of the sidereal year would not require there to have been a recorded major outburst of the Lyrids in 993 BC. Rather, I find it more compelling and plausible to suggest that Maya astronomers would have been capable of back-calculating a contrived sidereal interval of their Great Year of the Haab in order to target an estimated major outburst without necessitating it to have been recorded in such a remote time.

Conclusion: The Maya Great Year

The interval between the birth of the last mythological king U Kokan Chan at the end of the west panel of the Tablet of the Cross and the birth of the first historical king K'uk' Bahlam I at the beginning of the east tablet is a whole multiple of 1,389 sidereal years. Furthermore, the interval between the birth of U Kokan Chan and the accession of K'uk' Bahlam I is an interval of 1,423 tropical years, which commensurates with 1,999 Tzolk'ins. Taken together, these dates reflect an intentionally contrived birth date of U Kokan Chan that reflects an accurate understanding of both the sidereal and tropical years among Palenque astronomers. This is further supported by the placement of the accession date of K'uk' Bahlam I precisely 20 days prior to the return of the Haab to the same sidereal position as it was on the back-calculated birth date of U Kokan Chan, which represents one complete revolution of the 365-day Haab through the entire sidereal year to its original position. I am naming this 1,424-Haab cycle the Maya Great Year, analogous to the Egyptian heliacal *Annus Magnus*, which returned their 365-day Civil Calendar to the sidereal position of the heliacal rise of Sothis.

These specific and highly accurate intervals, located in the liminal period that precisely links historical Maya dates to the remote, mythological past, are the clearest and most direct example of the Maya measurement of the sidereal and tropical years. In keeping with Lounsbury's observations of contrived intervals, this text demonstrates that Maya astronomers were concerned with how the Tzolk'in and the Haab commensurated with actual astronomical cycles in a way that allowed them to predict and calculate positions of the sun in extraordinary ways. Understanding these intervals can thus help us to determine the intentional placement of many of the contrived, deep time intervals that Maya scribes meticulously recorded in Palenque and elsewhere in the Maya inscriptions. In a subsequent essay, I will be exploring some of these other deep time intervals, as well as the way in which the contrived 0 Pop New Year accession date for U Kokan Chan operates to track the slippage of the Haab from the sidereal year.

We need not adhere to the idea that all mythological dates should be understood to be intentional sidereal parallels. Instead, we should be willing to explore the significance of the other mythological dates which we cannot explain through direct sidereal parallels by acknowledging that the Maya understood *both* the sidereal year and tropical year positions of these contrived dates, which may yet unfold a rich tapestry of patterns that would otherwise be lost by looking at these cycles in isolation.

Why were Maya astronomers so interested in contriving such specific and ornate deep time intervals? This is certainly a question for further reflection. Bolstering and legitimizing royal lineages is one rationale, as Gerardo Aldana (2007) proposes, but who would know or care about such precise astronomical measurements that connect mythological events with the lives of contemporary and historical rulers? Surely the intricacies of the dates and events in the Cross Group texts were not for wide public consumption, and they served a more private purpose. But to incorporate such elaborately cryptic and accurate intervals demonstrates a virtuosity seemingly unparalleled in the world, and an appreciation of the sheer beauty of a rare inherited understanding of mathematical and astronomical order. Ludendorff writes:

> I do not believe that the Maya inscriptions would immediately reveal their astronomical meaning to someone who could read all hieroglyphs... Rather, the priest-astronomers may have had manuscripts in which the real meaning of the data recorded in the inscriptions was explained in detail. The inscriptions themselves were supposed to remain incomprehensible to the people and also to the educated layman, so that they were only viewed with shy awe. (Ludendorff 1938:58)

The importance of this text cannot be overstated. Despite his pessimism that the Maya records he analyzed did not statistically demonstrate that they understood and measured the sidereal year, Rosenfeldt reflects on why it would be historically important if we ever found such evidence. If we could find convincing data that demonstrate accurate astronomical measurements, he writes, “this would mean that even in classic times, Mayan astronomy had progressed beyond the descriptive level, as such an accuracy could not have been reached by direct observation alone.” (Rosenfeldt 1982:61-62)

The evidence presented in this paper supports that Maya astronomers had reached beyond mere observation and description of astronomical events to a predictive level that paralleled or exceeded that of their contemporaries in the West, and that is an important realization in the history of human scientific discovery.

Acknowledgments

I would like to first thank Barb MacLeod for insightful feedback reading and editing this paper, and for all of the years of encouragement, collaboration, and support. Barb and I first became friends when Matthew Looper told us that we had both independently come to the same conclusion about the 3-11 Pik interval that he had described in *Glyph Dwellers* in 2002. Additional thanks to Matthew Looper, David Mora-Marín, Yuriy Polyukhovych, Carol Karasik, Alonso Mendez, Ed Barnhart, and Martha Macri for their helpful feedback and comments on this paper. I would also like to thank Carlos Barrera Atuesta and Hutch Kinsman for their valuable contributions to the collaborative work of reconstructing Maya astronomical calculations, especially in taking seriously my work on the sidereal year. I am gratified knowing that we have all been on the same path coming to similar conclusions when looking at the same data, and I am thankful for our continued collaboration and exploration. May we continue to inspire one another, even in places where we may disagree. Thanks also to Carl Callaway and Mark Van Stone for their ongoing collaboration and support, and thanks always to Martha Macri and Matthew Looper for supporting my many years of work with the Maya Hieroglyphic Database that enabled me to gain access to the vast corpus of Maya inscriptions. For that I am eternally grateful. Lastly, a special thanks to David Schele and Ancient Americas at LACMA for permission to use Linda Schele’s beautiful drawings. Any unintended errors within this paper are my own.

Glossary of Terms

Annus Magnus:

the Latin name of the Egyptian 'Great Year' of 1,461 cycles of 365 days, returning the first day of the first month of Thoth in the 365-day civil calendar to the time of the heliacal rising of Sothis/Sirius

Annus Vagus:

the Egyptian 'Vague Year' or 'Wandering Year' of 365 days in the Egyptian Civil Calendar; the Annus Vagus continuously cycled with no added leap years

Contrived Number:

intervals of days that commensurate whole multiples of known cycles and thereby reveal that they have been designed to connect two dates (Lounsbury 1976)

E-Group:

Maya monuments that contain three alignments with a central viewing point that designate three rising points or azimuths on the horizon

Ecliptic:

the apparent path that the sun appears to take through the fixed stars as the Earth orbits the sun

Equinox J2000:

the sidereal position of the sun on the vernal (spring) equinox in the Epoch J2000, useful for establishing fixed solar longitudes for any year using degrees on the ecliptic calculated from this point as 0º

Era Base:

the base date of the Long Count on 13.0.0.0.0, 4 Ajaw 8 Kumk'u, with several correlations to the Gregorian and Julian Calendars, and to the Julian Day Number system; the GMT correlation of JDN 584285 equates the Era Base with 13 August, 3,114 BC (8 Sept. J)

Gregorian Calendar Year:

a fixed year of 365.2425 days that more closely approximates the mean tropical year of 365.24219 days; instituted by Pope Gregory XVIII on 4 October, 1582 in the Julian Calendar, which was followed by 15 October, 1582 AD in the Gregorian Calendar, since the Julian Calendar was 10 days out of phase with the seasons of the tropical year

Gregorian Proleptic Calendar:

a calendrical system used to determine seasonal positions in the past by back-calculating them using the Gregorian year of 365.2425 days prior to its actual first usage in 1582 AD; as with the Julian Calendar there is no year 0 in the Gregorian proleptic system; the Gregorian Proleptic Calendar differs from astronomical year numbering, in which years BC are given as negative numbers, offset by 1 less from the Julian and Gregorian proleptic years BC, so that 3114 BC is stated as -3113 in astronomical year numbering

GMT Calendar Correlation:

a family of correlations between the Maya Calendar and the Christian Calendars, instituted by Joseph Goodman, Juan Martinez Hernandez, and Eric Thompson (G.M.T.), usually equating the Long Count Era base to either JDN 584283 or JDN 584285

Haab:

the Maya 'Vague Year' of 365 days which continuously cycles without any added leap years, analogous to the Egyptian Civil Calendar Year; the Haab is composed of 18 periods of 20-day winals, with an epagomenal period of 5 days added prior to the New Year on 0 Pop

Heliacal:

referring to the appearance of a star or planet near the sun; a star can first reappear at sunrise after a period of invisibility when it is behind the sun, thereby allowing observers to record a sidereal year, just as the Egyptians observed the heliacal rise of Sothis which coincided with the annual flood of the Nile

Heliakos:

the 'Heliacal Year' and a Greek name of the Egyptian Annus Magnus

Intercalary Day:

the extra day inserted in a leap year, as on February 29th

Julian Calendar Year:

a fixed year of 365.25 days with leap years every four years, instituted in 46 BC by Julius Caesar

Julian Day Number (JDN):

a chronological and continuous count of days contrived by Joseph Scaliger in 1583 that counts from a back-calculated base date of noon on Monday, January 1st, 4,713 BC in the Julian Calendar, using UTC, or Greenwich Mean Time

Julian Proleptic Calendar:

a calendrical system used to extend the Julian year of 365.25 days prior to its original usage; the Julian Calendar observes no 0 year, so 1 BC immediately precedes 1 AD

Kunikon:

'Year of the Dog Star/Sirius', a Greek name for the Egyptian Great Year; 'Canicular' year in Latin, from which we derive the 'Dog Days of Summer' during which time Sirius heliacally rises in the Northern Hemisphere

Leap Year:

a year of 366 days added at various intervals to compensate for the short fall of the 365-day year against the tropical year, which is slightly less than one quarter of a day longer than 365 days

Long Count:

a Mesoamerican chronological count of days reckoned from a remote Era base, and composed of a positional system of vigesimal periods of 360-day Tuns; a standard Long Count begins with the 400-Tun Bak'tun, followed by the 20-Tun K'atun, the 360-day Tun, the 20-day Winal, and the 1-day K'in

Maya Great Year:

defined by the author as a cycle of 1,424 Haabs of 365 days, equivalent to 1,423 sidereal years; the Maya Great Year returns the Haab to the same position in the sidereal year after one complete revolution

Perihelion:

the closest point of the Earth in its elliptical orbit around the sun when the velocity of the Earth increases, thereby shortening the season in which it occurs (currently in early January); the perihelion is drifting forward in the year by one day approximately every 58 years

Precession of the Equinoxes:

the slow, backwards movement of the sidereal position of the sun on the two equinoxes against the fixed stars on the ecliptic; this movement is a an effect of the wobbling of the Earth's axis, primarily due to the gravitational effects of the moon; precession of the equinoxes causes the tropical year to be slightly shorter than the sidereal year

Sidereal:

with respect to the fixed stars and constellations, rather than to the seasons

Sidereal Year:

a year on Earth of 365.25636 days (epoch J2000) that represents the true orbital period of the Earth around the sun, relative to the fixed stars; the sidereal year effectively returns the Earth and the sun to the same positions in space relative to the stars

Solar Longitude:

a means of measuring the position of the Earth and the sun for any given time in fixed, sidereal space by using degree coordinates that count along the circle defined by the ecliptic from the 0º point of the vernal (spring) equinox in the Epoch J2000

Sothis:

the Greek name for the Egyptian star Spdt, 'triangle/sharp one', their name for Sirius, the 'Dog Star' and the brightest star in the Northern Hemisphere; the Egyptians observed the heliacal rise of Sothis, which coincided with the annual flood of the Nile, thereby measuring the Sothic Year

Sothic Year:

the Egyptian sidereal year of approximately 365.25 days, reckoned from the repeated heliacal rising of Sothis/Sirius

Tropical Year:

a seasonal year on Earth that returns the poles of the Earth to the same position relative to the sun, thereby returning the sunrise or sunset to the same position on the horizon; the tropical year is currently defined as the mean tropical year of 365.24219 days (Epoch J2000), which averages the lengths of the tropical years as measured from the two solstices and the two equinoxes.

Tzolk'in:

a neologism referring to the 260-day cycle of the Classic Maya, composed of 20 named days that cycle together with 13 numbers; the 260-day cycle was widely used throughout Mesoamerica, but found nowhere else in the world

Vigesimal:

a positional number system based on 20, akin to a decimal system, based on 10; the Maya used a vigesimal count of 360-day Tuns in the Long Count, while the Tun itself broke from a purely vigesimal count, in that it was based on 18 cycles of 20 days

Zenith Passage:

referring to the positioning of a celestial body like the sun at a point overhead, directly perpendicular to a given point on Earth; the solar zenith passage occurs in the tropics on two different days, depending on the latitude, with the two solar zenith passages basically equidistant to the summer solstice; at the latitudes of the two tropics, the solar zenith passages occur one on the summer solstice, while they occur on the two days of the equinoxes at the equator

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Glyph Dwellers is an occasional publication of the Maya Hieroglyphic Database Project at California State University, Chico, California. Its purpose is to make available recent discoveries about ancient Maya culture, history, iconography, and Mayan historical linguistics deriving from the project.

Funding for the Maya Hieroglyphic Database Project is provided by the National Endowment for the Humanities, grants #RT21365-92, RT21608-94, PA22844-96, the National Science Foundation, grants #SBR9710961 and IBSS1328928, the Department of Native American Studies, University of California, Davis, and the Department of Art and Art History, California State University, Chico.

ISSN 1097-3737