Type: Journal Article

A Comet, Christ's Birth, and Josephus's Lunar Eclipse

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Source: *Interpreter: A Journal of Latter-day Saint Faith and Scholarship*, Volume 52 (2022)
Published by: The Interpreter Foundation
Page(s): 279–320

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INTERPRETER

A Journal of Latter-day Saint Faith and Scholarship

Volume 52 · 2022 · Pages 279 - 320

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Offprint Series

ISSN 2372-1227 (print)
ISSN 2372-126X (online)

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A Comet, Christ's Birth, and Josephus's Lunar Eclipse

Charles Dike

Abstract: *A comet seen by the Chinese in 5 BC has been considered by some authors as a possibility for the Star of Bethlehem. This article starts with that premise and argues that Book of Mormon evidences reinforce that likelihood. The comet path can account for all events surrounding the Star of Bethlehem. Based on typologies in the scriptures, eyewitness reports, and the comet's timing, the date of Christ's birth can be determined. A proposal can then be made as to when and why the wise men began travelling to Jerusalem. The comet left a trail of debris the wise men saw on the night they located the house where Jesus was. The wise men and Joseph and Mary left Judea in mid-June of 5 BC and the slaughter of the innocents occurred later in that month. Using Josephus's "Antiquities," this article then argues strongly that Herod's death occurred sometime after a lunar eclipse on September 15, 5 BC and before the next Passover. This serves also to support his death in the spring of 4 BC, contrary to some scholars who opt for a 1 BC death. This study reaffirms the reality of the Star of Bethlehem.*

In this paper, I propose that Jesus Christ was born in March of 5 BC and that the wise men visited him in mid-June of 5 BC. This hypothesis[1] hinges on a comet seen by the Chinese in that month. The claim is that the appearance of the comet marked the day of Christ's birth and thus is the celestial apparition we refer to as the Star of Bethlehem.

The observers of the comet only left us with the month and year of the first observation, the length of time the apparition was seen, and a single celestial position. The information we have is summarized as follows:

1. While others have suggested possible causes for the night without darkness in 3 Nephi 1, none rise to the level of what could justifiably be called a hypothesis.

1. A single position (B1950 right ascension = 20 hours 20 minutes, declination = -15°). At the birth of Christ, the right ascension was 18 hours 27 minutes, declination = -19°.[2]
2. The approximate galactic coordinates (l = 30°, b = -25°).[3]
3. A lunar period wherein the comet first appeared (5 BC, March 9 to April 6).
4. A brief description (*hui-hsing*) indicating a tailed comet.
5. The length of time for the comet's visibility (70+ days).[4]

Others have also considered this comet as a contender for the Star of Bethlehem. Sir Colin Humphreys, a physicist, proposed that the 5 BC apparition the Chinese saw was a comet that first appeared during the Passover season. He felt that Christ could have been born in the Passover season, and he briefly mentioned that 10 Nisan (the day when Passover lambs were chosen for sacrifice) would be an apropos birth date and would fit with the words and prophecies of John the Baptist and the Apostle John.[5] I agree with much of his view. Humphreys did not address the two necessary positions of the comet, however. We know the apparition was observed for over 70 days, but there is no record showing that it moved to or from its stated location. Comets must move from

2. Right ascension and declination are the celestial coordinates to describe locations in the sky, similar to coordinates used to describe location on the Earth, with latitude corresponding to declination and longitude corresponding with right ascension. For a discussion of how celestial coordinates work, see Bob King, "Right Ascension & Declination: Celestial Coordinates for Beginners," *Sky and Telescope*, February 26, 2019, https://skyandtelescope.org/astronomy-resources/right-ascension-declination-celestial-coordinates/.

3. Galactic coordinates, also analogous to longitude and latitude, are described in COSMOS — The SAO Encyclopedia of Astronomy, s.v. "Galactic Coordinate System," https://astronomy.swin.edu.au/cosmos/G/Galactic+Coordinate+System. See also Wikipedia, s.v. "Galactic Coordinate System," https://en.wikipedia.org/wiki/Galactic_coordinate_system.

4. David H. Clark and F. Richard Stephenson, *The Historical Supernovae* (Oxford: Pergamon Press, 1977), 46. One translation reads, "In the second year of the period of *Ch'ien-p'ing* [reign period of Emperor Ai of the Han dynasty] the second month [March 10–April 7, 5 BC], a *hui-hsing* appeared in *Ch'ien-niu* for more than 70 days." Mark Kidger, *The Star of Bethlehem: An Astronomer's View* (Princeton, NJ: Princeton University Press, 1999), 234. Because of a comet's movement, it cannot stay in the same place in the sky for 70 days. The comet would have been first seen there or last seen there. I opt for the latter. A *hui-hsing* is a "broom star" and is usually considered to be a tailed comet.

5. Colin Humphreys, "The Star of Bethlehem, A Comet in 5 BC and the Date of Christ's Birth," *Tyndale Bulletin* 43, no. 1 (1992): 53.

a point of first visibility to a point of final visibility. Why are there not two positions?

The first we learn of the 5 BC comet is from the *Chhien (Ch'ien) Han Shu* (*History of the Former Han Dynasty*) written by Pan Ku (c. 100 AD).[6] The reference is from a history, not an astronomy text. Pan Ku would not have seen the comet and may have made a scribal error, a possibility that has been considered. The text most commonly copied appears to be from the *Wên Hsien Thung Khao*, a compendium written in 1254 AD by Ma Tuan-Lin.[7] This hypothesis proposes that the first position of the comet was lost, and the single location in that record is the final position of the comet before it lost visibility. The first position is based on scriptural typology and relies on the comet's rising heliacally with the sun. Making this change completely reconciles scriptural information with second-hand secular reports.[8]

The Comet of 5 BC

This section of the article will first present a chronology of the events involving the comet I consider the Star of Bethlehem. I will describe the characteristics of a generic comet and describe several possible light sources that might have played a role in the Nephites' night without darkness — some of these light sources probably did not have a significant presence on that night.

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6. *Encyclopedia Britannica Online*, s.v. "Ban Gu," by Glen W. Baxter, https://www.britannica.com/biography/Ban-Gu. Ban-Gu is also known as Pan Ku. Also see a paper by Ho Peng Yoke, which shows that Pan Ku wrote about the 5 BC comet in the *Chhien Han Su*. Ho Peng Yoke, "Ancient and Mediaeval Observations of Comets and Novae in Chinese Sources," *Vistas in Astronomy* 5 (1962): 148, https://doi.org/10.1016/0083-6656(62)90007-7.

7. Most of the comets on Ho's list come from the Wên Hsien Thung Khao. Ho, "Observations of Comets and Novae," 127.

8. Though he discusses the possibility that the Star of Bethlehem was a comet, Mark Kidger favors an opposing view — that it was a nova because of the single position. (See Kidger, *Star of Bethlehem*, 240–46.) Kidger chose a nova because he couldn't find a radio footprint expected from a supernova (ibid., 164). A nova is unlikely to appear as a morning star, then eventually disappear, and then reappear for a single day. Nephi didn't spot the apparition until after the night without darkness. If the nova was so bright during that night, then certainly the rest of the world would have experienced the same thing for more than a day or two. A nova would have been described more like a second sun rather than "great lights in heaven" by Samuel the Lamanite (Helaman 14:3). Additionally, Kidger's nova violates the claim by the magi that they saw the apparition rising heliacally. A fixed star/nova cannot resolve all the issues.

The chronological order of events is outlined as follows:

1. March 15, 5 BC, a comet arrives at the sun, unseen by Earth's inhabitants.
2. March 18/19, the night without darkness occurs in the locality of the Nephites.
3. March 19, the comet appears first in the Americas (but likely only to those considered to have astronomical skills). Christ is born in Bethlehem. In Jerusalem, lambs are set apart at roughly the same time that Christ is born.
4. Then the wise men see the comet at their sunrise because they have the requisite skills to see it.
5. The comet goes unnoticed in Jerusalem at sunrise.
6. March 22, the vernal equinox occurs.
7. March 23, Passover is celebrated and a total lunar eclipse occurs at Jerusalem during the meal.
8. The wise men journey to Jerusalem. They can, like the Chinese, observe the comet as they travel.
9. The wise men meet with Herod near the middle of June.
10. About June 12, the Earth arrives at the point where the comet had crossed the Earth's orbit 8 weeks previously. The wise men see the comet with its tail and debris field lit by the sun.
11. The wise men visit the Christ child and deliver the gifts, possibly on June 13.
12. In the middle of June, the wise men head east, and Joseph and Mary head to Egypt.
13. About the end of June, Herod begins killing the innocents.[9]
14. Shortly after that, Herod captures 40 seditious men who destroyed Herod's golden eagle at the temple gate.[10] The

9. One reviewer asked why Herod would kill all children under two if the comet was only seen 4 months before. This is a reasonable question. Herod's behavior here and in other instances seems geared to create outrage. It may also be possible that he added a significant "safety margin" in case of error in the calculation. For example, one scholar has argued that an earlier astronomical event, a triple conjunction of Saturn and Jupiter around October of 7 BC, could have been the sign of Christ's birth. If so, Herod's murderous command would also target those born at that time. See David W. Hughes, "The Star of Bethlehem," *Nature* 264 (December 1976): 513–17.

10. William Whiston, ed., *The Complete Works of Flavius Josephus* (Philadelphia: John E. Potter, 1895), 423–26, https://babel.hathitrust.org/cgi/pt?id=yul.1115973 7_000_00&view=1up&seq=1&skin=2021. The number 40 occurs occasionally in

report of these men by Josephus becomes important in the chronology, and it is for this reason that I mention it.

15. The men face a trial at roughly the beginning of September and are condemned to death.
16. September 11 (Yom Kippur), Herod replaces the high priest for the Day of Atonement.
17. September 15 (Sukkot), Herod burns the 40 men to death on the first day of the Feast of Tabernacles. Josephus reports that a lunar eclipse occurs on the night the men died.[11]
18. Herod's bad health takes an immediate turn for the worse. He dies before the next Passover.

Comet Basics

The nucleus of a comet is a conglomeration of rock, dust, and ice. This ice can be a lot of different materials — water, hydrogen cyanide, carbon dioxide, ammonia, formaldehyde, methane, carbon monoxide, or a host of other compounds. As the comet approaches the sun, these ices turn to gas. As shown in Figure 1, the gas forms a blue tail, the typical color of a gas tail. Because the gas is blown away from the comet by the solar wind, the tail always points away from the sun. At the same time, an environment of gas and dust forms around the nucleus: it is called the "coma." This is the orb that observers see in space. The coma can be massively larger than the nucleus, and its size is dependent on the location and the composition of the comet. Besides expelling gases, the comet also kicks off dust and rock. The dust tail is usually the most visible component of the comet because of its size.[12] The very lightest dust is affected by the solar wind (note the change of direction of the debris dust based on the wind direction in Figure 1). The heavier pebbles, rocks, and boulders are not as impacted by the wind. These fall behind the nucleus in a train. At times, this train is visible and is called an "anti-tail" because it tends to point in the opposite direction of the tail.

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ancient writings and is often a symbolic number. The number here is unlikely to be precise.

11. Whiston, *Complete Works of Flavius Josephus*, 425.

12. Generally, the coma would be the brightest area of the comet due to its density, but the tail, while less dense, supplies a larger area to reflect the sun's light. The Hale-Bopp comet apparition in the summer of 1995 serves as an example.

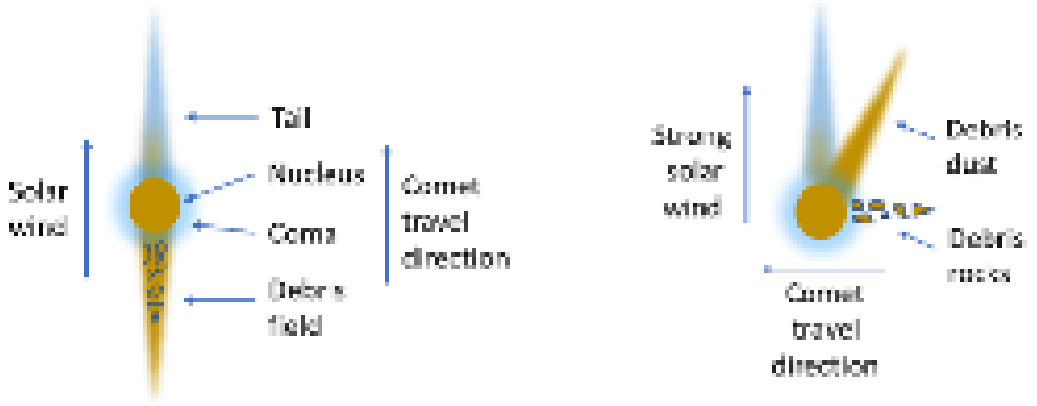

Figure 1. Comet components.

What we claim about the path of the 5 BC comet is that it departed the sun at roughly a 4.5-degree angle to the ecliptic heading for a destination near the star Algedi (Alpha Capricorni). Algedi is a rather small to average double star, but its location is useful as a general target for the comet. We can only determine the exact location where the comet was last seen within a 10-degree circle.[13] The center of that circle is at -19 degrees declination, and Algedi is near -16.5 degrees.

A Sungrazer

On about February 15, 5 BC, the comet crossed Earth's orbit heading toward the sun. By March 15, the comet was behind the sun. It had approached the sun from a direction such that it remained undetected by people on Earth. The comet was a *sungrazer*, passing within about ten sun radii of the sun itself at its perihelion, and perhaps it was much closer. It was also prograde, meaning it orbited the sun in the same direction as most of the planets.

Sungrazers become more fragile than other comets because of the strong gravitational field gradients (exacerbated by their incredibly high velocities) and extreme temperatures they pass through when circling the sun.[14] As is common for sungrazers, I propose that the 5 BC comet left significant debris in its path after perihelion. To match the description in the scriptures, the comet may have been immense — possibly much larger than Halley's Comet, which has a radius of 10 km — which is typical of a "great comet."[15] These sungrazers can be much brighter as

13. Kidger, *Star of Bethlehem*, 274.

14. Wikipedia, s.v. "Sungrazing comet," last modified February 25, 2022, 5:29 UTC, https://en.wikipedia.org/wiki/Sungrazing_comet.

15. The term "great comet" is a generic term applied to exceptionally bright and/or large comets.

they depart from the sun than they are on their approach. Outgassing from the comet during and after its encounter with the sun makes the coma grow. This would have made the comet visible in the daytime.[16] New comets, and this may be one, can be exceptionally bright because they have never gone through degassing before. For the purposes of this investigation, the comet was somewhat brighter than Venus. The average individual would not have been able to see the comet when it was close to the sun. Several comets through history have been visible with the naked eye as close as 5 degrees from the sun.[17] I do not claim that the 5 BC comet was one of these. I believe it could be seen only by astronomers on March 20, 5 BC in the Americas and then later by the wise men. At this time the comet would have been closer than 5 degrees from the sun. The comet might have not been seen for a few days after that by the average individual, but it would have been seen.

Only a sungrazer coming from the general direction of Algedi and returning toward Algedi will allow all the constraints imposed on the comet movement to be met. Also, by definition, sungrazers must be the fastest moving comets simply so that they can escape the sun's gravity. This comet was traveling at 300 km/sec at perihelion, perhaps faster. For a comparison, comet Lovejoy (C/2011 W3) produced a speed of 565 km/sec at perihelion.[18]

Also, the Great September Comet of 1882 followed a characteristically similar path in that it nearly avoided being spotted as it approached the sun. It then became bright enough to be seen in the daytime and remained visible with the naked eye for four months after perihelion.[19] The 5 BC comet was only observed for two and a half months.[20]

Light Sources

Four natural light sources could impact the night without darkness: zodiacal light, the gegenschein, aurorae, and meteors. A comet passing between the Earth and sun could supply materials that would greatly

16. David J. Eicher, *Comets!: Visitors from Deep Space* (New York: Cambridge University Press, 2013), 8.

17. Colin R. Nicholl, *The Great Christ Comet: Revealing the True Star of Bethlehem* (Wheaton, IL: Crossway, 2015), 103.

18. Wikipedia, s.v. "C/2011 W3 (Lovejoy)," last modified April 18, 2022, 20:25 UTC, https://en.wikipedia.org/wiki/C/2011_W3_(Lovejoy).

19. Wikipedia, s.v. "Great Comet of 1882," last modified July 7, 2021, 20:33 UTC, https://en.wikipedia.org/wiki/Great_Comet_of_1882.

20. The comet holding the record for longest naked-eye visibility is Hale-Bopp in 1996. It was seen for 569 days.

increase the illumination of Earth. My conclusion is that meteors, at best had a small role in the night without darkness.

The Zodiacal Light

Zodiacal light is due to forward-scattering from the interplanetary dust between the sun and the Earth. The zodiacal light is so named because its center is on the ecliptic (where the zodiac constellations are).[21] Figure 2 shows the zodiacal light with the "pillar" along the ecliptic. In the spring, the zodiacal light usually appears as a "false dusk." In the fall it is more typically seen as a "false dawn."[22]

On the evening of the night without darkness, the space between the sun and the Earth was inundated with dust and gases from the comet, thus producing something resembling the zodiacal light but far brighter, the primary commonality being that the light is forward-scattered. First, we see the dust between the sun and Earth, and later the dust will move beyond the Earth to play the major role in keeping the night as bright as day.

The Gegenschein

The gegenschein ("counter-shine")[23] is similar to zodiacal light except that its light is due to back-scattering to the Earth by interplanetary dust that is beyond the Earth. The dust tail could have added to the interplanetary dust, thereby increasing the luminosity of the gegenschein. This additional light is always opposite the sun (the antisolar point). Under normal circumstances, interplanetary dust is sparse, and individual small particles are trapped where the solar wind suspends them from falling into the sun. This precise mechanism would not play a significant role: a similar occurrence would. Once the tail of the 5 BC comet passed beyond the Earth, the backscattering from the much larger and denser particles and gases would be responsible for the night without darkness.

21. Wikipedia, s.v. "Zodiacal light," last modified April 15, 2022, 16:31 UTC, https://en.wikipedia.org/wiki/Zodiacal_light.

22. Debra Byrd and Bruce McClure, "Zodiacal Light: All You Need to Know," *EarthSky* (blog), September 6, 2021, https://earthsky.org/astronomy-essentials/everything-you-need-to-know-zodiacal-light-or-false-dawn.

23. Wikipedia, s.v. "Gegenschein," last modified June 9, 2022, 23:05 UTC, https://en.wikipedia.org/wiki/Gegenschein.

Figure 2. The top image is the zodiacal light captured by Mike Lewinski on 01/27/2019 06:57 pm at Tres Piedras, New Mexico.[24] The bottom image shows the ecliptic as determined by Starry Night Enthusiast 7 for the same time and location.

On the night of May 19–20, 1910, the Earth passed through the gas tail of Halley's Comet.[25] The dust tail missed the Earth by about 385,000 km (the average distance to the moon). Kidger says that astronomers have determined that the comet "has gone around the Sun perhaps 3,500 times in its history."[26]

24. Mike Lewinski, "Tres Piedras, New Mexico," *EarthSky* (blog), January 27, 2019, https://earthsky.org/earthsky-community-photos/entry/14688/.
25. Eicher, *Comets!*, 44.
26. Kidger, *Star of Bethlehem*, 117.

Eicher writes, "If Earth really did pass through the comet's tail, would a 'supertail' glow spanning 360° be visible? Amazingly, a passenger on a ship in the Mediterranean Sea claimed to have seen a large, faint glow like the Gegenschein, some 45° high and 60° wide with a 'pillar of light' at its center."[27] The 5 BC comet would have such a "supertail," but this article proposes that the coma of the 5 BC comet was stripped from the nucleus and driven directly across the Earth.

One challenge this hypothesis faces is demonstrating that the light sources discussed could have produced enough light to cause a night without darkness. An attached appendix argues that the unique situation with the comet tail on that night could have created a situation where there was 1,000,000 times more dust in the vicinity of the Earth than is normal. This would impact the brightness of the zodiacal light and gegenschein by six orders of magnitude.

An Aurora

Aurorae are natural lights in the sky caused by disturbances in the Earth's magnetosphere which are caused by the solar wind. The lights are caused by ionization of charged particles that rain into the upper atmosphere from the magnetosphere. Usually, these lights are seen near the Earth's polar regions — Aurora Borealis near the north pole and Aurora Australis near the south pole. Aurorae rarely reach the lower latitudes, and they are not normally capable of generating the brightness of the light $Nephi_3$ witnessed. On the night without darkness, the comet tail would add its own charged particles, which would intensify an aurora and allow it to appear at lower latitudes. The aurora could have produced some of the "great lights in heaven" (Helaman 14:3). The Carrington event, likely caused by a coronal mass ejection, in 1859 produced aurorae as far south as the Caribbean.[28]

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27. Eicher, *Comets!*, 44. The passenger stated that this was like the Gegenschein. I believe it was the zodiacal light.

28. In 1859 an interplanetary CME swept across the Earth. This is known as the Carrington Event. Some of the phenomena that occurred at that time are recorded at Wikipedia, s.v. "Carrington Event," last modified June 2, 2022, https://en.wikipedia.org/wiki/Carrington_Event. This event generated massive aurorae. One reviewer noted that he/she was unaware of any coronal mass ejection as bright as what would be needed for a CME in the scenarios considered here. Granted, modern astronomers have not seen anything like the CME plus comet tail combination that may have occurred at Christ's birth, for this was a highly unusual event. The most dramatic CME in modern history would be the Carrington event of 1859. But I would propose that the obviously unusual nature of the Star of

Coronal Mass Ejection

A coronal mass ejection, while not a light source, can play a role in producing light on Earth. "A coronal mass ejection (CME) is a significant release of plasma and accompanying magnetic field from the Sun's corona into the solar wind. CMEs are often associated with solar flares and other forms of solar activity, but a broadly accepted theoretical understanding of these relationships has not been established."[29] "When the ejection is directed towards Earth and reaches it as an interplanetary CME (ICME), the shock wave of traveling mass causes a geomagnetic storm that may disrupt Earth's magnetosphere, compressing it on the day side and extending the night-side magnetic tail."[30] The solar storm would cause a disruption in the sun's magnetic field and in turn cause the Earth's magnetic field to buckle. This we observe as both radio interference and aurorae (Northern and Southern Lights).[31]

Carolin Crawford, in a video lecture showed videos of a comet passing near the sun and another of comets falling into the sun; both of these produced solar flares.[32] Comet SOLWIND1 hit the sun on August 30–31, 1979, and the corona brightened.[33]

Scientists are not willing to state that comets passing by or falling into the sun can trigger a CME. Sometimes the sun's photosphere will erupt violently when a comet is present, while at other times nothing happens. The 5 BC sungrazing comet passing in front of the sun and the CME could have occurred simultaneously. The Earth engulfed by the CME wave would be ringed by the aurorae and from space would

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Bethlehem must necessarily involve highly unusual but not impossible events. My argument is that the mechanisms proposed here, while unusual, could still have been possible and may help provide useful explanatory power for events observed in two hemispheres.

29. Wikipedia, s.v. "Coronal Mass Ejection," last modified June 8, 2022, 17:14 UTC, https://en.wikipedia.org/wiki/Coronal_mass_ejection.

30. Ibid.

31. Ibid.

32. Carolin Crawford, "Comets: Visitors from the Frozen Edge of the Solar System," December 12, 2013, video, produced by Gresham College, https://www.youtube.com/watch?v=gBjnlfLxhEI, 53:50. Time 20:00–25:00 is of most interest; see especially 21:00–21:30, 23:10–23:30, and 23:50–24:10. Note that the comet that survived did not linger near the sun like the 5 BC model. The comet passed within about 6 solar radii.

33. Gary W. Kronk, "C/1979 Q1 Solwind 1," August 30, 1979, Cometography, José J. Chambó, http://cometography.com/lcomets/1979q1.html.

appear to shine. We could have the CME wave working in concert with the comet tail on the night of March 19 to brighten the sky.[34]

CMEs can travel at widely different speeds across space. The Space Weather Prediction Center of the National Oceanic and Atmospheric Administration (NOAA) reports that CMEs can reach Earth from the sun in as little as 15–18 hours. The same report states that "larger CMEs can reach a size comprising nearly a quarter of the space between Earth and the Sun by the time it reaches our planet."[35]

The NOAA indicated that a CME could be as large as 30+ million kilometers thick when it reaches the Earth. By the time the back edge of the CME passes the Earth, the CME could be much thicker — the backside moving slower than the front edge. It might be possible for the CME to engulf the Earth for 10 or so hours. The reflected light off of the CME would brighten the backside of Earth. The night without darkness could have been caused by the CME elements near the Earth, it could have been caused by the backscattering from the wavefront that had already passed the Earth, or it could have been a combination of the two. I have chosen to only describe the backscattering as the cause of the night without darkness.

The dashed line marked "3–17" in Figure 3 shows the expected coma/tail of the comet before the CME explosion. At perihelion, the CME would be generated and, roughly 24 hours later, would arrive at Earth. The CME, travelling at four or five times the solar wind, would flatten the coma around its wavefront. "CMEs travelling faster than the background solar wind speed can generate a shock wave. These shock waves can accelerate charged particles ahead of them — causing increased radiation storm potential or intensity."[36] The CME travelling much faster than the comet itself could effectively drive the coma ahead of the shock wave. If the CME, shown in Figure 3 as a continually expanding ball on 3–18 and 3–19, hit Earth directly on, then one would expect a thick wall of dust to appear beyond the Earth for some time. This would light up the whole night sky until the CME and solar winds drove the dust deeper into space.

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34. Naval Research Laboratory, "Coronal Mass Ejection and Huge Sun Diving Object," August 16, 2019, LASCO/NRL SOHO, https://www.youtube.com/watch?v=jApb_tb-BME. This video shows a comet hitting the sun followed by a CME.

35. "Coronal Mass Ejections," Space Weather Prediction Center, National Oceanic and Atmospheric Administration, https://www.swpc.noaa.gov/phenomena/coronal-mass-ejections.

36. Ibid.

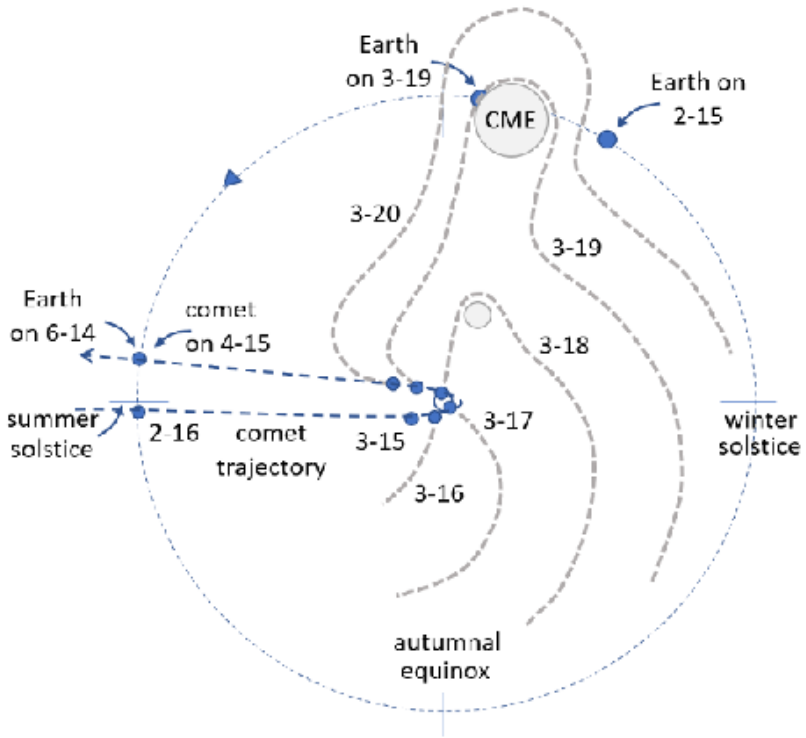

Figure 3. The tail of the comet over time. February 16 (2–16), the comet crosses Earth's orbit. April 15 (4–15), the comet moves beyond 1 AU leaving the sun.

Figure 3 also shows how the CME has stretched and smashed the tail such that the dust is a thin but wide sheet between the CME and the Earth. The flattened portion of the tail would be on the order of 50 million km long. As it crosses Earth's orbit the tail is much like a ribbon, very long, maybe many Earth diameters wide and with a thickness possibly less than the diameter of the Earth. At sunset (March 18 at about 6:30 PM American time) the distance from the Earth to the "ribbon" as shown in Figure 4 is close, but it cannot be drawn to scale. The distance could be much further from the Earth but closing fast.[37] The same holds for the view at sunrise. The ribbon would not be dense; however, the total illumination would be sufficient to keep the sky as bright as day from horizon to horizon in the location of the Nephites. I refer back to Eicher's statement: "If Earth really did pass through the comet's tail, would a 'supertail' glow spanning 360° be visible?"[38]

37. Earth moves at about 30 km/sec along its orbital path. The CME in this demonstration would be moving in the vicinity of 2000 km/sec and expanding in diameter as it moved away from the sun. For this intent and purpose, the Earth would appear to be standing still relative to the CME. Refer to "Coronal Mass Ejections," National Oceanic and Atmospheric Administration.

38. Eicher, *Comets!*, 44.

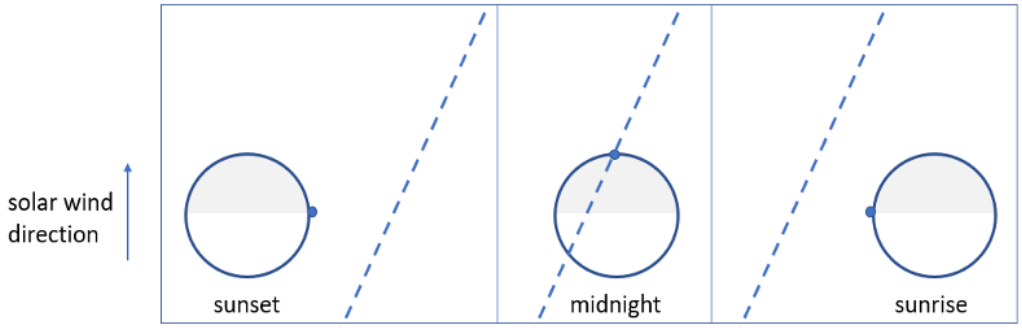

Figure 4. Earth in three different positions relative to the comet tail throughout the night without darkness. The small dark dot represents an American location. The dashed line is the flattened tail.

The Angle at Which the Coronal Mass Ejection Hit the Earth

If the CME were to pass in front of the Earth's orbit, then Asia, Europe, and Africa would see the brightness before the Americas. If the CME were to hit the Earth directly, they would see the brightness at the same time as the Americas. We have no indication in history from these continents of an event of this nature. Because of this, I propose that the CME caught planet Earth from the rear as the sun was setting in the Americas.

An angle of about 25 degrees for the dust tail/wave front crossing the Earth as shown in Figure 4 is reasonable to produce the desired results; however, some "tuning" of the speed and direction of the CME allows for a wide range of possible angles. I observe that the 25-degree angle (or any angle in the range of 15 to 45 degrees) serendipitously reduces the potential light impact on western Europe because of the directionality of what amounts to a wall of light. The Atlantic Ocean serves to provide a distance barrier of roughly 90 degrees. The angle of the wall of light is not so favorable for China at sunrise in the Americas, but it doesn't need to be, because the Pacific Ocean provides the distance barrier at about 180 degrees.

Beginning at sunset for the Nephites, a greatly enhanced false dusk Zodiacal light caused by forward-scattering would be manifest. A diffuse "pillar" would appear along the ecliptic similar in angle to the image in Figure 2. Back-scattering would add to the light in the western sky. Perhaps in the east the horizon would be dark.

As the night moved on, the collimation would improve to the point that, at midnight (Figure 4), the source of the reflected light might appear as a narrow pillar of light. At this point, though, the total luminescence of the sky would rival the sun. The pillar could have been running from

the eastern to the western horizon because of the density of the wall of dust.[39] After that, the pillar would begin to diffuse until by sunrise, the lighting would be similar to the lighting at the previous sunset.

On the Luminosity

Third Nephi 1:19 states "that there was no darkness in all that night, but it was as light as though it was mid-day." This discussion will assume that when the sun went down the light was the equivalent of direct sunlight at about 2,000 to 111,000 lux.[40] As a matter of definition, lux is a measure of how much light falls on a particular surface per square meter — in this case, the Earth. A full moon can deliver 0.25 lux on a good night.[41] Simple math shows that the sky actually has room for over 128,000 moons. If each moon area could produce 0.25 lux then the night would be at 32,000 lux at mid-day.[42] The moon is a sphere, so much of its light is scattered into space.[43] A dense wall of dust would reflect much more light to Earth, even a blinding light — and heat with it. The dust cloud was not particularly dense in the morning because the Nephites were able to see the sun at its rising. The comet (nucleus and a newly reformed coma) itself would now be rising with the sun even as the tail had swept across the Earth. (See Figure 3 for the position of the comet relative to its tail.)

A wall of interplanetary dust delivered by the comet's tail and the CME plasma is sufficient to keep an area of the Earth bright enough to validate "the night without darkness" statement. Given what we have here, I can find no solution to the night without darkness other than the massive dust, plasma, and gases provided by the comet and the CME. Further, at the lower end of the numbers given, there could have been a pillar of light as thin as perhaps 3 or 4 degrees in the sky in the late-night hours running in an east-west direction (along the ecliptic) and passing nearly overhead. The sky would be blue, but the light would

39. The pillar of light might move some of the observers to recall the pillar of fire in Exodus 13:21 and Nehemiah 9:12, 19. "[T]he pillar of fire by night, to shew them light, and the way wherein they should go."

40. Wikipedia, s.v. "Daylight," last modified May 11, 2022, 23:50 UTC, https://en.wikipedia.org/wiki/Daylight.

41. Christopher C. M. Kyba, Andrej Mohar, and Thomas Posch, "How Bright is Moonlight?," *Astronomy & Geophysics* 58, no. 1 (February 2017): 1.31–1.32, https://doi.org/10.1093/astrogeo/atx025.

42. The moon's angular size averages about 30 arcminutes.

43. Mike Luciuk, "How Bright Is the Moon?," Asterism.org, Amateur Astronomers, Inc., April 12, 2019, https://asterism.org/2019/04/12/how-bright-is-the-moon/.

be diffuse, so there would be almost no shadows on the ground. The lack of shadows likely would have made the night appear deceptively bright.[44]

Figure 11 shows the P17/Holmes comet. The perfectly white center is the coma, the nucleus would be a dot in the center of the coma. The coma of any comet is far brighter than the moon on a per area basis. Imagine that coma passing beyond the Earth. Night would turn to day.

The Chronology on the Ground

In the western hemisphere the sun set on the evening of March 18, but the sky did not darken all night long. After a night without darkness, if the comet appeared to emerge from the sun, then the first observers (astronomers) might see an odd bulge in the sun as it rose. Nephi only indicates that the new star appeared, the star might have become visible to him that day as it moved farther from the sun or later (3 Nephi 1:21).

On this Jerusalem afternoon (morning for Nephi) a child would be born in Bethlehem. The Paschal lambs were being set apart. This day was the tenth day of Abib (now called Nisan) on the Jewish calendar: this year that day fell on March 19, 5 BC.

There is a possibility that the shepherds at the birth of Christ saw a massive false dusk that night because of the unusual amount of dust between the Earth and the sun. Luke 2:9 states, in the same context, that "the glory of the Lord shone round about them." The glory of the Lord always indicates that light is present.

Several hours after the Nephite sunrise (13–15 hours? The initial location is unknown), the wise men watched the sun rise in the east with the comet's coma some 3 or 4 degrees to the south (see Figure 5). The coma might have had a line that seemed connected to the sun. This would be the glowing debris field dutifully following the comet — the anti-tail. The comet, with its coma shining, looked like a new sun being born. The glowing line would be reminiscent of an umbilical cord. The tail would also likely be visible to observers using the astronomers' tool. The wise men saw that comet for the first time on the morning after the Jews set apart the Paschal lambs for the Feast of the Passover.

44. One reviewer asked if a supernova would be a more likely source to provide the brightness required for the Star of Bethlehem. Factors ruling out a supernova or a nova are discussed in footnote 8. A fixed star, whether a nova or supernova, cannot fit the observations adequately.

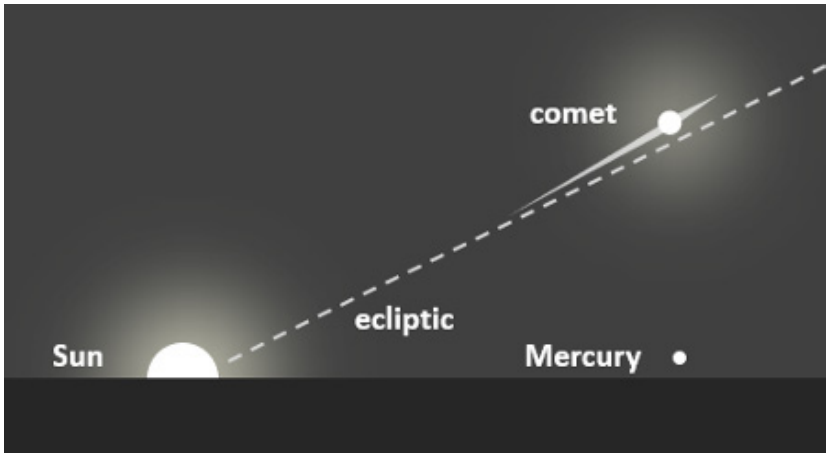

Figure 5. First view of the comet by the wise men as it pulled away from the sun's glare on the morning of March 20, 5 BC, as seen through a glass, darkly. What would be seen of the comet would be its coma and tail. Any trailing debris could also have comas. I don't believe Mercury would be visible, but its location is correct.

The Darkened Glass and Sun Spots

I believe the wise men, like $Nephi_3$, were well acquainted with scriptures and prophecies regarding the birth of the King of the Jews. As importantly, they were competent astronomers who knew, through prophecy, to expect the comet to manifest itself as a birth. Armed with this knowledge, they would have looked toward the sun through an astronomer's tool — a smoked piece of glass or obsidian[45] (just like multitudes of Americans did on August 21, 2017, when viewing a total solar eclipse) — and were able to discern the comet moving beyond the sun. This might mean that the wise men saw the 5 BC comet several days earlier than the Jews, who would not have been looking for it. Obsidian glass disks were available in the middle east at least from the 7th century BC. If this was a common astronomical tool, then we must assume that the wise men had that tool available to them when they saw the star of Bethlehem rising in the east for the first time.[46]

45. Obsidian filters are available today for cameras and for the same purpose. See one example at D1, a retail store selling the filters. "Phantom 4 Pro ND8 Filter (Obsidian)," D1, https://www.d1store.com.au/products/phantom-4-pro-obsidian-nd8-filter.

46. Polished "mirrors" of obsidian are known to have existed at least seven centuries before Christ. Some were disks polished on both sides and about 5/8 inch thick. A demonstration shows that when held up to the sun, the disk acts as a filter, allowing the safe observation of sunspots and eclipses. Typical disks are shown in Stuart Campbell et al., "The Mirror, the Magus and More: Reflections

The Comet's Travel

Table 1 shows the results of an estimation of the comet's location and speed at six locations from 0.1 AU to 1 AU. From the perspective of people on Earth, while the comet was separated from the sun by 3 degrees, it was roughly 14 hours beyond the point where it completed the transit of the sun. That is the location the wise men would have seen it. At 16 degrees from the sun, I suspect Herod's astronomers would have spotted the comet. Curiously, this would be close to the Passover meal day. Twenty-six days from the spotting by the wise men, the comet crossed the Earth's orbit at 3.64 Mkm/day (~42.1 km/sec). If my assumptions are correct, the 5 BC comet would have been brighter than Venus but far from the brightest of the great comets, some of which have been seen with the naked eye within 5 degrees of the sun.[47] Venus can sometimes be seen as a morning star with difficulty.[48]

Distance beyond the edge of the sun	Day count beyond the edge of the sun	Degrees separating the comet and sun	Estimated Date
0.1 AU	1	5°	March 20, 5 BC
0.2 AU	2.7	10°	March 22, 5 BC
0.3 AU	5.0	16°	March 24, 5 BC
0.4 AU	7.5	22°	March 27, 5 BC
0.5 AU	10	27°	March 29, 5 BC
1.0 AU	27	58°	April 15, 5 BC

Table 1. The angular separation of the sun and comet in degrees as the comet traversed the inner solar system.

on John Dee's Obsidian Mirror," *Antiquity* 95, no. 384 (December 2021): 1547–64, https://doi.org/10.15184/aqy.2021.132. Zoltan Simon argues that these disks were used long before the time of Christ and in the same general area. See Zoltan A. Simon, "Astronomy and Ancient Eclipse Art — Is It a Science?," *Art Humanities Open Access Journal* 2, no. 5 (2018): 283, https://medcraveonline.com/AHOAJ/astronomy-and-ancient-eclipse-artndashis-it-a-science.html.

47. Nicholl, *Great Christ Comet*, 103.

48. Starry Night Enthusiast 7 by Simulation Curriculum is a computer program designed for amateur astronomers, available at https://starrynight.com/Enthusiast7/index.html. It shows that Venus's apparent magnitude on April 1, 5 BC (Julian), at noon was -4.31. It was likely visible. The apparent magnitude of the sun is -26.7. The comet would have to move away from the sun far enough so that the background would be less bright than the comet in order for the comet to be seen with the naked eye. For that reason, I suspect the comet had an initial apparent magnitude of about -10.

Figure 6 was created to give a visual chronology of the comet path. After 86 days from first being spotted by the wise men and having traveled 315 million kilometers, it was spotted one last time. Observe that there are only 7 days from the time the comet first disappeared and the brief appearance. The comet was hidden by the distance, compounded by the coma of the comet shrinking as it traveled further away from the sun.

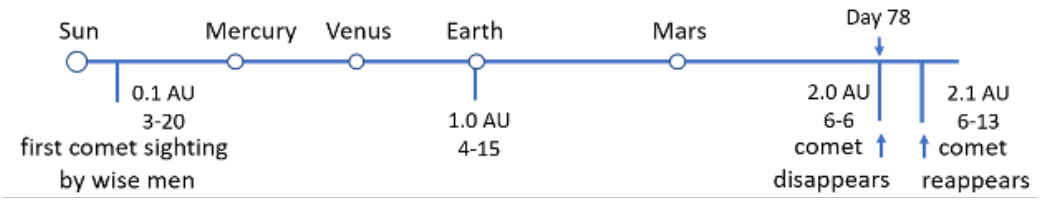

Figure 6. Timing of the comet as it traverses the inner solar system.

The comet crossed Earth's orbit heading for the sun on February 16. The dashed line in Figure 7 represents its unseen path. As it sped across Aquarius it was hidden by the sun's glare and the distance to Earth. The solid line is the visible transit across the constellations. Sometime after passing through Aquarius the comet disappeared in Capricorn. For discussion purposes the Chinese and the wise men lost track of the comet when it was directly on the same right ascension as Algedi. That was the last the Chinese saw of the comet. The wise men saw it again a few days later. Figure 7 indicates that the comet was heading toward Algedi at a rate understood by the astronomers. When the comet disappeared and then reappeared briefly later in an area anticipated by the wise men, they could confidently claim it was the star that they saw in the east and had watched it for close to 80 days. The comet would be expected to be about 7 degrees to the right of Algedi after 7 days. The apparent move to the right is due to parallax — the Earth is moving right to left relative to the comet.

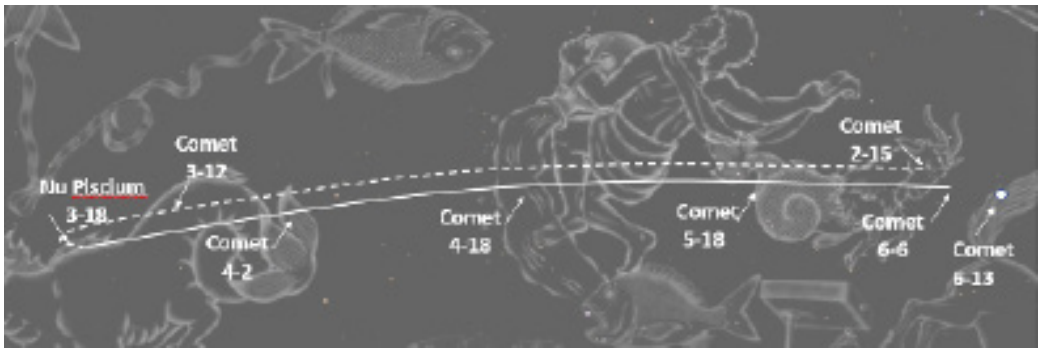

Figure 7. The comet travelling across the constellations.

The minimal date for the Chinese to see the comet disappear is 71 days after March 19. That puts the disappearance no sooner than May 30. The maximum date, because the end of the lunar cycle was April 6, was about June 24 (assuming roughly 78 days of visibility). There is a 25-day window in the whole year that allows my hypothesis to work. My solution places the final sighting by the Chinese on June 6, plus or minus 5 days. A perfect fit.

As the Earth rotates around the sun, the comet heads further away from the sun. By April 15 it crosses Earth's orbit. On June 6 (6–6) the comet arrives at the two AU mark. On that day in Figure 8 the comet would appear to be below Algedi at the same right ascension. The comet is now 300 million kilometers from the sun. Because of the temperatures in space, some of the materials that were gases have solidified and returned to the nucleus. Then, in the night hours of June 12/13, in the same spot that the comet crossed Earth's orbit on April 15, the wise men looked toward Algedi and saw their comet reappear.

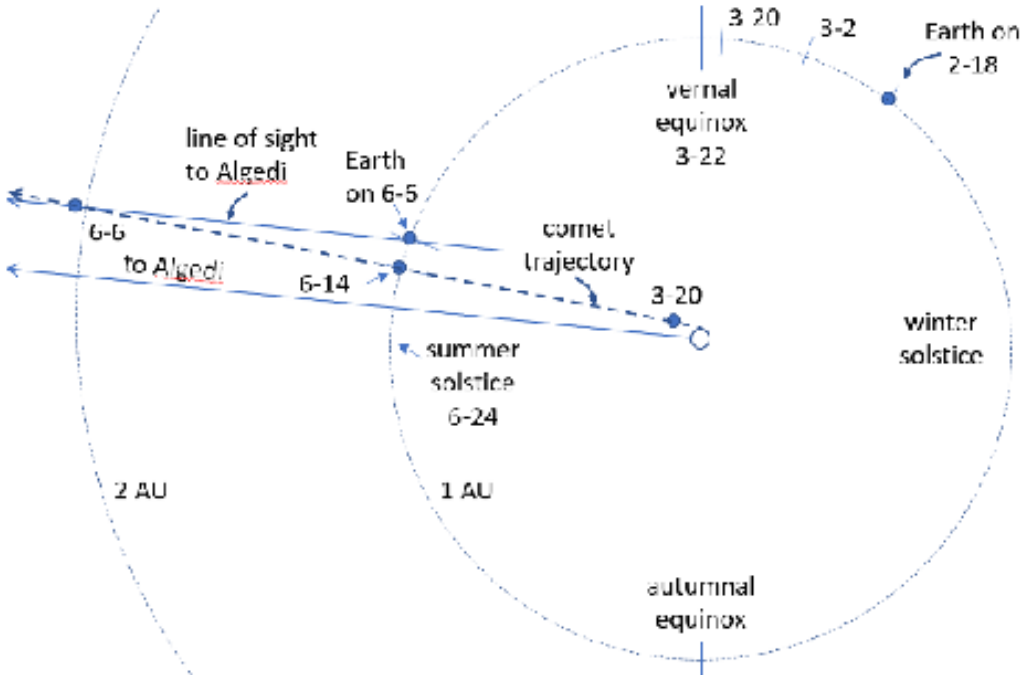

Figure 8. Movement of the comet relative to the movement of Earth.

Earth passes within 12 Mkm of the path on that night (Figure 9). The wise men may have seen faint traces in the evening as the comet began to become more visible, or they may have noticed the brightening later. At 5:30 in the morning, the sky is beginning to lighten. Sunrise is at 5:28. The comet is setting. Algedi will follow at 7:07. The comet must have reached an apparent magnitude of -1 or so as it was setting

(in astronomy "magnitude" is a logarithmic measure of brightness in which lower numbers are brighter, with the sun having a magnitude of -27 and the brightest star in the sky, Sirius, having a magnitude of -1.46, while the faintest stars the human eye can see have a magnitude around 6[49]). Because the wise men knew where to look and because the angular separation of the sun and comet is roughly 140 degrees, seeing the comet would be easy. I expect that this comet, like the Holmes comet (see Figure 11), subtended over roughly three arcminutes at its maximum.

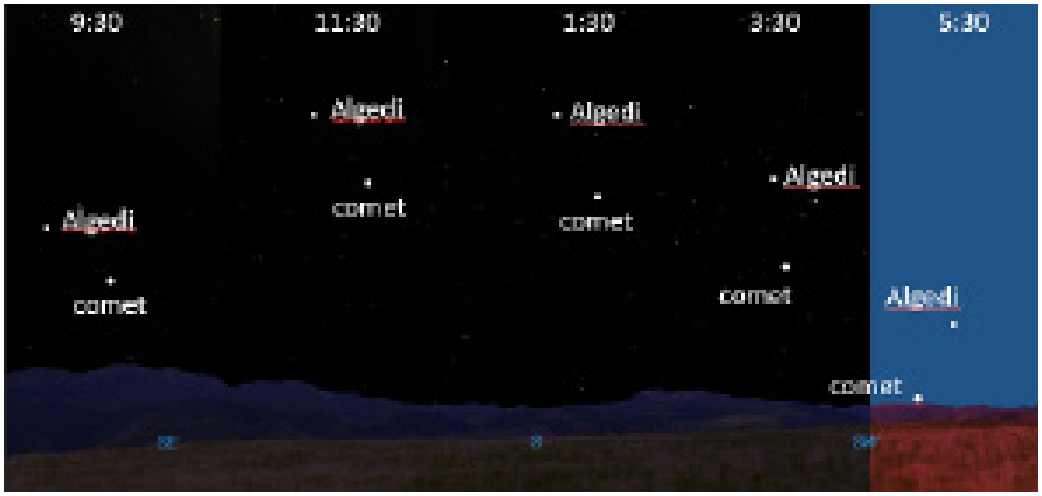

Figure 9. Panorama in five steps over 8 hours showing the comet's relationship to Algedi on the night of June 12/13, 5 BC.

The comet was never far from visibility before its brief reappearance. Figure 10 shows three different views of a comet all from the same distance from the observer. As the angle of approach shrinks to 0 degrees, the visual image increases, because more of the tail material aligns along the visual axis causing the area around the comet to become denser and causing more light to be reflected to Earth. In our case, as the Earth passes under the trail, the size of the apparition grows to the point of visibility. Because the 5 BC comet was likely a first-time visitor and a sungrazer, one would expect it to have a long and large tail.

The most conservative view is to assume at 1 degree from perfect alignment, the comet is just below the visibility threshold. That allows the comet to increase brightness constantly for about 24 hours before it disappears again below the horizon at Jerusalem at about 5:30 AM.

49. See Bruce McClure, "What is Stellar Magnitude?," *EarthSky* (blog), March 9, 2022, https://earthsky.org/astronomy-essentials/what-is-stellar-magnitude/, and Wikipedia, s.v. "Magnitude (Astronomy)," last modified April 6, 2022, https://en.wikipedia.org/wiki/Magnitude_(astronomy).

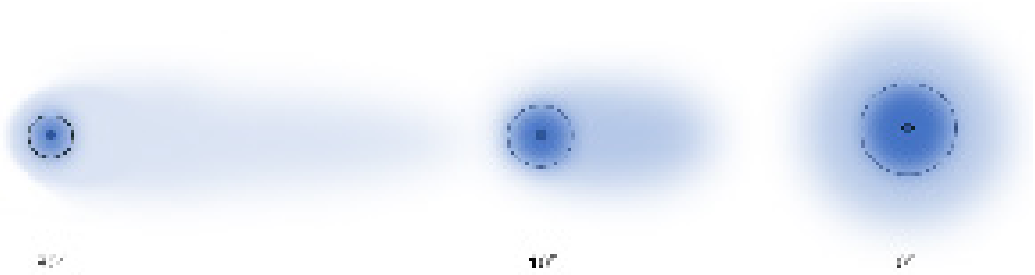

Figure 10. Three different angles of a comet in flight. The circle on each is the optical boundary. In this illustration, the tail is assumed to be too faint to be visible beyond that circle.

Under the right circumstances, this brief reappearance of a comet that seems to stand over a specific point is a given. Someone in Tehran or Rome could have seen the comet brighten in the predawn hours if they had been looking in the general direction of Algedi. It would hold no meaning for them. Once the Earth had passed under the comet trail, the comet brightness would begin decreasing, at the rate that it had earlier increased.

What we have is a tube thinly populated with dust and gases about 50,000 km wide at a distance from Earth of 160 million kilometers and a tail that is effectively half a million kilometers long. The photograph of the Holmes comet (Figure 11) is basically identical to the 0-degree angle shown in Figure 10. That bright center is not solid; it appears so only because of the density of the coma and the length of the tail. The nucleus would be a minuscule speck in the middle of the bright center. Because of the collimation, the center acts much more like a disk than a sphere when the sun's light hits it, and that greatly increases the apparent magnitude of the comet.

Holmes went from an apparent magnitude of 17 to 2.8 in 42 hours. This is an increase in brightness of 500,000 times.[50] I propose that the 5 BC comet went from 6.5 (just below visibility) to -1 (a bright star, almost as bright as Sirius) in 24 hours. This is an increase of 300 times and, because of its angular separation from the sun, is bright enough to be seen at dawn by someone looking for it. The wise men saw the comet shortly after sunset and watched it grow during the night. The 5:30 time in Figure 9 shows the position of the comet at sunrise. Holmes' brightness increase was amplified by the growth in its coma. I am not

50. Eicher, *Comets!*, 24. See also https://en.wikipedia.org/wiki/Comet_Holmes and https://apod.nasa.gov/apod/ap071026.html. Each magnitude difference is a factor of 2.512 times in brightness. Thus, a change of 14.2 magnitudes is a change of about 500,000 times in brightness; see McClure, "What is Stellar Magnitude?"

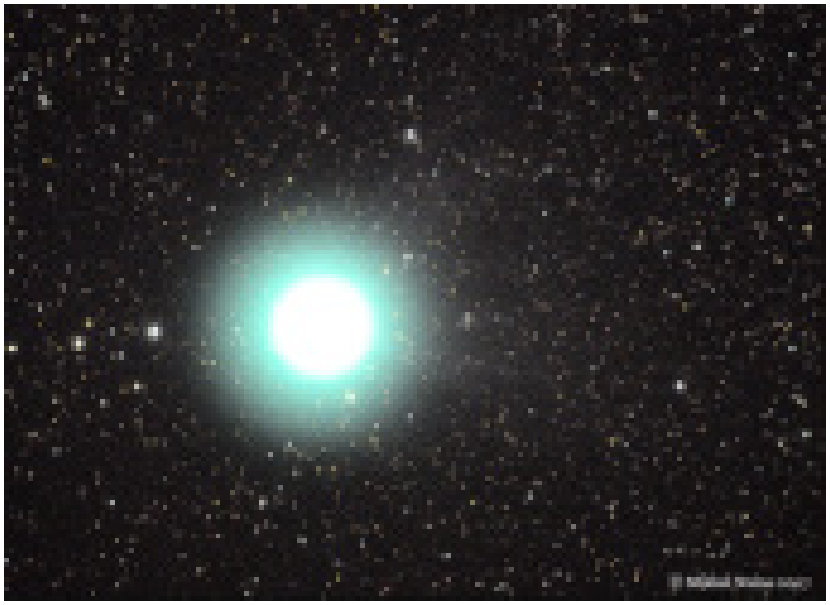

Figure 11. This Holmes comet photograph is by Mikkel Steine; Blaker, Norway; Oct. 30, 2007, https://spaceweather.com/comets/holmes/30oct07/Mikkel-Steine1.jpg.

suggesting the same thing happened to the 5 BC comet, though that can't be discounted. I think the collimation is enough to account for the increased apparent magnitude.

> Although large telescopes had already shown fine-scale cometary details, naked-eye observers saw Holmes as merely star-like until October 26 [2007]. After that date, 17P/Holmes began to appear more comet-like to naked-eye observers. This is because during the comet's outburst, its orbit took it to near opposition with respect to Earth, and because comet tails point away from the sun, Earth observers were looking nearly straight down along the tail of 17P/Holmes, making the comet appear as a bright sphere.[51]

I am claiming the same orientation for the 5 BC comet as Holmes. Curiously, the outburst occurred at 2 AU for Holmes. That is close to the same distance, 2.1 AU, from the sun where the 5 BC comet was last spotted. Holmes' apparent diameter, before the outburst, was 3.3 arcminutes.

51. Wikipedia, s.v. "Comet Holmes," last modified May 23, 2022, https://en.wikipedia.org/wiki/Comet_Holmes.

The Historical Record Mingled with Scripture

Numerous scriptures deal with the birth of Jesus. In the following sections, I examine these scriptures and discuss them relative to the historical record.

Samuel's Prophecy of Christ's Birth

Roughly five years before Christ was born, a prophet named Samuel appeared on a wall of a city in the Americas and castigated the inhabitants for their unrighteousness. On that day, Samuel prophesied the birth of the Son of God.

> And behold, he said unto them: Behold, I give unto you a sign; for five years more cometh, and behold, then cometh the Son of God to redeem all those who shall believe on his name.
>
> And behold, this will I give unto you for a sign at the time of his coming; for behold, there shall be great lights in heaven, insomuch that in the night before he cometh there shall be no darkness, insomuch that it shall appear unto man as if it was day.
>
> Therefore, there shall be one day and a night and a day, as if it were one day and there were no night; and this shall be unto you for a sign; for ye shall know of the rising of the sun and also of its setting; therefore they shall know of a surety that there shall be two days and a night; nevertheless the night shall not be darkened; and it shall be the night before he is born.
>
> And behold, there shall a new star arise, such an one as ye never have beheld; and this also shall be a sign unto you. (Helaman 14:2–5)

People around the world saw Halley's comet in September, 12 BC. This was a short seven years before the star appeared and less than two years before Samuel prophesied that "there shall a new star arise, such an one as ye never have beheld." (Helaman 14:5) This new star was to be far different than Halley's comet. Part of the difference would be the timing of the appearance of the star — the comet appearing to exit the sun and being bright enough to be seen in the daylight. The initial sighting of the 5 BC comet may have been when its coma was at its largest. Halley's comet would have first appeared dimly in the night sky and grown larger as it approached the Earth.

> And it came to pass that the words which came unto Nephi$_3$ were fulfilled, according as they had been spoken; for behold, at the going down of the sun there was no darkness; and the people began to be astonished because there was no darkness when the night came …
>
> For they knew that the prophets had testified of these things for many years, and that the sign which had been given was already at hand; and they began to fear because of their iniquity and their unbelief. And it came to pass that there was no darkness in all that night, but it was as light as though it was midday. And it came to pass that the sun did rise in the morning again, according to its proper order; and they knew that it was the day that the Lord should be born, because of the sign which had been given.
>
> And it had come to pass, yea, all things, every whit, according to the words of the prophets. (3 Nephi 1:15, 18–20)

Nephi$_3$ makes a simple statement regarding the star: "And it came to pass also that a new star did appear, according to the word (3 Nephi 1:21)." The statement allows the Nephites to first observe the star in the daytime immediately following the night without darkness. If the statement is taken at face value, the Nephites may have seen the star before the Jews in Jerusalem saw it, but that is uncertain. However, if the wise men saw the comet rising heliacally, then when the Nephites saw the sun rising, the comet would also be rising.

The consensus among scholars is that Herod the Great's death occurred early in 4 BC. While this dating is not uncontested, it will be used here.[52] This article lends some technical support for the timing of Herod's death in 4 BC. Given that Herod died in 4 BC and the comet appeared in the spring of 5 BC, Christ would have been born near Passover in 5 BC. Colin Humphreys thinks that Christ might have born on the day the lambs were set apart and that the Passover that year was in April; I think that Humphreys missed the Passover by one lunar cycle, and Christ was born on March 19, 5 BC. The Passover meal that year was eaten in the late evening on March 23.[53]

52. "The generally accepted date for the death of Herod the Great is the spring of 4 BC although other dates have also been suggested (e.g., 5 BC, 1 BC and 1 AD)." Colin Humphreys, "A Comet in 5 BC," 41.

53. Humphreys, "A Comet in 5 BC," 41.

Arguments from John the Baptist; from $Nephi_1$ the son of Lehi, in the Book of Mormon; from $Nephi_3$ the son of $Nephi_2$; and from Ezekiel[54] in the Old Testament support the date of March 19, 5 BC. Some members of the Church of Jesus Christ of Latter-day Saints have considered April 6, 1 BC, as the birth date because this is the date that the church was organized. Doctrine and Covenants 20:1 states that this was 1830 years "since the coming of our Lord and Savior Jesus Christ in the flesh." Scholars in the Church generally agree that the statement on the date of the founding of the Church is not intended as a prophetic statement about the date of Christ's birth.[55] The Book of Mormon appears to support the position that Christ was born shortly after the commencement of the 92nd year of the reign of the Judges (3 Nephi 1:4) and in the Passover season. That places his birth in the spring but does not confirm the April 6 date.[56]

Lamb of God and Passover

John the Baptist was the individual that applied the label "Lamb of God" to his cousin Jesus in the New Testament (John 1:29). What scant evidence we have implies that the Baptist knew the birth date of Christ and used that to propose that Jesus was the Lamb.[57] The Baptist must have been familiar with a tradition that has since been lost.

In the Book of Mormon, $Nephi_1$ used the term "Lamb of God" 600 years before the birth of Christ — this was before his brother Jacob learned the term "Christ."[58] The primary role of the Lamb of God is to be sacrificed in the temple, but there are chronological aspects to this title. The lamb will be born in the spring. It must be set apart 4 days before being sacrificed. It must be the meat course at the Paschal meal. It must

54. Ezekiel had a sunrise vision on the tenth day of the first month. In it he saw the glory of the Lord returning sometime in the future. Margaret Barker interprets this as Ezekiel seeing the birth of Christ. See Margaret Barker, *King of the Jews: Temple Theology in John's Gospel* (London: Society for Promoting Christian Literature, 2014), 303.

55. Jeffery R. Chadwick, "Dating the Birth of Christ," *BYU Studies Quarterly* 49, no. 4 (2010): 5–38, https://byustudies.byu.edu/article/dating-the-birth-of-christ/.

56. The Church was founded one or two days before the Jews' Passover meal in the year 1830, the Jewish date being Wednesday, April 7–Thursday, April 15, 15–22 Nisan, 5590. The Lord's Supper was one day earlier than the Jews' Passover.

57. Humphreys, "A Comet in 5 BC," 53.

58. $Nephi_1$ only learned the name "Christ" 30 or 40 years after he arrived in the Americas and after a temple was built (2 Nephi 10:3).

also be part of the flock of the slaughter (Zechariah 11:4) — the flock destined for the temple.

The Book of Mormon states that by the Nephite calendar — and this would be a liturgical calendar — Christ was born 4 days before the Nephite Passover meal.

> Now it came to pass that there was a day *set apart* by the unbelievers, that all those who believed in those traditions should be put to death except the sign should come to pass, which had been given by Samuel the prophet. (3 Nephi 1:9)

I propose that 3 Nephi 1:9 used the term *set apart* purposely. An eyewitness, $Nephi_3$, knew from earlier prophets the birth day of Christ. Probably those prophets had testified that Christ would be born at the setting apart of the lambs. I think the unbelievers also knew this and saw a particularly fitting, bitter irony in making that the day when the believers would be destroyed.

The Nephites tracked the seasons in a manner probably similar to the Jews. That is, the Nephites studied the solstices and equinoxes. Their Passover was also eaten on the first full moon after the vernal equinox. The Nephite priests tracked the heavens to time the holy days. But observe what happened after Christ was born: their calendar was changed, and the beginning of the new year moved. The only rational date for the new year would be the day Christ was born. With a shift of 10 days from the old calendar, Christ had to die on the fourth day of the first month of the year. So states the Book of Mormon (3 Nephi 8:5). We can state with certainty that this date was near or on a full moon immediately following the vernal equinox.

> And it came to pass in the thirty and fourth year, in the first month, on the fourth day of the month, there arose a great storm, such an one as never had been known in all the land. (3 Nephi 8:5)

This storm marked the death of Christ. He was born 4 days and 33 Nephite years earlier. Based on typology, this is further evidence that Christ was born on the day that lambs were set apart before the Passover in the Spring of 5 BC. In other words, he was born on what would have been the tenth day of the month Abib. The lamb in Exodus 12:3 serves as a type: "In the tenth *day* of this month they shall take to them every man a lamb."

A challenge can be made that the actual Passover dates in Jerusalem were known to occasionally violate the standard rules of the Law of

Moses. If the Jews Passover would have been wrong for any reason then the righteous Nephites' lives were in jeopardy (3 Nephi 1:9). The correct alignment between the Jews and the Nephites is most logically determined to be when both parties met the Law of Moses standard.

The Bright and Morning Star

As stated, my hypothesis depends on the first position of the comet rising with the sun as witnessed by the wise men, and the Chinese position being where the comet was last seen. The expectations of the first century Israelites must be met and account for typology and prophecy. If, for instance, Christ is the Paschal Lamb, then they would expect his birth and death to be tied to the lambs of the slaughter (Zechariah 11:4, Jeremiah 12:3, Psalm 44:22, Romans 8:36). Jesus dying on the cross while the lambs are being sacrificed in the temple is perhaps the most common type, and we see that in the four gospels. The wise men claimed they saw the star rising heliacally (Matthew 2:2). David Hughes states, "The term 'in the east' … originally was written *en té anatolé* (Greek singular) whereas 'the east' is usually *anatolai* (Greek plural). *Anatolé* has a special astronomical significance, indicating the earliest visible rising of a star at day break (the heliacal rising), and so [Matthew 2:2] should read 'for we have seen his star appear in the first rays of dawn.'"[59] We see here that the wise men saw the star rising. Samuel prophecies something similar: "There shall a new star arise" (Helaman 14:5).

It would appear to those watching as if the sun had birthed the comet. Typologically we could equate this to "the root and the offspring of David, and the bright and morning star" of Revelation 22:16. Germanus I of Constantinople (c. 634–733), in expounding on the birth of Christ, quoted his version of Psalms 110:3: "Out of the womb before the morning star I have begotten you."[60] This scripture is significantly different than present-day translations; nevertheless, it ties the birth of Christ to the morning star.[61] If the wise men had this passage available to them, they would be looking for a morning star to mark the birth of the Messiah. Peter calls him the day star (2 Peter 1:19). Luke calls him the dayspring (Luke 1:78). What we are looking for then is a star

59. Hughes, "The Star of Bethlehem," 513.

60. Margaret Barker, *The Great High Priest: The Temple Roots of Christian Liturgy* (London: T&T Clark, 2003), 99.

61. The KJV Psalm 110:3 reads, "[I]n the beauties of holiness from the womb of the morning: thou hast the dew of thy youth."

that first appears in the morning. Malachi 4:2, calls him "the sun of Righteousness."[62] Christ is both the Lamb and the morning star.

What the Wise Men Saw

Raymond Brown offers three possible locations for the home of the wise men: Parthia or Persia, Babylon, and Arabia or the Syrian desert. He comments, "While the thesis that the magi came from Persia became the dominant view among the Church Fathers, the thesis that they came from Arabia is the earliest attested view."[63] I favor the earliest view because there were Jewish colonies in Arabia, and gold, frankincense, and myrrh moved along trade routes in that region. What we can surmise is that the wise men were very interested in the king of the Jews, they possibly knew somewhat different scriptures than the disciples had and they were competent astronomers.[64] I note here that their use of the term "King of the Jews" implies that they were not from the tribe of Judah, but that does not mean they were not Israelites.

The wise men expected a star to mark the birth based on the vision of Balaam (Numbers 24:17): "I see him, but not now; I behold him, but not nigh: a star shall come forth out of Jacob and a scepter shall rise out of Israel." The reference to a scepter both indicated a ruler and effectively described the tail of certain comets by the ancient astronomers and so it appears that Balaam may have seen a comet.[65] Expecting to see a sign on the day that the Messiah was to be born, the wise men looked to the sunrise on March 20, 5 BC, saw a comet emerging from the sun, and recognized that the Messiah had been born the previous evening.

As the wise men traveled toward Jerusalem, the comet rose earlier each day. It left the inner solar system, crossing the Earth's orbital path at the place where the Earth would be in June. By mid-May the comet could be observed rising around 11:00 PM and drawing closer to Capricornus: aiming for the head of the Sea-goat. The comet was getting dimmer as

62. See also Psalm 84:11; 3 Nephi 25:2; and Ether 9:22. Revelation 22:16 is interesting because here Jesus is calling himself the bright and morning star. This is after the evident display of a bright and morning star at his birth. This is not a prophetic statement; for the early Christians it is a reminder and confirmation of the star.

63. Raymond E. Brown, *The Birth of the Messiah: A Commentary of the Infancy Narratives in the Gospels of Matthew and Luke* (New York: Doubleday, 1999), 169.

64. The wise men did not know about the birth place of the King of the Jews, but they did know the birth time.

65. Nicholl, *Great Christ Comet*, 192–96. Nicholl goes deeply into Numbers 24:17 and demonstrates that the scepter-star was both literal and metaphorical.

it moved away from the sun. Near mid-June (70 plus days after its first spotting by the Chinese), it could no longer be seen. But the astronomers knew its direction of travel and apparent speed, and when it disappeared, it was in the vicinity of Algedi.

The Vernal Equinox

The first full moon — the Passover moon — occurred one day after the vernal equinox that year. The equinox occurred on March 22; therefore, Christ was born on March 19, 5 BC. We also infer from the angels visiting the shepherds at night (Luke 2:8) that Christ was born in the afternoon or early evening in Bethlehem. The eight- or nine-hour time difference between the Americas and Jerusalem indicates that from an American perspective, Christ was born in the morning. $Nephi_3$'s eyewitness statement allows this to be correct (3 Nephi 1:21).

A remarkable event took place that Passover evening — the moon over Jerusalem rose in eclipse. This total eclipse (on March 23) lasted for 102 minutes,[66] and the partial lasted for 222 minutes. This virtually perfect total eclipse was an auspicious sight on the night of Passover. Perhaps the next morning, the average Israelite became aware of a comet with a tail rising just before sunrise.

Wherever they started from, the wise men were not under time constraints. They probably arrived at Jerusalem in early June and met with Herod for the last time near the 12th of June. In audience with Herod, the wise men asked, "Where is he that is born King of the Jews? For we have seen his star in the east, and are come to worship him" (Matthew 2:2).

Herod was surely aware of the comet. What neither he nor his scribes and priests were aware of was when the comet first appeared. Not knowing that prevented them from drawing any significant conclusions. Herod must have had some suspicion as to when the birth star of the King of the Jews should appear because, in private, he inquired diligently about the timing (Matthew 2:7). If the word got out as to the time these astronomers first saw the star, the result could be an insurrection. Herod recognized the religious implications and made plans to destroy the child. Typology based on the law of Moses suggests that the Messiah would be born when the lambs were chosen as the paschal sacrifices.

66. Fred Espenak and Jean Meeus, "Five Millennium Canon of Lunar Eclipses: -1999 to +3000," NASA Technical Publication TP-2009–214172, January 2009, https://eclipse.gsfc.nasa.gov/5MCLEmap/-0099-0000/LE-0004-03-23T.gif.

A child born on the 10th day of the Jewish year — the day set apart for choosing the sacrifices — could be recognized as the Lamb of God.

> When they had heard the king, they departed; and, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was.
>
> When they saw the star, they rejoiced with exceeding great joy. (Matthew 2:9–10)

The wise men had not seen the comet for nearly a week. On that night the Earth traveled under the track of the long-departed comet. Humphreys states, "Phrases such as 'stood over' and 'hung over' appear to be uniquely applied in ancient literature to describe a comet, and I can find no record of such phrases being used to describe any other astronomical object."[67]

Having departed Jerusalem, the men and their entourage camped by the road that led southwest to Bethlehem. Perhaps in the late evening, they observed a star-like object beginning to brighten 2.5 degrees below Algedi. At about 3:30 AM (local), Algedi was in view in the southwest and dropping toward the horizon. The "star" they had seen in the east grew brighter as it settled lower. Saying that "the star, which they saw in the east, went before them" is apropos. But what caused this apparition? On about June 12, the Earth was about to cross the path of the comet as it was leaving the inner solar system.

Figure 9 shows different positions of Algedi on the night of June 12/13. At 1:30 AM, the star Algedi was past its zenith for the night. What is happening is that the Earth is rotating — causing the star to sink toward the horizon. By 5:30 AM the comet became a (relatively) bright ball over a house as the wise men looked toward Bethlehem — "it came and stood over where the young child was." They were looking down the "barrel" of the debris field and would see something similar to the comet in Figure 11.

The wise men visited the child immediately after the sighting of the apparition and could have arrived at the house essentially at day break.[68] Herod would have expected the wise men to take a couple of days to find the Christ child. Instead, they found him at their first opportunity

67. Humphreys, "The Star of Bethlehem," 36.

68. Bethlehem sits on a high plain across a valley from Jerusalem, Jerusalem being at the same elevation as Bethlehem. One can image the wise men seeing the comet light reflecting off the limestone abode some 3 or 4 miles from their camp in the early morning hour before the visit.

to search. "And being warned of God in a dream that they should not return to Herod, they departed into their own country another way." (Matthew 2:12)

Then Joseph had a dream: "When he arose, he took the young child and his mother by night, and departed into Egypt" (Matthew 2:14). It is doubtful that a lone man with a wife and infant could travel to Egypt unaccompanied. Joseph and Mary most likely immediately joined a caravan. They left Bethlehem probably within hours of the wise men's departure. Because of the generosity of the wise men, Joseph and Mary had the financial means to flee into Egypt.

The September Lunar Eclipse and Herod's Death

"Then Herod, when he saw that he was mocked of the wise men, was exceeding wroth, and sent forth, and slew all the children that were in Bethlehem" (Matthew 2:16). Enraged, Herod went looking for the child and killed all the children under two years old around Bethlehem.[69] According to Josephus, Herod had another problem on his hands — sedition. This sedition occurred possibly weeks before an eclipse of the moon late on September 15, 5 BC. It was his response to this that buried the story of the slaughter of the innocents.[70]

Briefly, Herod had taken upon himself to create a golden eagle to be placed over the great gate of the temple. This image was a violation of the law of Moses and profaned the temple. Moreover, the eagle was a despised symbol of their Roman masters. Some outraged Jews decided to destroy the eagle, and so they did. But no less than 40 of these men, including the leaders, refused to retreat as Herod's soldiers approached and were captured on that day. These men were moved to Jericho; then important Jews were called to Jericho to observe the trial. The seditionists were sentenced to death. As a further punishment to the Jews, "Now it happened, that during the time of the high priesthood of this Matthias, there was another person made high priest for a single day, that very day which the Jews observed as a fast."[71]

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69. Jesus would have been barely 3 months old at this time, according to my hypothesis. Some researchers consider that Herod killed the children from two years old and under because the first sign heralding his birth was the triple conjunction of Saturn and Jupiter in Pisces in 7 BC. See for example, Hughes, "The Star of Bethlehem," 516. The three conjunctions were in May 29, September 29, and December 4. Herod may have assumed that the wise men had lied to him about the birth date.

70. Whiston, *Complete Works of Flavius Josephus*, 423–26.

71. Ibid., 425.

Josephus was writing a history for non-Jews. His description lacks details that would be foreign to his audience. The Passover was eaten on March 23. Based on that date, Yom Kippur (the Day of Atonement) would fall on September 11. Yom Kippur is the most solemn day of the year for Jews and is a fast day. This is the date that the high priest was substituted: no other day would serve as a meaningful punishment. He points out that "Herod deprived this Matthias of the priesthood, and burnt [the man] who had raised the sedition, with his companions, alive. And that very night there was an eclipse of the moon." Replacing the high priest on Yom Kippur was the greatest affront to the Jews that Herod could arrange. Herod was not finished offending the Jews; he chose to burn the 40 men to death on September 15. This was the first day of Sukkot, the Feast of Tabernacles.[72] That night there was a total lunar eclipse over Jerusalem. Totality lasted for 99 minutes, virtually identical to the eclipse during the Passover meal but 2 hours later.[73] Because of the feast, there was a large audience to observe the eclipse.

"But now Herod's distemper increased upon him after a severe manner, and this by God's judgement upon him for his sins."[74]

Josephus suggests that the eclipse was a portend of Herod's death. It could have occurred any time after September of 5 BC until the next Passover.[75]

Conclusion

"The heavens declare the glory of God;
and the firmament sheweth his handiwork" (Psalm 19:1)

At one time, the Israelites understood typological constructs to be manifest literally. Christ, as the Lamb, follows the rules applied to the

72. The first day of Sukkot is treated as a Sabbath, where no work is allowed. On that year, September 15 was an actual Sabbath. The Book of Ecclesiastes was read, emphasizing the "ephemeralness of life." The death of the 40 men at Sukkot was another insult by Herod aimed at the Jews. See Wikipedia, s.v. "Sukkot," last modified May 30, 2022, 8:20 UTC, https://en.m.wikipedia.org/wiki/Sukkot.

73. This is a strong argument for the only eclipse that Josephus mentions in his writing being on the night of September 11, 5 BC. It serves also to support his death in the spring of 4 BC, contrary to some scholars who opt for a 1 BC death.

74. Whiston, *Complete Works of Flavius Josephus*, 425.

75. There was a partial eclipse on March 13, 4 BC, visible from Jerusalem sometime after midnight. It lasted for 138 minutes. It was dramatically less impressive than the March 23 or September 15 eclipses in 5 BC. Some scholars, however, consider this to be the eclipse that preceded Herod's death before the 4 BC Passover.

flock of the slaughter. He is the morning star, and therefore, a star must appear in the morning. He is the firstborn, so he must be the firstborn lamb, and so forth. The Book of Mormon has very little typology relative to the Bible; however, it has the technical information that directs us to the biblical typology.

The Chinese provided one location for the comet. This location allows the comet to approach the sun without being seen from the Earth in order to meet the morning star typology. At the same time, this comet could account for the night without darkness and the appearance of the "star" on the day of the birth of Christ.

A comet seen by multiple groups around the world in 5 BC directs us to a single month for the nativity. Then Jewish rituals direct us to the specific day of the year. This particular day validates the firstborn typology, leading to evidence that the wise men saw a comet rising heliacally in the east.

The vernal equinox occurred 3 days after the appearance of the comet. At the Passover meal following the vernal equinox, the moon rose in total eclipse over Jerusalem. The wise men saw the comet for over 70 days based on Chinese records and interpreted it as the sign that the King of the Jews had been born. They watched the apparition travel toward a particular spot in the sky. They then saw something during one dawn near that particular spot that directed them to a specific dwelling. The comet was in a precise location at its setting to fulfill all of the prophecies concerning the Star of Bethlehem. The comet's movement, along with typology, places Christ's birth on March 19, 5 BC, and the wise men's visit at approximately June 13, 5 BC.[76]

The proposed chronology and mechanisms appear to work well for the birth of Christ, the travel time of the wise men, their finding the Christ child, and the flight to Egypt of Joseph and Mary, followed by the events around the Day of Atonement, the Feast of Tabernacles, and the eclipse mentioned by Josephus. Perhaps because of the other political outrages of Herod, the slaughter of the innocents was lost to secular history, only being recorded biblically.

What has been shown in this article is that a single comet in a fairly precise orientation and trajectory could have accounted for all the events associated in any way with the Star of Bethlehem. With many scholars

76. Kidger, *Star of Bethlehem*, 274. Kidger stated that the target was a 10-degree circle; the given information prevents a more accurate determination. Because of this, the date the wise men saw the comet over Bethlehem could be much closer to the summer solstice.

doubting the reality of the appearance of the star, the Book of Mormon presents a critical piece of evidence, the night without darkness, that may be the key to resolving all of the Star of Bethlehem issues.

Charles E. Dike *joined the Navy to see the world. That got old pretty fast so he joined the Church and got a BSEE at BYU (1977), then while raising a family, he completed an MSEE (1984). He spent roughly 35 years in design and research of integrated circuits. Much of his later work entailed on-chip security for microprocessors. Charles retired in 2014 and has been exploring technical details in scriptures since then with his primary focus on the Book of Mormon.*

Appendix: Estimating the Material Involved in Lighting the Night Sky in 3 Nephi 1:15–20

The dark wedge in Figure 12 represents the expansion of the comet dust pattern as it is driven from near the sun toward Earth. The outer circle is the orbit of Jupiter, roughly marking the boundary of the interplanetary dust cloud. Within this cloud, most dust particles range from 10 to 300 microns.

> The material producing the zodiacal light is located in a lens-shaped volume of space centered on the sun and extending well out beyond the orbit of Earth. This material is known as the interplanetary dust cloud. Since most of the material is located near the plane of the Solar System, the zodiacal light is seen along the ecliptic. The amount of material needed to produce the observed zodiacal light is quite small. If it were in the form of 1 mm particles, each with the same albedo (reflecting power) as Earth's moon, each particle would be 8 km from its neighbors. The gegenschein may be caused by particles directly opposite the sun as seen from Earth, which would be in full phase.[77]

77. Wikipedia, s.v. "Coronal Mass Ejection."

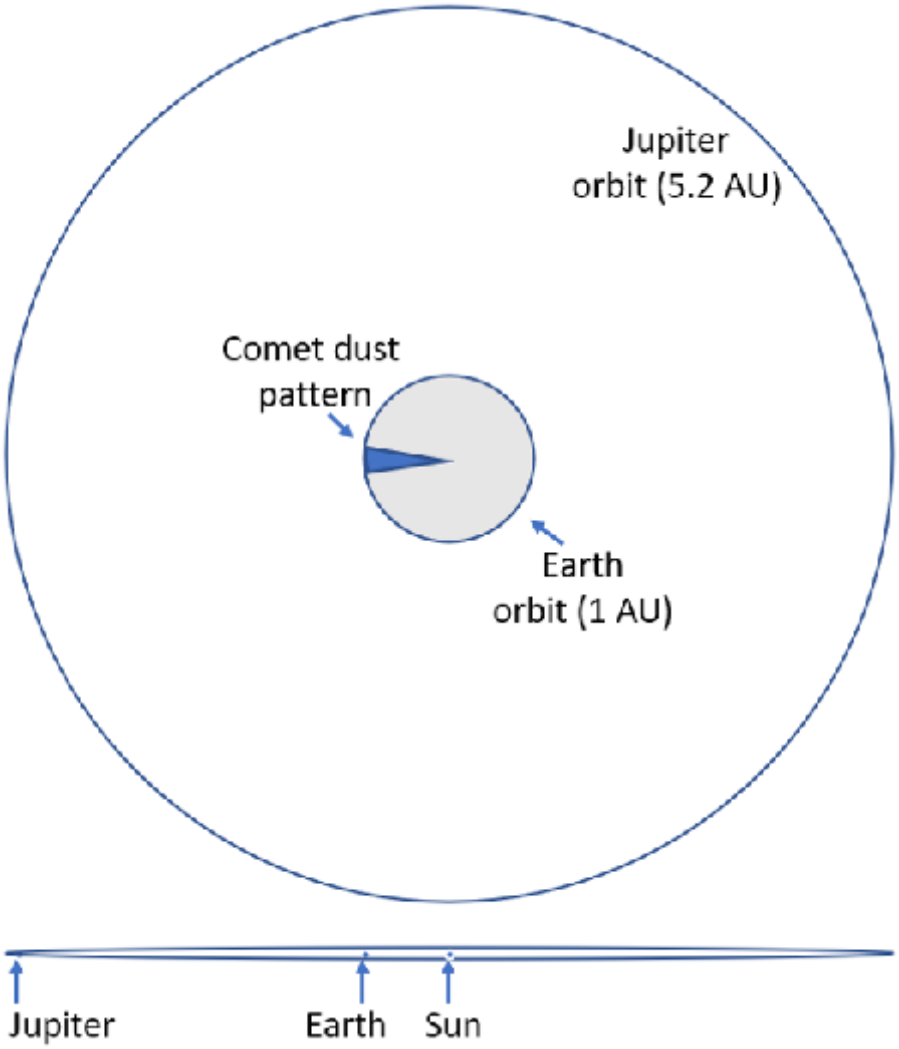

Figure 12. Interplanetary dust cloud. Top and side views.

Trying to estimate the dust added to interplanetary space is rife with assumptions that can produce gross uncertainties.

1. I will assume that the interplanetary dust discussed here is distributed throughout the solar system bounded by the orbit of Jupiter at 5.2 AU from the sun.
2. The distribution will be in the form of a disk on the ecliptic. The thickness of the disk at Earth is probably about 100 times the diameter of Earth. The diameter of the sun is about 109 times the diameter of Earth.
3. The total mass of the normally existing interplanetary dust is the equivalent of an asteroid with a diameter of 15 km and

a density of 2.5 g/cm^3. This information was taken from the Wikipedia link given.[78]

4. For simplicity, the Star of Bethlehem dust production will be the identical size to the mentioned asteroid. This assumes a "great comet" that is highly impacted by its near approach to the sun.

The interplanetary dust is not uniformly distributed throughout the solar system. The dust tends to be denser around the orbital paths of the planets, and there is an area in the sun's corona where no dust exists.[79] For the purposes of this appendix, these facts will be ignored. Figure 12 compares the disk area at 1 AU and at 5.2 AU.

A quick glance at the density of the comet dust compared to the zodiac disk suggests that the comet dust is easily one million times denser than the zodiac dust. Assume the Earth is covered in a hemisphere of comet dust with a radius of 385,000 km. Assume further that the zodiac disk is as thick as the sun's diameter. The number of these hemispheres contained within the circle defined by the Earth's orbit would be about 600,000. The comet dust density is probably greater than 600,000 times the zodiac dust density with a comparable brightness increase. The luminosity of starlight (see Table 2) implies that the one million times increase is correct within one order of magnitude. I believe having this perspective helps in visualizing the massively brighter gegenschein and zodiacal light on the night without darkness. A more rigorous approach follows.

If the hypothesis is correct and the comet dust cloud exists, then Helaman 14:4 has an interesting statement: "[F]or ye shall know of the rising of the sun and also of its setting; … nevertheless the night shall not be darkened; and it shall be the night before he is born." The cloud is thin enough to allow the sun to be visible behind it. This is an important eyewitness observation: a cloud so dense as to be able to hide the sun would most likely reflect so much light and heat that it would be a health hazard. We saw that the zodiacal cloud is extremely sparse and the eye-witness report effectively states that the comet cloud is not completely opaque during that night.

78. Wikipedia, s.v. "Interplanetary Dust Cloud," last modified May 8, 2022, 9:12 UTC, https://en.wikipedia.org/wiki/Interplanetary_dust_cloud.

79. Lina Tran, "What Scientists Found after Sifting through Dust in the Solar System," Goddard Space Flight Center, NASA, March 12, 2019, https://www.nasa.gov/feature/goddard/2019/what-scientists-found-after-sifting-through-dust-in-the-solar-system.

The interplanetary dust around the Earth ranges in size from about 10 to 100 microns. The dust from the coma would also contain much larger particles. As a curiosity, because the gegenschein is at the antisolar point, as the sun sets in the west, the bright antisolar area in this case would appear to arise in the east and travel along the zodiacal light band (which runs nearly perfectly east-west near the vernal equinox).

How Bright was the Night?

How bright is a day? Lux is a measure of lumens; 1 lux equals 1 lumen per square meter. A 75-watt incandescent bulb produces roughly 1,000 lumens.

Illuminance	Example
120,000 lux	Brightest sunlight
20,000 lux	Shade illuminated by entire clear blue sky, midday
1,000–2,000 lux	Typical overcast day, midday
400 lux	Sunrise or sunset on a clear day (ambient illumination)
0.25 lux	A full moon, clear night sky
0.0001 lux	Starlight, overcast moonless night sky

Table 2. Examples of illuminances.[80]

Bright daylight illuminance can be measured as high as about 120,000 lux for direct sunlight at high noon. If this amount of illuminance lasted for a few hours instead of for a short time around high noon, the temperature on the ground could rise to the point that it would be a health risk. I suspect that the night without darkness illuminance ranged from 2,000 lux to 20,000 lux. From Table 2, the lower end of the illuminance has to be above 400 lux, and the top end could be satisfied with 1,000 lux (though pessimistically), so I feel the range suggested is fair. The relevant scriptures are below.

> Helaman 14:3 And behold, this will I give unto you for a sign at the time of his coming; for behold, there shall be great lights in heaven, insomuch that in the night before he cometh there shall be no darkness, insomuch that it shall appear unto man as if it was day.
>
> Helaman 14:4 Therefore, there shall be one day and a night and a day, as if it were one day and there were no night; and this shall be unto you for a sign; for ye shall know of the rising

80. Wikipedia, s.v. "Daylight."

> of the sun and also of its setting; therefore they shall know of a surety that there shall be two days and a night; nevertheless the night shall not be darkened; and it shall be the night before he is born.
>
> 3 Nephi 1:15 And it came to pass that the words which came unto Nephi were fulfilled, according as they had been spoken; for behold, at the going down of the sun there was no darkness.

Based on the distribution of the light from what can be described as a cloud, one would not expect to see shadows. This would likely cause the night to appear brighter than would be evidenced by the amount of illumination.

Moon Shine

The sky has room for nearly 128,000 moons at 385,000 km from the Earth. We have a total volume for the comet material of 1.7 x 10^12 cu meters. If that material were spread in a hemisphere shape with a radius of 385,000 km, this hemispherical shell would be 1.81 microns thick. From a practical perspective, this thin shell could not be made of dust — the dust particles being much larger. For the purpose of this appendix, I will assume that an average thickness of over 100 microns is needed to practically deal with dust from the comet. To simplify the mathematics, I have chosen to increase the thickness of the shell by 64 times. The thickness then becomes 116 microns on average. Doing this effectively shrinks the number of moons by 64 times so now the sky would appear to only have 2,000 moons. With each moon delivering 0.25 lux to Earth the total illumination is 500 lux.

In Table 3, 2,000 moons completely fill the sky at a distance of 48,000 km from Earth. This produces 32,000 lux on Earth, which is more than enough to account for a day as bright as mid-day.

Dust Distance from Earth	Hemisphere Area in Moons	Reflective Moon Count	Thickness of Hemisphere	Illuminance on Earth
385,000 km	128,000	2,000	116 microns	500 lux
192,000 km	32,000	2,000	116 microns	2,000 lux
96,000 km	8,000	2,000	116 microns	8,000 lux
48,000 km	2,000	2,000	116 microns	32,000 lux

Table 3. Illuminance on Earth from the cloud with a fixed thickness of dust. The albedo is 0.12.

Recall that Eicher wrote, "If Earth really did pass through the comet's tail, would a 'supertail' glow spanning 360° be visible?"[81] This exercise meets our expectations with the coma material of the new comet sweeping over the Earth. The coma would be far brighter than Halley's comet tail at the same distance from Earth simply because there is far more material.

Practically, the dust cloud would be hundreds of kilometers thick with the particles sparsely scattered through the cloud. If the dust distance were viewed as an average distance, then the illuminance would be fairly accurate.

What about the Albedo?

The Moon's albedo (reflectivity) is, on average, 0.12. If the Moon were a perfect reflector, its albedo would be 1.0. In other words, 12% of the light that hits the Moon is reflected — the Moon is a poor reflector. That is a reason why Earth receives only 0.25 lux from it on perfect conditions. If the Moon did not have the dark seas (maria) then the albedo would be 0.18.

People on Earth never see a true full moon, because when the Moon is perfectly aligned with the sun and Earth, there is a lunar eclipse. According to Mike Luciuk in an article at asterism.org, "Apollo astronauts reported that a true full Moon is about 30% brighter than what we see on Earth."[82] Adding 30% to the improved Moon brings the albedo to about 0.24. If the improved lunar number is double the average albedo of the Moon at a distance of 48,000 km, the cloud could deliver 64,000 lux.

Studies of interstellar dust have shown that an albedo of 0.60 is not unreasonable.[83] If we dare use the interstellar dust albedo of 0.60, that would deliver 160,000 lux — with a life destroying brightness and heat. If the dust had this high of albedo, we would simply need much less dust. Curiously, if an albedo of 0.5 is used — this being measured albedo for the interplanetary dust — the dust cloud would deliver a maximum of 120,000 lux. This is the same illuminance as a bright sunlit day at high noon.

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81. Eicher, *Comets!*, 44.

82. Luciuk, "How Bright Is the Moon?"

83. John S. Mathis, "Interstellar Dust and Extinction," *Annual Reviews of Astronomy and Astrophysics* 28 (1990): 37–70, https://ned.ipac.caltech.edu/level5/Mathis/Mathis4.html.

Conclusion

The dust cloud is feasible. Whether it existed is conjecture. A zodiacal light and gegenschein combination that can approach one million times brighter than nominal events is capable of producing a night without darkness. With or without adding the gases from the coma and aurorae generated from the CME the dust is sufficient to satisfy this hypothesis. And the night without darkness occurs before a star appears.