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The traditions of the Nativity and Epiphany between faith and science

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Abstract. In Western tradition, the Nativity of Jesus is placed on December 25, 1 BC, according to the calculation made by Dionysius Exiguus in the sixth century. In Eastern tradition, January 6 is associated with both the birth of Jesus and the Epiphany (visit of the Magi). The historicity of events related to the Star of Bethlehem and the accuracy of tradition in determining the beginning of the Christian era have long been debated. This study, conducted through astronomy and the reconstruction of ancient calendars, has shed new light on this longstanding issue. In fact, an ancient fourth-century source, the *Apostolic Constitutions*, indicates that the Nativity of Jesus occurred on the 25th of Kislev, the first day of the Jewish festival of Hanukkah. The same source places the Epiphany of Magi on the 6th of Tevet. The astronomical-calendar analysis shows that, under certain assumptions, the 25th of Kislev and the 6th of Tevet can exactly coincide with the dates of the Eastern tradition for both the Nativity and the Epiphany, i. e. January 6 , precisely at the beginning of the Christian era, according to the calculation made by Dionysius Exiguus. The probability that this is coincidental is so low that it implies these traditions must necessarily have a historical origin, demonstrating the reasonableness of the faith passed down to us by the early Christians.

Keywords: Birth of Jesus, Epiphany, Eastern and Western Christian Traditions, Hanukkah.

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Introduction

History has a clear dividing line, evident already in the use of the current calendar: before Christ and after Christ. The so-called Gospels of the Infancy detail many events, some of which are directly susceptible to possible astronomical verification, such as the adoration of the Magi guided by the Star of Bethlehem (cf. Mt 2,1ff). It has long been debated whether this was a simple literary topos or an astronomical event, interpreted by astronomers 2000 years ago as a sign of the birth of the Messiah. Since the fourth century, efforts have been made to associate this Matthew's account with precise temporal coordinates. Among these efforts, the most important is that of Dionysius Exiguus, who in the sixth century fixed the origin of our calendar with the birth of Christ 2024 years ago, a calculation considered today unreliable by many historians (De Caro et al. 2021). In fact, one of the historical constraints that seems to prevent considering Dionysius' calculation of the beginning of the Christian era correct is the dating of the death of Herod the Great, who was alive when Jesus was born (cf. Mt 2,1ff). According to the historian Josephus, the Idumean king would have died after a lunar eclipse visible from Jerusalem.[1] E. Schürer, who was not an astronomer, found a lunar eclipse visible from Jerusalem on March 13, 4 Before Christ (BC) (Schürer 1896) by consulting the as-

[1] Josephus Flavius, *The Jewish War*, I, 33; 1; 5-6; 8; II, 1; 3; *Antiquities of the Jews,* XVII, 146-199.

tronomical almanacs of his time. From this astronomical data and other historical considerations, regarding the duration and end of the reigns of Herod's three sons who succeeded their father, Schürer deduced the date of Herod's death in 4 BC. Since the end of the 19th century, following Schürer's hypothesis, a growing number of historians have placed this dating in 4 BC, so it is referred to as the "classical dating" of Herod's death, indicating how it is commonly accepted by many historians.

Since then, the calculation of the beginning of the Christian era, made about 14 centuries ago by Dionysius Exiguus, has been questioned, and today most historians believe that the birth of Jesus should be placed at least in 5 BC, relegating 1 BC to a "conventional dating" of the beginning of the Christian era. However, recently, by studying the naked-eye visibility of partial lunar eclipses, with a low percentage of shadow on the lunar disk (the one in 4 BC was 36%), it has been possible to demonstrate that, for an occasional night observer 2000 years ago, in the middle of the night, it would have been easy to confuse the eclipsed moon with a not perfectly full moon and, consequently, the astronomical phenomenon would not have been noticed (De Caro et al. 2021). The analysis of lunar eclipses visible to the naked eye at the beginning of the Christian era allows reconsidering as historically correct the calculation made by Dionysius Exiguus (De Caro et al. 2021).

Given the above recent results, we could wonder about the historical readability of the dates of the Western and the Eastern traditions of the Nativity and the Epiphany, December 25 and January 6. Many hypotheses have been suggested by scholars, to explain the historical root of these dates and their critical analysis goes beyond the scope of the present work. An important research paper concerning this topic, which summaries all the classic attempts proposed to explain the origin of these dates of the Christian tradition, is (Nothaf 2012). Instead, the focus of the present study will be a more detailed analysis of a new hypothesis, recently proposed, relating the Nativity's Day to the Hebrew feast of the Hanukkah (De Caro et al. 2022), extending further the investigation, also to the roots of the Epiphany's Day. We will see how astronomy, the reconstruction of ancient calendars, and a-priori probability analysis of the

obtained results will allow to shed light on the historical readability of the dates of the Eastern tradition of the Nativity and the Epiphany and, thus, indirectly, on the accounts in the Gospels of the Infancy, reported by Matthew (Mt) and Luke (Lk).

1. The tradition of Jesus' birth at the beginning of winter

The first point that we want to address is that even the tradition of Jesus' birth at the beginning of winter might also have a historical root. In fact, the chronological annotation reported in the Lucan gospel that Elizabeth was in the 6th month of pregnancy at the time of the Annunciation, if correlated with the timing of pilgrimage festivals in Jerusalem, becomes binding on the possible period of the year in which Jesus would have been born. In fact, the three pilgrimages took place at Passover, Pentecost (50 days after Passover), and Tabernacles (6 months after Passover). Therefore, the maximum period that could elapse between two successive pilgrimages was 6 months, from Tabernacles to the following Passover, in the case of 12-month years, or 7 months in the case of embolismic years, with 13 months. Luke notes how Joseph and Mary were diligent in observing the Mosaic law (cf. Lk 2:41), which required pilgrimage to Jerusalem on the three festivals. Therefore, it is entirely plausible to hypothesize that if there had been a pilgrimage festival between the angel's announcement to Zechariah and the Annunciation, Joseph would have gone to Jerusalem and already known about Elizabeth's unexpected pregnancy, the wife of the priest Zechariah, a relative of Mary, an extraordinary news that could not be kept silent, as Elizabeth was very advanced in years and had no children. Since Luke's account implies that Mary, at the time of the Annunciation, did not know about Elizabeth's pregnancy, it necessarily follows that for a period of at least five months before that moment there had been no pilgrimages, as Elizabeth was already in the sixth month of pregnancy. In fact, the angel's news about Elizabeth's pregnancy seems to be completely unexpected for Mary. All this implies that the Annunciation should have taken place at least 5 months after a pilgrimage festival. Since the intervals between Passover and Pentecost, and between the

latter and Tabernacles are less than 5 months, it follows that the period in which to place the Annunciation is between Tabernacles and Passover, and that the angel's visit to Mary must necessarily fall shortly before a Passover. The Jewish Passover marked the beginning of the liturgical year and fell on the first full moon of spring, usually at the end of March, beginning of April. If we add the 9 months of pregnancy, we arrive at the end of December, beginning of January. Consequently, the Nativity could indeed have occurred precisely in the period of the year indicated over the centuries by the tradition of the Western and Eastern Churches, that is, at the beginning of winter.

2. The Feast of Hanukkah in relation with the birth of the Messiah

At the beginning of winter, another Jewish festival also takes place, Hanukkah, also known as the Festival of the Dedication of the Temple, which lasts for 8 days, and which begins at sunset on the 24th of Kislev when, by convention, the 25th of the month starts. In the Tradition of the Eastern Church, we find references to the "Festival of Lights" in relation to Jesus, which is another name for the Hanukkah festival, a festival introduced in the second century BC. For example, Gregory Nazianzen, from the 4th century, relates the "Festival of Lights" both to the baptism of Jesus and to the Epiphany.[2] There is also a 4th-century Syrian document, the Apostolic Constitutions (Metzger 1986), in which the Nativity is placed on the 25th of the 9th month and the Epiphany on the 6th of the 10th month (Constit. Apost. lib. V, 13, 1-2) of the lunisolar calendar (Constit. Apost. lib. V, 14, 1), that is, the 25th of Kislev for the birth of Jesus and the 6th of Tevet for the Epiphany.

It is also interesting to note that the date of the 25th of Kislev as that of the Nativity may also have indirect biblical evidence and could even be found in rabbinic tradition (Chilton 2006). The biblical evidence is based on the 4th Gospel, which states that Jesus went to the Temple during the

[2] Nazianzenus, Gregorius. In *Patrologia Graeca*, T. XXXVI, *Orat*. 39, col. 335.

Hanukkah festival (cf. Jn 10:22–29), which was not a pilgrimage festival. If the public life of Jesus lasted 3 years plus few months, John does not describe all the public Passovers of Jesus (cf. Jn 2:13; 6:4; 12:1), because one would be missing, in which Jesus surely went to Jerusalem. Nevertheless, John describes this episode of the Hanukkah festival. Chilton deduces from this episode that Jesus has a special connection with this festival, with the 25th of Kislev in particular, the day of the victory of the Maccabean revolt, a connection at least symbolic, as Jesus is the true light of the world (cf. Jn 1:9; 8:12), and because the liberation of the profaned Temple and Jerusalem occupied by the army of Antiochus Epiphanes IV is prophetic of the messianic mission. These connections with Jewish traditions support the conclusion that for the early Christians, among whom there were many Jews, Jesus of Nazareth, recognized as the Messiah, must have been born precisely on the 25th of Kislev, the first day of the Hanukkah festival.

It is therefore legitimate to verify whether these dates of the lunisolar calendar (25th of Kislev for the Nativity and 6th of Tevet for the Epiphany) can be related to Western and Eastern traditions. The existing relationships between the Nativity traditions of the Western and Eastern Churches (December 25 and January 6) with the Hanukkah feast have already been partly explored in a recent study (De Caro et al. 2022). In the next section we will delve deeper into this analysis, also considering the other calendar information reported in the Apostolic Constitutions, regarding the Epiphany placed on the 6th of Tevet. If, in fact, the tradition of the dating of the Nativity has been questioned, even more so would be that of the Adoration of the Magi, guided by the Star, placed on January 6, because it would be the fact itself, and not just its traditional dating, that raises doubts about its possible historical reliability. Let us see in the next section what emerges from the astronomical and calendar analysis.

3. Conversion of the dates of 25 Kislev and 6 Tevet in the Julian Calendar

3.1. Embolismic years of the Hebrew lunisolar Calendar

To convert the 25th of Kislev into Julian calendar terms, it is necessary to convert from the Jewish lunisolar calendar to the solar calendar used at the beginning of the Christian era. To correctly perform this date conversion from the Jewish lunisolar calendar to the Julian calendar, we must consider a series of factors. The beginning of the lunar months in the Jewish calendar, two thousand years ago, was not predetermined by a precompiled calendar but was determined by the direct observation of the first crescent of the new moon. Additionally, the year began with the month of Nisan with the first new moon after the spring equinox, which two thousand years ago astronomically fell on March 23rd of the Julian calendar used in the Roman Empire.

However, in some years, an additional intercalary month was inserted into the year that was about to end, to astronomically realign the lunisolar calendar with the seasons, as the lunar month lasts about 29.53 days and, therefore, 12 lunar months are approximately 12×29.53=354 days, a total which is about 11 days less than the 365.24 days of the solar year. We do not know when the additional months—called the "second month of Adar"—were introduced, as the decision was made by the Sanhedrin, as also attested by the Sanhedrin tractate, based on both climatic and astronomical reasons (Finegan 1998, 38). In fact, it was necessary that the ripening of the fruits of the earth and the grain and/or barley was not particularly delayed, as the liturgy of the 16th of Nisan required the offering of sheaves of the first harvests of barley and/or grain at the temple. Additionally, the beginning of the new year, in Nisan, had to see the Sun rise against the backdrop of the constellation Aries. Evidently, even if the Sun was already in Aries but there were no mature barley or grain ears, the liturgy scheduled for the 16th of Nisan could not take place, and Passover was postponed by inserting a second month of Adar. The only certain constraint is the astronomical one, as 2000 years ago the Sun's entry into the constellation Aries occurred a few days after the spring equinox (after

March 23rd). Therefore, the month of Nisan should not have started before this date of the Julian calendar.

3.2. Leap years of the Julian Calendar

Another issue to consider is that in the first decades of the introduction of the Julian calendar, more leap days were introduced than necessary. The Julian calendar in use during those years was, in fact, affected by an incorrect counting of leap years, because from the year 45 BC, the first leap year, until 9 BC, the years of 366 days were most likely inserted every three years instead of every four, due to a misinterpretation of the rule to insert a leap year after three normal years. Therefore, every 12 years instead of having three leap years (12:4 gives 3), four were inserted (12:3 gives 4). In other words, the correct sequence should have been: 45 BC, 41 BC, 37 BC, 33 BC, 29 BC, 25 BC, 21 BC, 17 BC, 13 BC, 9 BC, 5 BC, 1 BC, 4 Anno Domini (AD), 8 AD, and continuing with a leap year every 4 years. This calendar situation will be referred to as the "Correct Sequence". In reality, no one knows what the actual sequence of leap years was, instead of the correct one. Only hypotheses can be done.

The simplest hypothesis involves the miscalculation of a leap year every three years instead of every four. This would have led to the following sequence of leap years: 45, 42, 39, 36, 33, 30, 27, 24, 21, 18, 15, 12, 9 BC, interrupting the sequence for a few years to astronomically realign the calendar, then resuming it in 8 AD, continuing with a leap year every 4 years. Consequently, extending the calculation to the entire period from January 45 BC to January 9 BC, there were most likely 13 leap years instead of 10, with an astronomical discrepancy of three days on the calendar. This calendar situation will be referred to as the "First Hypothesis" of incorrect sequence.

It was then Caesar Augustus, perhaps in 8 BC, who corrected the error by ordering that for a certain number of years there would be no more leap years. The correction of this error meant that only from 8 AD onwards was the Julian calendar correctly computed in terms of leap years with a four-year cadence. However, it is also possible that Caesar Augustus addressed the problem of the incorrect sequence of leap years only af-

ter 6 BC. Under this hypothesis, which we will refer to as the "Second Hypothesis" of incorrect sequence, there would have been 14 leap years – 45, 42, 39, 36, 33, 30, 27, 24, 21, 18, 15, 12, 9, 6 BC – instead of 12. Therefore, at the end of 6 BC, there would have been 4 extra days compared to the Correct Sequence. From the end of 5 BC to the end of 2 BC, the difference would have been 3 days. And at the end of 1 BC, the difference would have been 2 days. This discussion is summarized in Table 1.

Table 1. Possible sequences of leap years in the Julian Calendar before the beginning of the Christian Era

Leap Year Sequence	Leap Years Before the Beginning of the Christian Era (BC)
Correct Sequence	45, 41, 37, 33, 29, 25, 21, 17, 13, 9, 5, 1
First Hypothesis of Incorrect Sequence	45, 42, 39, 36, 33, 30, 27, 24, 21, 18, 15, 12, 9
Second Hypothesis of Incorrect Sequence	45, 42, 39, 36, 33, 30, 27, 24, 21, 18, 15, 12, 9, 6

Consequently, when determining a date in the Julian calendar for the decade straddling the end and the beginning of the Christian era, using astronomy programs that report the Correct Sequence, it is necessary to consider the aforementioned error of days to determine the actual date. Why is this correction important?

If we assume there is a historical root regarding a certain date, for example, December 25 concerning the birth of Jesus, since it falls precisely in the period when the Julian calendar was astronomically misaligned by one or two days, we must take this misalignment into account to verify if the hypothesis of the historical memory of that date is indeed possible.

3.3. The Epiphany in relation to the Nativity

Regarding the tradition of the Epiphany (adoration of the Magi), the evangelist Matthew calls Jesus, παιδίον, a Greek term suitable not for a newborn but for a child of 1 or 2 years of age at most. The same maximum age should also be considered for the constraint of the Massacre of the Innocents, which saw children up to the age of two being killed (cf. Mt 2:1ff). If

we assume that the Infancy Gospels have a historical root in events that actually happened, then it is possible to deduce that the Epiphany and the Nativity did not occur in the same year. We are, therefore, faced with at least two possibilities:

1. Epiphany and Nativity occurred in the same lunisolar year. In this case, the Epiphany would be placed a few days after the Nativity, in the next lunar cycle. Despite the Greek term used by Matthew seems to exclude this possibility, we will still consider it, and this possibility will be indicated as "Epiphany in the same lunisolar year" of the Nativity.
2. The Epiphany occurred a year after the Nativity. The 6th of Tevet, that is, falls about 12 or 13 lunar months after the Nativity. This possibility will be indicated as "Epiphany one year after" the Nativity.

Therefore, after calculating the corresponding Julian day of the 25th of Kislev according to both the astronomically correct calendar (Correct Sequence) and the two hypotheses of incorrect sequences of leap years reported in Table 1, we can relate this day to the 6th of Tevet, the day of the Epiphany according to the Apostolic Constitutions, assuming it fell immediately after the Nativity, or after a year, to verify if there are any relationships between the dates thus obtained and the traditions of December 25 and January 6 handed down by Christianity.

3.4. The determination of the beginning of Lunar Months

To perform this conversion between different calendars, another point to clarify is that the beginning of the lunar month was determined by direct observation. To create a possible lunisolar calendar in terms of Julian calendar days, it is necessary to adopt a criterion for the visibility of the new crescent moon. For this purpose, as already done in another of our studies (La Greca et al. 2017), it could be imposed that at least 2% of the lunar disk was already illuminated, just after sunset, to be effectively visible to the observers appointed to indicate to the Sanhedrin the beginning of the new month, two witnesses who had to agree that they both

saw the small crescent moon, answering some ritual questions (Finegan 1998, 37). However, studies show a variety of criteria (Doggett et al. 1994).

Indeed, sometimes the first crescent of the new moon could not be seen even if the percentage of the lunar disk illuminated by the sun was at least 2%. This could happen, for example, due to adverse weather conditions, such as a particularly cloudy sky. Given the flexibility of the calendar 2000 years ago, since lunar months could have either 29 or 30 days, but not 31, it was customary to postpone the beginning of the month by one day when the moon was not visible due to clouds. In this study, we will impose that this could only happen when the illuminated fraction of the moon, on the day it would become visible, was at most around 2.5% because, for higher values, the month just ended would likely already be 30 days long and, by convention, its end could not be delayed by an additional day, as the months of the Hebrew lunisolar calendar were never 31 days long. Furthermore, under particularly favorable astronomical conditions, associated with an extremely clear sky, the moon could be visible even with a slightly lower illuminated fraction, but not less than 1%. For this reason, in the conversion from the Hebrew lunisolar calendar to the Julian calendar, it is prudent to associate a range of dates to account for the different possibilities discussed so far. In this way, the risk of excessively constraining the possible dates obtained to the chosen criterion for determining the beginning of the month is avoided. Given the previous criteria, the calendar analysis discussed in the next section is obtained.[3]

3.5. The beginning of Hanukkah in terms of the Julian Calendar

After these clarifications, in Table 2 we have summarized the results of the calculation of the beginning of the lunar month of Kislev and the beginning of the Festival of the Dedication of the Temple (25 Kislev) for the years from 6 BC to 1 AD, the historical period in which the birth of Jesus can be placed. Since we do not know which were the embolismic years of the Hebrew lunisolar calendar, of 13 months, we have also considered in

[3] The astronomical calculations were performed using the Skychart program, developed by Patrick Chevalley: website http://www.ap-i.net/skychart/.

Table 2 the case of an intercalary year whenever the 15th of Nisan, the day of the Jewish Passover, fell too close to March 23rd, the day of the spring equinox. Furthermore, taking as a reference what was understood from the studies of the Babylonian calendar (Parker et al. 1956), of which we know the sequence of embolismic years and which had a significant influence on the calendar used in the land of Palestine (Finegan 1998, 33–39), we have considered no alternative calendar hypothesis to the insertion of the 13rd month each time the 15th of Nisan would have fallen less than three days from the spring equinox. In other words, these cases have been considered with certainty embolismic years. In Table 2, the dates of the 1st and 25th of Kislev have been also indicated in case the year was embolismic, marked with an "E". Additionally, in Table 2, besides the Julian calendar dates determined by astronomy programs (Correct Sequence), those recalculated for the actual calendar of the time are included, taking into account, depending on the years, the days of discrepancy compared to the dates provided by astronomical calculation programs, caused by the excessive insertion of leap years in the Julian calendar before the beginning of the Christian era, according to the two hypotheses previously discussed and summarized in Table 1.

The dates of the first of Nisan in the Hebrew lunisolar calendar have been reported by specifying two days of the Julian calendar because, by convention, the Jews began the new day at sunset and ended it at the sunset of the following day. In this regard, it is also necessary to consider that tradition places the birth of Jesus at night, thus, after the sunset of the 24th of Kislev, that is, at the beginning of the 25th. Therefore, of the date range reported in the last column of Table 2, the most relevant should be the lower limit, corresponding to the transition from the 24th to the 25th of Kislev. Additionally, the dates of the month of Kislev have been associated with a range of Julian calendar days, as the actual visibility of the new moon at the beginning of the month depends on the chosen criterion. By varying the percentage of the lunar disk illuminated by the sun from 1% to 2.5%, as previously discussed, the date ranges reported in Table 2 have been obtained.

Table 2. Beginning of Nisan and the Feast of Hanukkah (25 Kislev), in terms of the Julian Calendar, in the years from 1 AD to 6 BC, according to the sequences of leap years summarized in Table 1. E=Embolismic year

Year	1 Nisan Correct Sequence	Possible Date Range for 25 Kislev Correct Sequence	Possible Date Range for 25 Kislev First Hypothesis of Incorrect Sequence	Possible Date Range for 25 Kislev Second Hypothesis of Incorrect Sequence
1 AD	15-16 Mar	29 Nov-1 Dec	28-30 Nov	27-29 Nov
---	---	---	---	---
1 AD E	13-14 Apr	29-31 Dec	28-30 Dec	27-29 Dec
1 BC	25-26 Mar	10-12 Dec	9-11 Dec	8-10 Dec
---	---	---	---	---
1 BC E	24-25 Apr	8-10 Jan 1 AD	7-9 Jan 1 AD	**6**-8 **Jan 1 AD**
2 BC	6-7 Apr	21-23 Dec	19-21 Dec	18-20 Dec
3 BC	18-19 Mar	2-4 Dec	30 Nov-2 Dec	29 Nov-1 Dec
---	---	---	---	---
3 BC E	16-17 Apr	2-3 Jan 2 BC	31 Dec-1 Jan 2 BC	30-31 Dec 2 BC
4 BC	28-29 Mar	14-15 Dec	12-13 Dec	11-12 Dec
5 BC	8-9 Apr	23-25 Dec	21-23 Dec	20-22 Dec
6 BC	21-22 Mar	6-7 Dec	3-4 Dec	2-3 Dec
---	---	---	---	---
6 BC E	20-21 Apr	4-6 Jan 5 BC	1-3 Jan 5 BC	31 Dec 6 BC-2 Jan 5 BC

We are looking for coincidences of the 25th of Kislev either with December 25, the date of the Nativity according to Western tradition, or with January 6, the date of the Nativity according to Eastern tradition. From the data reported in Table 2, we observe that January 6, 5 BC, could have been a 25th of Kislev if the Correct Sequence of leap years had been used. But we know for certain that this did not historically occur. Therefore, this coincidence can be excluded. There is only one possible coincidence, that of January 6, 1 AD, in the case of the Second Hypothesis of incorrect sequence of leap years, which is precisely the date of the Eastern tradition not only in terms of day but also of year. Thus, a singular coincidence.

3.6. The Epiphany on the 6th of Tevet in terms of the Julian Calendar

Tables 3 and 4 summarize the astronomical-calendar analysis for the conversion of the 6th of Tevet into the Julian calendar, for the years from 1 AD to 6 BC, according to the two hypotheses of leap year sequences indicated in Table 1. It is very interesting to note that only in the year 1 BC, precisely the one calculated by Dionysius Exiguus, under the hypothesis that it was embolismic, the 25th of Kislev of 1 BC and the 6th of Tevet of the following lunisolar year could have coincided, respectively, with January 6 of 1 AD, according to the Eastern tradition for the Nativity, and with January 6 of 2 AD for the Epiphany. This occurs according to the second hypothesized sequence of leap years (Table 4). The Western tradition – December 25 of 1 BC for the Nativity together with January 6 of either 1 AD or 2 AD for the Epiphany – is never obtained.

Table 3. Conversion of the 6th of Tevet in Terms of the Julian Calendar, in the years from 1 AD to 6 BC, according to the First Hypothesis of incorrect sequence of leap years discussed in Table 1. E=Embolismic Year

Year in which Nisan falls	Date range for the 25th of Kislev	Date range for the 6th of Tevet assuming Epiphany in the same lunisolar year	Date range for the 6th of Tevet assuming Epiphany after 1 year
1 AD --------- 1 AD E	28-30 Nov ------------- 28-30 Dec	8-10 Dec 1 AD ------------- 7-9 Jan 2 AD	28-29 Nov 2 AD ------------- 27-29 Dec 2 AD
1 BC --------- 1 BC E	9-11 Dec ------------- 7-9 Jan 1 AD	19-21 Dec 1 BC ------------- 18-20 Jan 1 AD	8-10 Dec 1 AD ------------- 7-9 Jan 2 AD
2 BC	19-21 Dec	30 Dec 2 BC – 1 Jan 1 BC	18-20 Dec 1 BC
3 BC --------- 3 BC E	30 Nov-2 Dec ------------- 31 Dec-1 Jan 2 BC	11-13 Dec 3 BC ------------- 10-11 Jan 2 BC	30 Nov-2 Dec 2 BC ------------- 30 Dec 2 BC-1 Jan 1 BC
4 BC	12-13 Dec	22-23 Dec 4 BC	11-13 Dec 3 BC
5 BC	21-23 Dec	1-3 Jan 4 BC	22-24 Dec 4 BC
6 BC --------- 6 BC E	3-4 Dec ------------- 1-3 Jan 5 BC	13-15 Dec 6 BC ------------- 12-13 Jan 5 BC	2-3 Dec 5 BC ------------- 31 Dec 5 BC-2 Jan 4 BC

Table 4. Conversion of the 6th of Tevet in terms of the Julian Calendar, in the years from 1 AD to 6 BC, according to the Second Hypothesis of incorrect sequence of leap years discussed in Table 1. E=Embolismic Year. Dates that would coincide with Eastern or Western traditions are in bold

Year in which Nisan falls	Date range for the 25th of Kislev	Date range for the 6th of Tevet assuming Epiphany in the same lunisolar year	Date range for the 6th of Tevet assuming Epiphany after 1 year
1 AD --------- 1 AD E	27-29 Nov ------------- 27-29 Dec	7-9 Dec 1 AD ------------- **6**-8 **Jan** 2 AD	27-28 Nov 2 AD ------------- 26-28 Dec 2 AD
1 BC --------- 1 BC E	8-10 Dec ------------- **6**-8 **Jan 1 AD**	18-20 Dec 1 BC ------------- 17-19 Jan 1 AD	7-9 Dec 1 AD ------------- **6**-8 **Jan** 2 AD
2 BC	18-20 Dec	29-31 Dec 2 BC	17-19 Dec 1 BC
3 BC --------- 3 BC E	29 Nov-1 Dec ------------- 30-31 Dec 2 BC	10-12 Dec 3 BC ------------- 9-10 Jan 2 BC	29 Nov-1 Dec 2 BC ------------- 29-31 Dec 2 BC
4 BC	11-12 Dec	21-22 Dec 4 BC	10-12 Dec 3 BC
5 BC	20-22 Dec	31 Dec 5 BC – 2 Jan 4 BC	21-23 Dec 4 BC
6 BC --------- 6 BC E	2-3 Dec ------------- 31 Dec 6 BC-2 Jan 5 BC	13-15 Dec 6 BC ------------- 11-12 Jan 5 BC	1-2 Dec 5 BC ------------- 30 Dec 5 BC-1 Jan 4 BC

In summary, for the Nativity, we analyzed a range of 7 years, from 6 BC to 1 AD. The dates that would confirm the Western or Eastern traditions, both for the Nativity and the Epiphany, are only three:

1. December 25 of 1 BC for the Nativity and January 6 of 1 AD for the Epiphany, a few days after the birth;
2. December 25 of 1 BC for the Nativity and January 6 of 2 AD for the Epiphany, about a year after the birth;
3. January 6 of 1 AD for the Nativity and January 6 of 2 AD for the Epiphany, exactly one year after the birth.

Since the year zero does not exist, between the Western tradition of December 25 of 1 BC (no. 2 in the list) and the Eastern tradition of January 6 of 1 AD, there are only 12 days. Therefore, both can be considered in agreement with the year calculation made by Dionysius Exiguus. However, from the analysis summarized in Tables 3 and 4, it emerges that only

tradition no. 3 in the previous list is compatible with the Nativity placed on the 25th of Kislev and the Epiphany placed on the 6th of Tevet, one year later. And this happens precisely in correspondence with the year calculated by Dionysius Exiguus. It is too singular this coincidence to be accidental and, consequently, requires a further mathematical in-depth step.

3.7. Probability calculation

Indeed, the a priori probability of having, by chance, the 25th of Kislev fall exactly on January 6 is 1/29.5 = 0.034, which is the inverse of the duration in days of a lunar month. The a priori probability of having, by chance, the 25th of Kislev coincide with January 6 only for the year 1 AD, according to the calculation of Dionysius Exiguus, over the 7-year period considered, is 1/(7×29.5) = 0.005. The a priori probability that the Epiphany also falls, by chance, on January 6, exactly one year later, if it were an event independent of the Nativity, would be 0.005^2 = 25/1,000,000. This probability is so small that it implies that the dates of the Eastern tradition for the Nativity and the Epiphany must necessarily have a historical root and that the Nativity and the Epiphany are not independent traditions. For the same reason, the 25th of Kislev for the Nativity and the 6th of Tevet for the Epiphany, indicated by the Apostolic Constitutions, must also have a historical root.

4. Discussion and conclusions

An ancient source from the 4th century (Constit. Apost. lib. V, 13, 1–2) attests the Nativity on the 25th of Kislev and the Epiphany on the 6th of Tevet. The finding that in the year of the Jewish lunar-solar calendar from 1 BC to 1 AD, the Feast of the Dedication of the Temple (25th of Kislev), converted to the Julian calendar, could correspond exactly with the date of Jesus' birth according to the Eastern tradition (January 6), and the deduction of the embolisimic-year constraint from a careful chronological analysis of Luke's narrative of the Annunciation, allow us to hypothesize that the date of the Nativity according to the Eastern tradition, January 6, 1 AD, could be historically correct. The date of the Nativity on Decem-

ber 25, according to the Western tradition, would also have a historical root if related to the 25th of Kislev, as Kislev and December represent the first winter month in their respective calendars, lunar-solar and Julian. Among Christians of Greco-Latin culture, over time, the ability to correctly convert lunar-solar dates into Julian calendar terms would have been increasingly lost, a skill that remained in some regions of the East thanks to the continuous use of the lunar-solar calendar. Thus, in the West, the 25th of Kislev could have become December 25, that is, the 25th of the first winter month of the Julian calendar, still indirectly maintaining a historical root, as it is closely related to the feast of Hanukkah as the day of the Nativity.

Furthermore, it is possible also to deduce the date of January 6 from the ancient Eastern liturgy of Christmas, attested precisely in Jerusalem, through the writings of Egeria (Silvia of Bordeaux), a pilgrim in the Holy Land in 385. According to this ancient tradition, Jesus should have been baptized on the same day of his birth, which would be January 6. Moreover, the day of Jesus' baptism, according to the liturgical practice of the 4th century in Jerusalem, was always January 6, the traditional day for the visit of the Magi, but also considered the day of his Birth in the Eastern tradition, as attested in even older sources – such as that of Clement of Alexandria, dating back to 215 – connected to the Basilidian Gnostics (Martindale 1909).

According to Förster (2007), the roots of Christmas, found in 4th century Palestine, can be considered a new trend in pilgrimages to the Holy Land, a "historicizing" trend to celebrate the main Christological feasts in the appropriate place and time. Particularly noteworthy in this regard was the annual celebration of the birth of Christ at the Church of the Nativity in Bethlehem, which was then incorporated into the liturgies of other Churches following pilgrims who brought back the practices they had witnessed in the Holy Land to their home communities. Since it is known that the nativity celebrations in Jerusalem and Bethlehem took place on January 6 from the 6th century, Förster assumes that this was the original date of "Christmas," which was then exported to Rome and changed to December 25 under the influence of the winter solstice. How-

ever, considering our analysis, the reasons that would have led to December 25 would be different, not linked to a mere replacement of a pagan festival, that of Sol Invictus, with a Christian one, but dependent on the historical memory of the Nativity occurring at the beginning of the Hanukkah festival, on the 25th of the first winter month (Kislev).

We have analyzed, indeed, the source dating back to the 4th century, which refers to the birth of Jesus on the 25th of the ninth lunar-solar month (Constit. Apost. lib. V, 13, 1–2). It is therefore possible that this source was erroneously converted in the West, in the Julian calendar, as December 25, since the ninth month, Kislev, is the first winter month of the year, thus giving rise to the Western tradition of December 25, which is later than the Eastern tradition of January 6. To support this conclusion, we recall what is reported in the writings of the venerable Bede, where we find: "the ninth, Kislev, in December; the tenth, Tevet, in January" (Wallin 1999). Therefore, even in Bede's time, in the 8th century, the ninth lunar month (Kislev) was associated with December in the Julian calendar. On the other hand, in the 3rd or 4th century, it was not easy to astronomically reconstruct which day of the Julian calendar, centuries earlier, would have corresponded to the 25th of Kislev for the birth of Jesus. This justifies the possible association of December 25 with the 25th of Kislev, as it is the first winter month in both calendars. Therefore, the determination of the beginning of the Christian era made by Dionysius Exiguus could be correct, since the calendar analysis leads to placing the 25th of Kislev on January 6, 1 AD, a couple of weeks after December 25, 1 BC, as there is no year zero in the calendar.

The 4th-century source also indicates the Epiphany on the 6th of Tevet. The evangelist Matthew uses a Greek term to refer to Jesus that is not suitable for newborns. Therefore, at least about a year must have passed from his birth to the arrival of the Magi in Bethlehem. But from the 25th of Kislev to the 6th of Tevet of the following year, there is a solar year of 365 days. This means that the two dates from the 4th-century source, converted to Julian dates, give the same day of the year. So, if the Nativity is to be placed on January 6, so is the Epiphany, and based on our astronomical calendar analyses, this is possible only if the year of Jesus' birth

is the one calculated by Dionysius Exiguus, which marks the beginning of the Christian era. All this suggests the actual historicity of these Church traditions, which the 4th-century source we referred to explicitly states in terms of the lunar-solar calendar: Jesus would have been born on January 6, 1 AD; the adoration of the Magi (Epiphany) would have occurred on January 6, 2 AD.

The calculation of probabilities has shown that these cannot be causal coincidences. Rather, it should be concluded that January 6 in the Eastern tradition, as the date of the Nativity and the Adoration of the Magi, should have a historical root. In particular, the latter has often been questioned as a historically real event and relegated to a literary topos used by the evangelist Matthew. However, ancient documents such as the Apostolic Constitutions, astronomy, and the calculation of probabilities demonstrate that this account reported in chapter 2 of the Gospel of Matthew also has a precise calendar date from the origins of Christianity, January 6, implying a plausible historical root of what the evangelist narrated. Once again, science (astronomy, calculation of a-priori probability) proves to be a useful aid in demonstrating the reasonableness of the Christian faith, witnessed by the early Christians and made known, after 2000 years, through the Gospels and the tradition.

Nevertheless, it should also be underlined that the Christian faith is not based on historical certainty about the dates of the birth of Jesus and/or the Epiphany and/or any other event in the life of Jesus. In fact, even if it were possible to demonstrate without any doubt the place and time of all the events of his life, faith in him does not depend on the certainty of historical research. However, the scientific light in the world of faith leads to an additional motivational force in trusting Jesus Christ. In this regard, showing that the dates of celebration of the most important events for Christianity are not accidental confirms that Christianity is well rooted in history, and that accepting the divine gift of faith should also be considered reasonable from a rational point of view.

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