

On Dating the Lunar Eclipse of Alexander and the Battle of Gaugamela: Discussion of Evidence and Use of Archaeoastronomy for Chronology

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Here we propose an archaeoastronomical discussion of evidence concerning the dating of the Battle of Gaugamela. This battle was preceded by a total lunar eclipse, which is also known as the eclipse of Alexander, used to date the decisive battle of the invasion of the Persian Achaemenid Empire.

This eclipse is one of the many used for chronology.

Keywords: Chronology, Archaeoastronomy, History of Science, Joseph Scaliger, David Brewster, Pliny the Elder, Software, CalSKY, Stellarium.

Written in Turin, 30 June 2019. DOI: 10.5281/zenodo.3263733

Let us imagine that we had a DeLorean time machine (the time travel vehicle featured in the movies *Back to the Future*), and that, by means of it, we could observe some events in the past. After we have decided the event to study, what is the “destination time”, month, day, year, hour, minute, that we have to set into the time circuits of the DeLorean? Of many of the events of the past we do not know a specific date. Historical sources are lacking, and, even in the case that a date is reported, it could be questionable. In any case, if we are in the lucky position of possessing the date, we have to convert it into the numbers required by the time machine.

The time circuits of the DeLorean are using a calendar with years limited to four digits and negative years are not allowed, so that the DeLorean can travel to any time from 1 January 1 AD to 31 December 9999 AD. Therefore, the machine is using a proleptic Gregorian Calendar, produced by extending the Gregorian calendar backward to dates preceding its official introduction in 1582. So, for the dates given by the historical Julian Calendar for instance, we have to convert them into Gregorian dates. In any case, in doing the conversion, we need to be very careful, as shown and previously discussed [1-5]. Let us remember that the Gregorian Calendar is the reform of Julian Calendar, the calendar established by Julius Caesar and that started on the first of January, 45 BC [1]. Previously, the Romans had a calendar based on the observation of the phases of the moon, like those used by the Greeks.

If we possess a historical date of an event, given according to a specific calendar, we can convert it

into a date of the universal time used by astronomers, which is known as the Julian Period, a chronological system proposed by the scholar Joseph Justus Scaliger in 1583, that is, at the time of the Gregorian reform. In astronomy, the measure of time is mainly represented by the continuous count of days since the beginning of the Julian Period. The Julian day number 0 is assigned to the day starting at noon on January 1, 4713 BC, of the proleptic Julian calendar, or November 24, 4714 BC, of the proleptic Gregorian calendar. Let us stress that this astronomic manner of representing time is different from the historical Julian Calendar.

Tools for converting calendars exist. If we have not a date that we can use for the conversion, we can try to find, in the historical records, some related events of which we know the date, or the mention of some relevant astronomical events, which can be identified by means of some astronomical investigations (freely-available astronomical software exist to find the events according to the Julian dates in the Julian Period). This approach to chronology is therefore linked to archaeoastronomy. Here we will consider a case study: it is the date of the Battle of Gaugamela. We discuss evidence concerning the dating of the Battle, which was the decisive battle of Alexander the Great in his invasion of the Persian Achaemenid Empire. Its date is coming from a lunar eclipse. This eclipse, known also as the Alexander eclipse, is one of the many eclipses – solar and lunar – used for chronology.

Encyclopedia Britannica and Wikipedia In 331 BC, Alexander's army met the Persian army of Darius III near Gaugamela, close to the modern city of Dohuk in Iraqi Kurdistan, about 30 km from Mosul. The Encyclopaedia Britannica tells that it was on October 1, 331 BC [6]. The same date we find in Wikipedia. From that battle, “Though heavily outnumbered, Alexander emerged victorious due to his army's superior tactics and his deft employment of light infantry. It was a decisive victory for the Hellenic League and led to the fall of the Achaemenid Empire.” [7]

In [7] it is told that “After the Macedonian army had crossed the Tigris a lunar eclipse occurred. [W15] Following the calculations, the date must have been October 1 in 331 BC [W17]. Alexander then marched southward along the eastern bank of the Tigris. On the fourth day after the crossing of the Tigris his scouts reported that Persian cavalry had been spotted, numbering no more than 1000 men.” The sentence of Wikipedia - following the calculations, the date must have been October 1 in 331 BC - is not good, because it seems referring to the lunar eclipse and not the Battle. In any case, let us consider the given notes [W15] and [W17], and investigate how the date had been determined.

[W15] refers to Arrian's *Anabasis*, that we can find at the following link https://en.wikisource.org/wiki/The_Anabasis_of_Alexander/Book_III/Chapter_VII . This *Anabasis*

of Alexander was translated by E. J. Chinnock. Chapter VII - Passage of the Euphrates and Tigris. Here the part concerning the lunar eclipse and the related notes.

Anabasis of Alexander [W15] Alexander arrived at Thapsacus in the **month Hecatombaion**,[a1] in the **archonship of Aristophanes at Athens**; and he found that two bridges of boats had been constructed over the stream. But Mazaeus, to whom Darius had committed the duty of guarding the river, with about 3,000 cavalry, 2,000 of which were Grecian mercenaries, was up to that time keeping guard there at the river. For this reason the Macedonians had not constructed the complete bridge as far as the opposite bank, being afraid that Mazaeus might make an assault upon the bridge where it ended. But when he heard that Alexander was approaching, he went off in flight with all his army. As soon as he had fled, the bridges were completed as far as the further bank, and Alexander crossed upon them with his army.[a2] Thence he marched up into the interior through the land called Mesopotamia, having the river Euphrates and the mountains of Armenia on his left. When he started from the Euphrates he did not march to Babylon by the direct road; because by going the other route he found all things easier for the march of his army, and it was also easier to obtain fodder for the horses and provisions for the men from the country. Besides this, the heat was not so scorching on the indirect route. Some of the men from Darius's army, who were dispersed for the purpose of scouting, were taken prisoners; and they reported that Darius was encamped near the river Tigris, having resolved to prevent Alexander from crossing that stream. They also said that he had a much larger army than that with which he had fought in Cilicia. Hearing this, Alexander went with all speed towards the Tigris; but when he reached it he found neither Darius himself nor any guard which he had left. However he experienced great difficulty in crossing the stream, on account of the swiftness of the current,[a3] though no one tried to stop him. **There he made his army rest, and while so doing, an eclipse of the moon nearly total occurred.**[a4] Alexander thereupon offered sacrifice to the moon, the sun and the earth, whose deed this was, according to common report. Aristander thought that this eclipse of the moon was a portent favourable to Alexander and the Macedonians; that there would be **a battle that very month**, and that victory for Alexander was signified by the sacrificial victims. **Having therefore decamped from the Tigris, he went through the land of Aturia**,[a5] having the mountains of the Gordyaeans [a6] on the left and the Tigris itself on the right; and on the **fourth day after the passage** of the river, his scouts brought word to him that the enemy's cavalry were visible there along the plain, but how many of them there were they could not guess. Accordingly he drew his army up in order and advanced prepared for battle. Other scouts again riding forward and taking more accurate observations, told him that the cavalry did not seem to them to be more than 1,000 in number.

Notes: [a1] June-July, B.C. 331; [a2] We learn, from Curtius (iv. 37), that Alexander took eleven days to march from Phoenicia to the Euphrates; [a3] Curtius (iv. 37) says that Tigris is the Persian word for arrow; and that the river was so named on account of the swiftness of its current. The Hebrew name is Chiddekel, which means arrow. ...; [a4] This eclipse occurred September 20th, B.C. 331; [a5] The part of Assyria lying between the Upper Tigris and the Lycus was called Aturia; [a6] Called Carduchi by Xenophon. These mountains separate Assyria and Mesopotamia from Media and Armenia.

The Greek text is given at <http://www.perseus.tufts.edu/hopper/text> : καὶ τῆς σελήνης τὸ πολὺ ἐκλιπὲς ἐγένετο: καὶ Ἀλέξανδρος ἔθυε τῇ τε σελήνῃ καὶ τῷ ἡλίῳ καὶ τῇ γῇ, ὅτων τὸ ἔργον τοῦτο λόγος εἶναι κατέχει. Flavii Arriani Anabasis Alexandri. Arrian. A.G. Roos. in aedibus B. G. Teubneri. Leipzig. 1907.

CHAPTER VIII. Description of Darius's Army at Arbela. Alexander therefore took the royal squadron of cavalry, and one squadron of the Companions, together with the Paeonian scouts, and marched with all speed; having ordered the rest of his army to follow at leisure. The Persian cavalry, seeing Alexander, advancing quickly, began to flee with all their might. Though he pressed close upon them in pursuit, ... The whole army of Darius was said to contain 40,000 cavalry, 1,000,000 infantry, and 200 scythe-bearing chariots. ... With these forces Darius had encamped at Gaugamela, near the river Bumodus, about 600 stades distant from the city of Arbela, in a district everywhere level; for whatever ground thereabouts was unlevel and unfit for the evolutions of cavalry, had long before been levelled by the Persians, and made fit for the easy rolling of chariots and for the galloping of horses. For there were some who persuaded Darius that he had forsooth got the worst of it in the battle fought at Issus, from the narrowness of the battle-field; and this he was easily induced to believe.

*CHAPTER IX. Alexander's Tactics.—His Speech to the Officers. When Alexander had received all this information from the Persian scouts who had been captured, **he remained four days in the place where he had received the news**; and gave his army rest after the march. He meanwhile fortified his camp with a ditch and stockade, as he intended to leave behind the baggage and all the soldiers who were unfit for fighting, and to go into the contest accompanied by his warriors carrying with them nothing except their weapons. Accordingly he took his forces by night, and began the march about the second watch, in order to come into collision with the foreigners at break of day. As soon as Darius was informed of Alexander's approach, he at once drew out his army for battle; and Alexander led on his men drawn up in like manner. Though the armies were only sixty stades from each other, yet they were not in sight of each other, for between the hostile forces some hills intervened. ...*

So we see from Arrian, that more than eight days passed from the eclipse to have the two armies close each other.

The *Anabasis of Alexander* was composed by Arrian of Nicomedia in the second century AD, most probably during the reign of Hadrian. The *Anabasis* – complete, in seven books - is the history of the campaigns of Alexander the Great, between 336 and 323 BC. From the *Anabasis of Alexander* we have the year, 331 BC, of the Battle of Gaugamela. It is given as the year of the archonship of Aristophanes at Athens. It seems that the year in the calendar used by Athenians was starting from the summer solstice. So the Aristophanes' rule was covering half year 331 BC and half 330 BC. However, we have another remarkable detail in Arrian's text, the lunar eclipse. And this astronomical event is giving the year. In the note [a4], we read that it was on 20 September 331 BC.

CalSKY and Stellarium As previously told, we can use some astronomical software to simulate the sky in the past. In particular, we will use CalSKY and Stellarium. The date is given according to the Julian Period. First, let us use CalSKY. We can set the place of observation in Mosul, about 30 km from the place of the Battle. Let us ask software to give us the lunar eclipses during the year 331 BC. The result is that of 20 September (Julian day). Besides giving all the details about the moon, software is also providing a graphical chart (Figure 1).

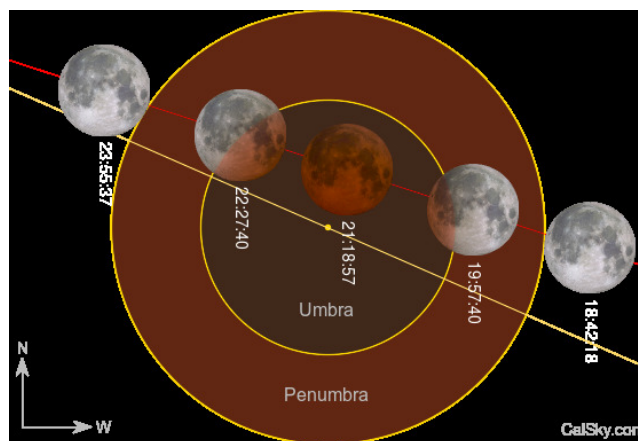


Figure 1. The simulation of the eclipse. Courtesy CalSKY.com

At the time 21h18m57s (ET-UT1=241.38m), it was the total Lunar Eclipse. Saros-Number: 51, Magnitude=1.217, Position angle=162.1°, Position angle vertex=202.2°. Brightness=-1.8mag, Danjon scale L=2.7 (bright), Diameter=33.78'. Duration total phase=65.1 minutes, Duration partial phase=198.0 minutes, Duration penumbral phase=313.3 minutes, ET-UT=14482.6sec. Altitude=35.2°, Azimuth=127.1° SE, Sun altitude=-35.7°.

If we know the astronomical event, we can properly define the time of it, given in the astronomical

framework of the Julian date in the Julian Period. If we use Stellarium, we can also observe the part of the sky where it was occurring (Figure 2). We need to be careful using Stellarium, where year “0” means 1 BC. The conventional BC/AD scheme has no year 0, thus the year before 1 AD is 1 BC. Astronomers often use a different scheme, referring to AD dates as a positive integer, and re-designating 1 BC/BCE as the year 0. Then, -330, 9, 20 gives us the moon in the same position given by CalSKY.

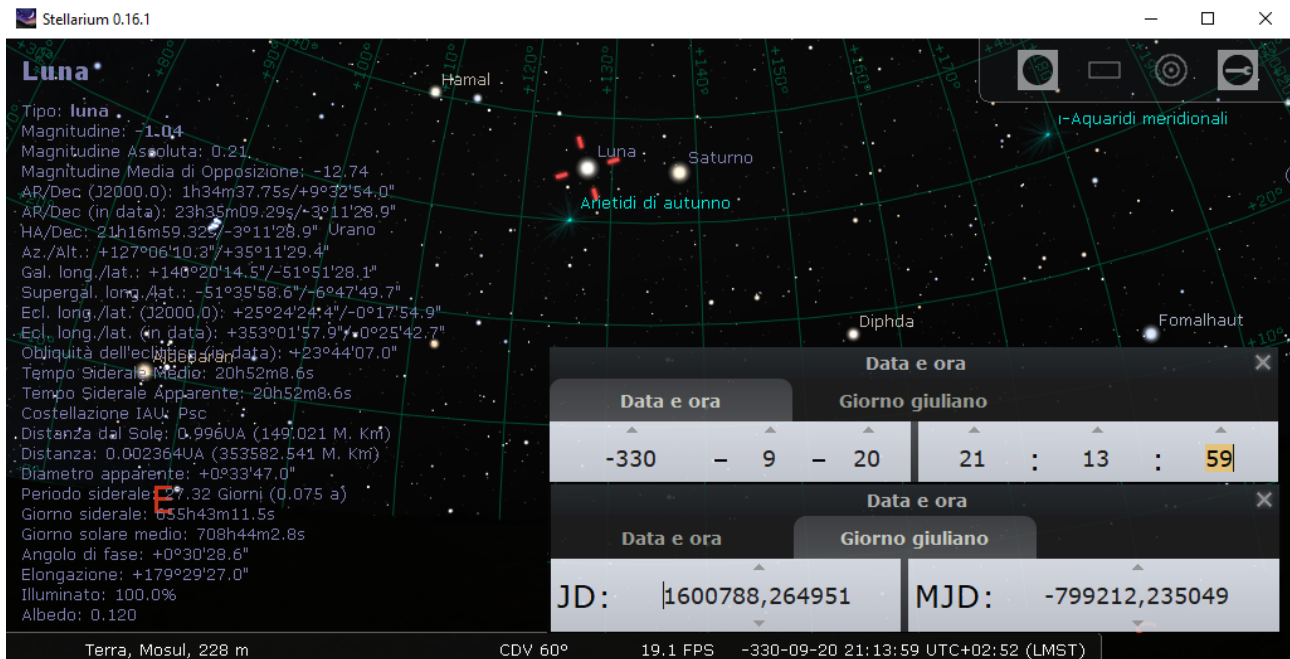


Figure 2: Thanks to Stellarium we can see the part of the sky where the moon was during the eclipse. Two panels are shown with the Julian day (lower panel) and its conversion into a proleptic Julian Calendar. For a discussion on conversion and a tool for the conversion, see please the page of the United States Naval Observatory at the link <https://aa.usno.navy.mil/data/docs/JulianDate.php>.

Diodorus Siculus, Plutarch, Curtius and Arrian again Let us continue our discussion of the references given by Wikipedia. [W17] refers to a note given to the text of Diodorus Siculus: http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Diodorus_Siculus/17C*.html note 77. The link corresponds to The Library of History, Diodorus Siculus, published in Vol. VIII of the Loeb Classical Library edition, 1963. Diodorus Siculus (1st century BC) or Diodorus of Sicily was a Greek historian. He wrote, between 60 and 30 BC, a monumental universal history, much of which survives. The history had been arranged in three parts. The first covers mythic history up to the destruction of Troy. The second covers the Trojan War to the death of Alexander the Great. The third covers the period to about 60 BC.

Alexander, nevertheless, when he came to the crossing of the Tigris River, learned of the ford from

some of the local natives, and transferred his army to the east bank. This was accomplished not only with difficulty but even at substantial risk. The depth of the water at the ford was above a man's breast and the force of the current swept away many who were crossing and deprived them of their footing, and as the water struck their shields, it bore many off their course and brought them into extreme danger. But Alexander contrived a defence against the violence of the river. He ordered all to lock arms with each other and to construct a sort of bridge out of the compact union of their persons. [DS76] Since the crossing had been hazardous and the Macedonians had had a narrow escape, Alexander rested the army that day, and on the following he deployed it and led it forward toward the enemy, then pitched camp not far from the Persians. [DS77]

The notes [DS76] and [DS77] tell the following. [DS76] Curtius, 4.9.15-21. Arrian (3.7.5) merely remarks that Alexander crossed with difficulty. [DS77]. The tradition of the date of the battle is confused. Eleven days before it (Plutarch, Alexander, 31.4) there occurred in the Attic month Boedromion an eclipse of the moon which has been identified as that of 20/21 September 331 B.C. (Curtius, 4.10.2; Arrian, 3.7.6). If the Attic month followed the moon in practice as it did in theory, this should have been on the 15th of Boedromion, and the battle fought on the 26th or 27th. Arrian, however, states that the battle took place in Pyanepsion (3.15.7), presumably the month of the eclipse also. Justin (11.13.1) simply says that the battle occurred "postero die" after the dismissal of Dareius's embassy.

The note is mentioning Plutarch (c. AD 46 – c. 120). He was a Greek biographer and essayist, known for his Parallel Lives. He was later named, upon becoming a Roman citizen, Lucius Mestrius Plutarchus. Plutarch's surviving works were written in Greek. Plutarch, Alexander, 31.4 is available at http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Plutarch/Lives/Alexander*/4.html#31.4

*Now, the great battle against Dareius was not fought at Arbela, as most writers state, but at Gaugamela. The word signifies, we are told, "camel's house," since one of the ancient kings of the country, after escaping from his enemies on a swift camel, gave the animal a home here, assigning certain villages and revenues for its maintenance. It so happened that in the month Boëdromion the moon suffered an eclipse, about the beginning of the Mysteries at Athens, **and on the eleventh night after the eclipse, the armies being now in sight of one another**, Dareius kept his forces under arms, and held a review of them by torch-light; but Alexander, while his Macedonians slept, himself passed the night in front of his tent with his seer Aristander, celebrating certain mysterious sacred rites and sacrificing to the god Fear. Meanwhile the older of his companions, and particularly Parmenio, when they saw the plain between the Niphates and the Gordyaeon mountains all lighted up with the barbarian fires, while an indistinguishably mingled and tumultuous sound of voices arose from their camp as if from a vast ocean, were astonished at their*

multitude and argued with one another that it was a great and grievous task to repel such a tide of war by engaging in broad day-light. They therefore waited upon the king when he had finished his sacrifices, and tried to persuade him to attack the enemy by night, and so to cover up with darkness the most fearful aspect of the coming struggle. But he gave them the celebrated answer, "I will not steal my victory"; whereupon some thought that he had made a vainglorious reply, and was jesting in the presence of so great a peril. Others, however, thought that he had confidence in the present situation and estimated the future correctly, not offering Dareius in case of defeat an excuse to pluck up courage for another attempt, by laying the blame this time upon darkness and night, as he had before upon mountains, defiles, and sea. For Dareius would not give up the war for lack of arms or men when he could draw from so great a host and so vast a territory, but only when he had lost courage and hope, under the conviction brought by a downright defeat in broad day-light.

Then, the note to Diodorus Siculus is mentioning Curtius, 4.10.2. It is given at

http://penelope.uchicago.edu/Thayer/L/Roman/Texts/Curtius/4*.html#10

Quintus Curtius Rufus was a Roman historian, probably of the 1st century, author of his only known and only surviving work, *Historiae Alexandri Magni*, "Histories of Alexander the Great".

Sed prima fere vigilia luna deficiens primum nitorem sideris sui condidit, deinde sanguinis colore suffuso lumen omne foedavit, sollicitisque sub ipsum tanti discriminis casum ingens religio et ex ea formido quaedam incussa est.

The passage of Arrian (3.15.7) is telling that *The elephants and all the chariots which had not been destroyed in the battle were also captured. Such was the result of this battle, which was fought in the archonship of Aristophanes at Athens, in the month Pyanepsion; and thus Aristander's prediction was accomplished, that Alexander would both fight a battle and gain a victory in the same month in which the moon was seen to be eclipsed.*

So we see that the last report is giving another name of the month. In the Appendix, a discussion (in Italian) of the Calendar that the ancient Greek writers probably used. The calendar was based on the new moons after the summer solstice.

Let us repeat a part of the note given above: *Eleven days before [as Plutarch told, ...], there occurred in the Attic month Boedromion an eclipse of the moon which has been identified as that of 20/21 September 331 B.C. If the Attic month followed the moon in practice as it did in theory, this should have been on the 15th of Boedromion, and the battle fought on the 26th or 27th. Arrian, however, states that the battle took place in Pyanepsion (3.15.7), presumably the month of the eclipse also. Really, the confusion about the names of the months exists: we will find it again in the Scaliger's discussion, and another month mentioned.*

Let us use again CalSKY, to see when the new moon was. First, let us see when the summer solstice was, given by the Julian date. It was on 27 or 28 of June 331 BC. The following equinox (the sun rising on East) is given on 29 September. With the effect of atmospheric refraction, we have 28 September. The first new moon after the summer solstice is given on 8 July 331 BC (full moon 24 July). On 7 August we find a new moon. The third new moon is on 6 September. As we have previously told, the full moon was on 20 September, coincident to total lunar eclipse. The following new moon was on 5 October 331 BC.

Archaeoastronomical studies in the past The fact that the ancient literature mentioned the lunar eclipse stimulated in the past several studies concerning the date of the battle. Even Pliny the Elder involved Alexander's eclipse when he was talking of sun and moon eclipses, in a sort of archaeoastronomical discussion ante litteram.

Here the link <http://www.perseus.tufts.edu/hopper/text> to The Natural History. Pliny the Elder. John Bostock, M.D., F.R.S. H.T. Riley, Esq., B.A. London. Taylor and Francis, Red Lion Court, Fleet Street. 1855.

CHAP. 72.—IN WHAT PLACES ECLIPSES ARE INVISIBLE, AND WHY THIS IS THE CASE.

Hence it is that the inhabitants of the east do not see those eclipses of the sun or of the moon which occur in the evening, nor the inhabitants of the west those in the morning, while such as take place at noon are more frequently visible [P1]. We are told, that at the time of the famous victory of Alexander the Great, at Arbela [P2], the moon was eclipsed at the second hour of the night, while, in Sicily, the moon was rising at the same hour. The eclipse of the sun which occurred the day before the calends of May, in the consulship of Vipstanus and Fonteius [P3], not many years ago, was seen in Campania between the seventh and eighth hour of the day; the general Corbulo informs us, that it was seen in Armenia, between the eleventh and twelfth hour [P4]; thus the curve of the globe both reveals and conceals different objects from the inhabitants of its different parts. If the earth had been flat, everything would have been seen at the same time, from every part of it, and the nights would not have been unequal; while the equal intervals of twelve hours, which are now observed only in the middle of the earth, would in that case have been the same everywhere.

Notes: [P1] We may presume that the author meant to convey the idea, that the eclipses which are visible in any one country are not so in those which are situated under a different meridian. The terms "vespertinos," "matutinos," and "meridianos," refer not to the time of the day, but to the situation of the eclipse, whether recurring in the western, eastern, or southern parts of the heavens. [P2] Brewster, in the art. "Chronology," p. 415, mentions this eclipse as having taken place Sept.

21st, U.C. 331, eleven days before the battle of Arbela; while, in the same art. p. 423, the battle is said to have taken place on Oct. 2nd, eleven days after a total eclipse of the moon. [P3] It took place on the 30th of April, in the year of the City 811, A.D. 59; see Brewster, ubi supra. It is simply mentioned by Tacitus, Ann. xiv. 12, as having occurred among other prodigies which took place at this period. [P4] We have an account of Corbulo's expedition to Armenia in Dion Cassius, lx. 19–24, but there is no mention of the eclipse or of any peculiar celestial phænomenon.

Brewster? Yes, Sir David Brewster (11 December 1781 – 10 February 1868) the British scientist, inventor, author, and academic administrator, in science principally remembered for his experimental work in physical optics, which concerned the polarization of light and the angle, which is known as the Brewster's angle. He studied the birefringence of crystals under compression and discovered photoelasticity. David Brewster edited the *Edinburgh Encyclopædia*, in 18 volumes, printed and published by William Blackwood between 1808 and 1830. In the Volume 6 of this Encyclopedia, we find the item “Chronology”, and there, as told in the note to Pliny’s text, the Alexander’s lunar eclipse is mentioned. Brewster is giving September 21.

For Brewster, fundamental elements of Chronology were the eclipses. Brewster was not the first scholar that proposed the use of eclipses for determining the date of a historical event. In [8], we find that the eclipse of Alexander was dated by Joseph Scaliger: “as well from astronomical calculations, as the account of other writers, [Scaliger] fixes that to the twentieth day of September, in the year 4383, and of this opinion are Dionysius Petavius and James Usher.” The page of Scaliger’s text (*Opus de emendatione temporum*. Joseph Juste Scaliger. typis Roverianis, 1629) is reproduced in the Figure 3.

Joseph Justus Scaliger (5 August 1540 – 21 January 1609) was a French religious leader and scholar, known for expanding the classical history from Greek and Roman history to include Persian, Babylonian, Jewish and ancient Egyptian history. Aiming to find a universal approach to dates, he proposed the Julian Period, in 1583, at the time of the Gregorian calendar reform. This Period is the least common multiple of three calendar cycles used with the Julian calendar: 15 (indiction (fiscal) cycle) \times 19 (Metonic cycle) \times 28 (Solar cycle) = 7980 years. The years of the Julian Period are counted from 4713 BC, which was chosen as before any historical record.

The eclipse of Alexander happened during the year of the Julian period 4383, on the 20th day of September. Although sometimes it is told that the Julian in "Julian Period" refers to Scaliger's father, Julius Scaliger, in his *Opus de Emendatione Temporum* he writes, "Iulianam vocauimus: quia ad annum Iulianum dumtaxat accomodata est" [9]. Julian refers to Julius Caesar, who introduced the Julian calendar. In origin, the Julian Period was used to count years, but in his book *Outlines of Astronomy*, first published in 1849, the astronomer John Herschel added the counting of

days elapsed from the beginning of the Julian Period [9,10]. Today, astronomers adopted the Herschel's "days of the Julian period" to count time, using the meridian of Greenwich.

DE PVGNA AD ARBELA, ET INITIO IMPERII ASIATICI ALEXANDREI.

QUEMADMODVM pugna ad Arbela, qua cum Dario Alexander vltima belli fortuna expertus est, nobilissimi & amplissimi imperij initium fuit, ita eam antecessit nobilissimus B character, vt posteriorum cognitionem effugere non potuerit. Vnde decim enim diebus, inquit Plutarchus, ante pugnam Luna defecit. Quod & Plinius testatur ita scribens: *Nobili apud Arbela Magni Alexandri victoria Luna defecisse noctis hora secunda prodita est, eademque in Sicilia exoriens.* Hæc defectio omnino contigit anno secundo Olympiadis cxii, cyclo Lunæ xiii, Nabonassari 417, Epiphi xi, feria secunda, cyclo Solis xv, cum Sol fere sextantem gradus 24 Virginis transmisisset, horis 7.42' in Prutenia: anno periodi Iulianæ 4383, Septembris xx, sequente xxi, anno mundi 3619, Parthenonos xxi. Neomenia Zygonos antecedentis 2.15.7, Septembris xxviii. anno Iudaico 3431, Tisri xv, sub exitum τὸ σκῶπον της: cuius C Tisri character 2.14. 723, Septemb. vi. Erat annus 28 periodi Atticæ. Proinde contigit τῇ εἰκοτῇ Μεταγειτνιών, non autem Βονδορομίων, vt plane hallucinatur Plutarchus. ἡ μὲν δὲ ἐν Γαλλίᾳ, inquit, ἔστι Βονδορομίων ἡ ἐξελίπεν, πρὶν τὴν τῶν μουσειῶν τῶν Ἀθηνῶν δεχέσθαι. Sed Arrianus ineptius. ἔστι τέλος τῇ μετὰ τὴν ἐξελίξιν ἐπὶ ἀρχόντος Ἀθηνῶν Αἰσοφάνους μὲν δὲ Πυανυσίων. Sed nihilo sequius Ciceronem fugit ratio primo de Diuinatione: Idemque mittit ἔστι signa nobis eius generis, qualia permulta historia tradidit. Quale scriptum illud videmus: Si Luna paulo ante Solis ortum defecisset in Signo Leonis, fore, vt armis Darius, ἔστι Persæ ab Alexandro, ἔστι Macedonibus pralio vincerentur, Dariusque moreretur. Dux hic hallucinationes. Nam neque in Leone fuit Luna, cum defecit, neque ante Solis ortum, sed Sole ipso occidente, in Calabria, aut pauxillo ante Solis occasum in Hetruria. Huic errori germanus est ille in libello de ortu & occasu siderum, qui falso Ptolemæo attribuitur (est enim antiquior Ptolemæo) vbi a. d. iiii. eid. avg. notatum est: *Lunaris defectus in hanc diem incurrere solet.* Habuit nimirum in animo hunc defectum, secutus opinionem eorum, qui Lunam in Leone positam defecisse scripserunt, quibus etiam assensum accommodauit Cicero, vt vidimus. Sed si hoc verum esset, oportebat hanc pugnam contigisse Sole Aquarium obtinente. Quod est falsum,

Figure 3. Scaliger is involving the Μεταγειτνιών month.

A Contemporary Account Besides the western literary sources, a historical report exists. The remarkable fact is that it is a contemporary account of the facts. It is contained in the Astronomical Diaries, a collection of Babylonian texts in which astronomical observations and political events are recorded. <https://www.livius.org/articles/concept/astronomical-diaries/>

The document is given at <https://www.livius.org/sources/content/oriental-varia/a-contemporary-account-of-the-battle-of-gaugamela/> [11]. Here we give only some parts. For the discussion given by the Editor of Livius.org, see please it at the link previously given. The Julian dates are added.

***The thirteenth** (20 September 331 BC). Moonset to sunrise: 8°. Lunar eclipse, in its totality covered. 10° night ... Jupiter set; Saturn ... during the totality the west wind blew, during clearing the east wind; ... during the eclipse, deaths and plague occurred in **The fourteenth** (21 Sept.). All day clouds were in the sky. **Night of the fifteenth** (22 Sept.): Sunset to moonrise: 16°. Clouds. The moon was 32/3 cubits, the moon having passed to the east; a meteor which flashed, its light was seen on the ground; very overcast, lightning flashed.*

*... **The twenty-first** (28 Sept.): Equinox. I did not watch. **Night of the twenty-second** (29 Sept.): Last part of the night, the moon was six cubits below Epsilon Leonis, the moon having passed ½ cubit to the east. **Night of the twenty-third** (30 Sept.) Last part of the night, the moon was 1 cubit behind Alpha Leonis. **Night of the twenty-fourth** (1 Oct.): Clouds were in the sky.*

*... **That month, the eleventh** (18 Sept.), panic occurred in the camp before the king encamped in front of the king. The twenty-fourth (1 Oct.), in the morning, the king of the world [Alexander] standard Opposite each other they fought and a heavy defeat of the troops. The king, his troops deserted him and to their cities. They fled to the land of the Guti.*

This contemporary account tells us that, when the eclipse started occurring Jupiter was setting, and that the moon was near Saturn; using Stellarium we can see Saturn (see the Figure 2) and Jupiter setting. We find also the date of October 1, 331 BC, was that we have found by means of Plutarch. Because of the above mentioned Babylonian astronomical diary, according to a translation of it, Jona Lendering, Livius.org Editor, concludes that Darius was deserted by his troops. What is reported by the Greek sources is different.

Let us read [7], to understand how the Battle ended according Arrian. “The Persian infantry at the center was still fighting the phalanxes, hindering any attempts to counter Alexander's charge. This large wedge then smashed into the weakened Persian center, taking out Darius' royal guard and the Greek mercenaries. Darius was in danger of being cut off, and the widely held modern view is that he now broke and ran, with the rest of his army following him. This is based on Arrian's account:

For a short time there ensued a hand-to-hand fight; but when the Macedonian cavalry, commanded by Alexander himself, pressed on vigorously, thrusting themselves against the Persians and striking their faces with their spears, and when the Macedonian phalanx in dense array and bristling with long pikes had also made an attack upon them, all things together appeared full of terror to Darius, who had already long been in a state of fear, so that he was the first to turn and flee. A less common view is that Darius' army was already broken when he ran; this view is supported by an astronomical diary from Babylon written within days of the battle” [7].

Actually, the passage concerning Darius’ army break in the tablet of the Astronomical Diary has two possible translations, that we can find in [12] and [13]. A detailed discussion is given in [14].

From [12]: (14’) That month (VI = Elul), on the 11th (18 September 331 BC), panic occurred in the camp before the king. [The Hanaeans . . .] (15’) encamped in front of the king. On the 24th (1 October 331 BC), in the morning, the king of the world [erected his] standard [. . .] (16’) Opposite each other they fought and a heavy defeat of the troops [of the king he inflicted]. (17’) The king, his troops deserted him and to their cities [. . .] (18’) [to the l]and of the Gutians they fled.

From [13]: (14’) In the same month, on the eleventh day, ‘panic’ struck the camp (as well as) the king. [...] (15’) made their camp (immediately) in front of the king. On the twenty-fourth day, early in the morning the king of the world [erected his] standard [...] (16’) Standing opposite one another they fought. A heavy defeat of the troops [of the king ...] (17’) The king and his troops abandoned it (ie. the camp). Into their cities [...] (18’) [Into the la]nd of the Gutaeans they fled. [...]

In any case, the contemporary record tells us that, as given by Plutarch, the armies were facing each other on October 1.

Appendix Calendario Ateniese

Here a discussion (in Italian) of the Calendar that the ancient Greek writers probably used, from <https://www.grecoantico.com/dizionario-greco-antico-calendario.php>

“I mesi: L’anno ateniese si divideva in dodici mesi, con uno aggiunto in più ad anni alterni e della durata di 30 giorni posto tra Poseidone e Gamelione. Questo mese si chiamava Poseidone II, Poseideon δεύτερος o ὕστερος ottenuto semplicemente raddoppiando il mese di Poseideon e aggiungendo la parola “secondo”, δεύτερος. L’inizio dell’anno coincideva con il solstizio d’estate e per i mesi si derivava il nome dalle feste principali che in essi si svolgevano”. Come nota il sito grecoantico, “Le festività erano un’ottantina e un altro gruppo di celebrazioni religiose era posto all’inizio di ogni mese: i compleanni degli dei cui erano dedicati i primi quattro e i giorni dal sesto all’ottavo di ogni mese. Questi giorni portavano il numero delle festività da aggiungere ogni volta

ad una sessantina circa. In tutto questo intercalare spesso congelato di giorni, all'inizio dell'anno bisognava anche definire circa 15 date sparse in cui gli affari non potevano essere trattati.”

Ecco quindi che il calendario poteva finir trattato con una relativa incertezza. “Ecatombeone, Ἑκατομβαιών, era il primo mese e cadeva a cavallo tra gli odierni luglio e agosto. Il nome trae origine dall'”ecatombe”, il sacrificio di cento buoi in onore di Apollo che aveva luogo il settimo giorno. Il primo di Ecatombeone coincideva con la prima Luna nuova dopo il solstizio d'estate e quindi era variabile: poteva corrispondere a qualsiasi data tra il nostro 22 giugno e il 21 luglio e durava trenta giorni.”

I mesi erano i seguenti: Hekatombaion – Ἑκατομβαιών, Metageitnion – Μεταγειτνιών, Boedromion – Βοηδρομιών, Pyanepsion – Πυανεψιών, Maimakterion – Μαιμακτηριών, Poseideon - Ποσειδεών (later Ποσειδεών), Gamelion – Γαμηλιών, Anthesterion – Ἀνθεστηριών, Elaphebolion – Ἐλαφηβολιών, Mounichion - Μουνυχιών (later Μουνιχιών), Thargelion – Θαργηλιών, Skirophorion – Σκιροφοριών.

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