Their Equinox: Mesopotamian Conceptions of Solstices and Equinoxes

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1 Introduction

In his well-known 1997 article "Whose Equinox?", Clive Ruggles highlights a significant methodological problem within archaeoastronomy: the imposition of modern (Western) ideas of what constitutes a significant astronomical event upon ancient and/or non-Western cultures (Ruggles, 1997). To illustrate his point, Ruggles takes the example of the equinox. Archaeoastronomers, and, according to Ruggles, increasingly archaeologists, have frequently claimed that various monuments, buildings, etc., possess "equinoctial alignments", tacitly understood to be the direction towards either the position on the eastern horizon at which the sun rises or the position on the western horizon at which the sun sets at the equinox. But as Ruggles points out, it is important to examine closely what we mean by an "equinoctial alignment", or, more fundamentally, what we mean by an "equinox". And, perhaps even more importantly, whether the culture we are studying had the same interpretation of what an equinox is as our modern definition and, indeed, whether the equinox was a meaningful and significant concept at all within their worldview.

In modern astronomy, an equinox is defined as the moment at which the sun crosses the celestial equator. At that moment, the sun will have a declination of 0°, day and night will be of equal length, and, assuming a perfectly flat horizon, the sun will rise due east and set due west. In fact, only the first of these statements is accurate in practice. Because the sun reaches the equinox at a precise moment and continues to move after it has reached it, day and the following night will only be equal if the moment of equinox coincides with the moment of sunset (and even this is not precisely true because the sun's speed is not constant); similarly, the sun will only rise precisely due east if the equinox occurs exactly at sunrise and only set due west

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if it occurs exactly at sunset. Thus, we have three definitions of the equinox which are not precisely the same: true astronomical equinox when the sun has a declination of 0°, the day at which day and night are (most nearly) of the same length, and the day at which the sun (most nearly) rises due east or sets due west at a flat horizon. Observationally, therefore, the equinox can be determined either by direct observation of its declination using a calibrated instrument such as an equatorial ring (which requires both the concept of a celestial sphere and precise knowledge of geographical latitude), by measuring the length of day or night, or by observing the sun's rising or setting azimuth. All of these methods will have different types of uncertainties built into them: How precisely can an instrument be aligned and how accurately is a site's geographical latitude known? What tool is used to measure the length of day and night and what is its error? And how flat is the horizon and how well is the east-west line known?

The aim of this paper is to examine how one particular group—the people of ancient Mesopotamia, i.e., the area of ancient Iraq and its neighbours, during the last two millennia BC—conceived of solstices and equinoxes. Even within this group we may expect some diversity of understanding of these phenomena: the popular and scholarly conception may have different and even among the literate elite we should not necessarily expect that the authors of literary works, for example, and the scribes who wrote astronomical texts agreed on precisely what is an equinox, nor that this understanding remained constant over more than 2000 years.

I begin this paper by presenting a brief overview of Mesopotamian calendars before examining a range of textual sources which refer to solstices and/or equinoxes in order to try to answer a very basic question: in those texts, were the solstices and/or equinoxes defined calendrically, i.e., by their position in the year, temporally, i.e., by the length of daylight, or spatially, either with reference to the place on the horizon when the sun rises or sets or to the intersection of the ecliptic and the celestial equator, or by a combination of these possibilities?

2 Mesopotamian Calendars

The basic Mesopotamian calendar used over the whole of the period from which we have written evidence (late fourth millennium BC to first century AD) employed lunar months which began on the evening of the first visibility (observed or in later times often calculated) of the new moon crescent (Steele, 2011). A normal year contained 12 months. In order to keep the calendar in line with the seasons, in certain years an extra "intercalary" month was inserted, usually after either the 6th or the 12th month of the year. For most of Mesopotamian history, the decision over when to intercalate was ultimately the decision of the king, and kings could—and sometimes did—make this decision for short term gain, for example in bringing forward or delaying the payment of taxes and tributes. Several schemes providing astronomical criteria for when to intercalate are attested from the early first millennium (Hunger & Reiner, 1975; Ratzon, 2016; Hunger & Steele, 2019: 209–213), but we do not know whether they were ever used in practice. Beginning in the early fifth century BC, however, a fixed 19-year cycle of intercalation was adopted and, as far as we can tell, operated without interruption until the end of our sources in the first century AD (Britton, 2007; Ossendrijver, 2018). According to this cycle, 7 years out of every nineteen contained an intercalary month.

One result of intercalation, whether it was governed by royal decision or followed a regular cycle, was to keep the beginning of the year fairly near to the date of the vernal equinox. We should not *a priori* assume, however, that keeping the beginning of the year aligned with the equinox was the intention of the Mesopotamians: the desire may simply have been to keep the beginning of the year in the early spring and the fact that this is close to the date of the vernal equinox is a by-product of that decision.

Luni-solar calendars, especially those based upon observing the new moon crescent and which have irregular intercalation, make the calculation of things like interest on loans and the payment of rations difficult. Almost certainly for this reason, therefore, a simplified "schematic" calendar was used in many administrative and astronomical contexts. This calendar simply assumed that each month contained 30 days and that there are always 12 months in the year, making a total of 360 days (Brack-Bernsen, 2007; Steele, 2011). This 360-day calendar also appears in certain literary and religious texts where it seems to represent the "ideal" state of the universe at creation (Brown, 2000). It is important to stress, however, that this schematic 360-day calendar, although appearing frequently in early astronomical texts, never operated as a real calendar, nor was 360 days ever thought to the actual length of the year. Instead, it always acted purely as a computational device to simplify calculations.

3 The Early Second Millennium BC

Two compositions preserved in Old Babylonian copies contain the earliest references to solstices and equinoxes: a small part of a Sumerian literary composition concerning the goddess Inana (Brown & Zólyomi, 2001), and an Akkadian text which presents a scheme for the change in the length of day and night over the schematic year (Hunger & Pingree, 1989: 163–164). Neither text refers to the solstices or equinox by name but both are concerned with the length of night on one or more of the solstices or equinoxes.

The relevant part of the Sumerian composition concerning Inana is preserved in two copies. The two manuscripts show some differences, most significantly in switching the order of the two lines relevant to us. These differences do not change the overall content of the passage, however. The passage can be transliterated and translated as given below. The transliteration is a composite of the two sources as reconstructed by Brown and Zólyomi (2001) except that I have reversed the order of the two lines (following their MS B) because the text seems to make better sense ordered this way. The translation follows Brown and Zólyomi (2001) except in translating šid literally as "counted" rather than "normal". For a detailed discussion of the reading of this passage, see Brown and Zólyomi (2001).

> ud-da-ta en-nu-ug$_3$-bi 3-am$_3$ ud gi$_6$-bi-a ba-an-da-sa$_2$
> i$_3$-ne-eš-ta ud-da šid-bi ba-da-tur ud gi$_6$-bi-a ba-da-bur$_2$

> From today when its (i.e., the day's) watch is 3 long, daylight is equal to night-time.
> From now on the counted length of daylight becomes shorter, daylight converts to night-time.

The passage begins by stating that on a given day the day's watch, a term which is known from other texts to be used to refer to the whole length of daylight, has the length 3. The number 3 is given without units and can be interpreted in two ways: either as a place value sexagesimal number of the kind found in mathematical texts which can be equated to a measurement value by means of a metrological table of equivalences, or, more simply, as the measurement value 3 with an implied unit. Comparison with later texts suggests that the 3 can be understood as either 3 *mina* or 3,0 (= 180) UŠ. The text continues by stating that on this date daylight is equal to night-time. Thus, both day and night are 3 in length, and the passage is therefore concerned with the date of the equinox defined temporally as day and night being of equal duration in time. The passage then states that as we move forward in time, the length of daylight becomes shorter as part of what had been day becomes night.

The second text, BM 17175 + 17284, presents values for the length of day and night at the equinoxes and the solstices. The text can be transliterated and translated as follows (the transliteration follows Hunger & Pingree, 1989: 163 but the translation is my own):

> [*i-na* ^{iti}ŠE.GUR$_{10}$ UD.15.KAM 3 EN].⸢NU⸣ *u*$_4$*-mi* 3 EN.NU GE$_6$ [*u*$_4$*-mu ù* GE$_6$ *mi*]*-it-*⸢*ḫa*⸣*-ru* [*iš-tu* ^{iti}ŠE.GUR$_{10}$.KU$_5$ UD.15.KAM *a-di* ^{iti}SIG$_4$] ⸢UD⸣.15.KAM ITI 3.KAM [*i-na* ^{iti}SIG$_4$ UD.15.KAM 1 EN.NU GE$_6$ *a-n*]*a u*$_4$*-mi i-na-ap-pa*(!)*-al* [… 4 EN].⸢NU⸣ *u*$_4$*-mi* 2 EN.NUN GE$_6$

> [*iš-tu* ^{iti}SIG$_4$ UD.15.KAM] ⸢*a*⸣*-di* ^{iti}KIN.^{d}INANNA UD.15.KAM ITI 3.KAM [*i-na* ^{iti}KIN.^{d}INANNA UD.15.KAM 1 E]N.NU *u*$_4$*-*⸢*mu a-na*⸣ GE$_6$ *ut-te-er* […] 3 EN.NU *u*$_4$*-mi* 3 EN.NU GE$_6$ [*u*$_4$*-mu ù* GE$_6$] *mi-it-ḫa-ru*

> [*iš-tu* ^{iti}KIN.^{d}INANNA UD.1]5.KAM *a-di* ^{iti}GAN.GAN.È UD.15.KAM ITI 3.KAM [*i-na* ^{iti}GAN.GAN.È UD.15.KAM 1 EN].NU *u*$_4$*-mu a-na* GE$_6$ *i-na-ap-pa-al* [… 2] EN.NU *u*$_4$*-mi* 4 EN.NU GE$_6$

> [*iš-tu* ^{iti}GAN.GAN.È UD.15.KAM *a-d*]*i* ^{iti}ŠE.⸢GUR$_{10}$.KU$_5$⸣ UD.15.KAM ITI 3.KAM [*i-na* ^{iti}ŠE.GUR$_{10}$.KU$_5$ UD.15.KAM 1 EN].⸢NU GE$_6$ *a-na*⸣ *u*$_4$*-*⸢*mi i*⸣*-na-ap-pa-al* […] 3 EN.NU *u*$_4$*-*⸢*mi* 3⸣ EN.NU GE$_6$ [*u*$_4$*-mu ù* GE$_6$] *mi-it-ḫa-ru*

> [On Month XII day 15, 3 is the wat]ch of the day, 3 is the watch of the night. [Day and night are e]qual. [From Month XII day 15 to Month III] day 15 is 3 months. [On Month III day 15, 1 (of) the watch of the night] converts into day. [… 4 is the wat]ch of the day, 2 is the watch of the night.

> [From Month III day 15] to Month VI day 15 is 3 months. [On Month VI day 15, 1 (of) the wa] tch of the day returns to the night. […] 3 is the watch of the day, 3 is the watch of the night. [Day and night] are equal.

> [From Month VI day 1]5 to Month IX day 15 is 3 months. [On Month IX day 15, 1 (of) the wat]ch of the day coverts into night. [… 2] is the watch of the day, 4 is the watch of the night.
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> [From Month IX day 15 t]o Month XII day 15 is 3 months. [On Month XII day 15 1 (of) the wat]ch of the night converts into day. [… 3] is the watch of the day, 3 is the watch of the night. [Day and night] are equal.

The text presents a scheme giving the length of day and night on the 15th of Months III, VI, IX and XII. On the 15th of Months XII and VI day and the night are said to be of equal length. As in the previous text, this length is given as three without a unit (it can again be assumed to refer to either 3 *mina* or 3,0 UŠ), and therefore corresponds to the equinox. On the 15th of Month III, day is said to be of length 4 and night of length 2. These lengths of day and night are reversed on the 15th of Month IX. Thus, the summer solstice is taken to be on the 15th of Month III and the winter solstice on the 15th of Month IX. The scheme states that between the summer solstice in Month III and the winter solstice in Month IX part of the day is converted into night, and vice versa between winter solstice and the summer solstice. Comparison with later texts makes it almost certain that the length of day and night are assumed to vary linearly between the extremes of 2 and 4 at the solstices and that the dates given in the scheme are to be understood as being within the schematic 360-day calendar. These extremes are greatly exaggerated for the latitude of anywhere within Mesopotamia and seem to have been chosen for their simplicity (Brown, Fermor, & Walker, 1999–2000).

Both the passage in the Sumerian literary text and the scheme on BM 17175 + 17284 show a concern with the length of day and night. In BM 17175 + 17284 the length of day and night is connected to four equally-spaced dates in the schematic calendar. Thus, although the texts do not name these dates as the solstices and equinoxes, it is clear that what is of interest to the authors of these texts are the occasions when day and night are of equal length or when they are their shortest and longest. For these authors, therefore, solstices and equinoxes are defined by the length of day and night and, secondarily, by equal divisions of the schematic year.

4 The Late Second and Early First Millennium BC

Table C of the fourteenth tablet of the celestial omen series *Enūma Anu Enlil* (Al-Rawi & George, 1991–1992) contains a list of length of day and night on the 15th and 30th day of each month in the schematic 360-day calendar. The date of composition of *Enūma Anu Enlil* is not known but must lie somewhere in the late second or early first millennium BC; the work was already widely known and copied by the beginning of the seventh century BC. According to this text the lengths of day and night follow zigzag functions with maximum and minimum 4 *mina* and 2 *mina*. The scheme is clearly an elaboration of that found on the Old Babylonian tablet BM 17175 + 17284 discussed in Sect. 3, extended to give values for the schematic dates of the lunar and solar opposition and conjunction. The entries for the 15th of Months III, VI, IX and XII once more refer to the solstices and equinoxes as defined by the length of day and night. For example, the entry for the winter solstice on the 15th of Month IX reads as follows:

> [DIŠ *ina* ^{iti}GAN] ⸢UD⸣.15.KAM 2 *ma* EN.NUN UD 4 *ma* EN.NUN GE$_6$
> [DIŠ *ina* ^{iti}GAN UD].16.KAM GE$_6$ *ana ur-ru i-na-pal* UD^{me} GÍD^{me} GE$_6$^{me} LUGUD^{me}

> [¶ On Month IX] day 15: 2 *mina* is the watch of the day, 4 *mina* is the watch of the night.
> [¶ On Month IX day] 16: night converts to day; the days become longer, the nights become shorter.

This passage is similar to the entry for the winter solstice on the Old Babylonian tablet BM 17175 + 17284. Here, however, it is made clear that the change in the length of day and night occurs each day. Thus, the day after the solstice, part of the night is converted into day and from then on the day will become longer each day and the night will become shorter.

Another text relevant to our discussion dating to the late second or early first millennium BC, which was again widely known and copied by the early seventh century BC, is MUL.APIN (Hunger & Steele, 2019). MUL.APIN is a compendium of astronomical and astrological material including several lists of stars, schemes for intercalation, the intervals between synodic phenomena of the planets, the length of night and the duration of visibility of the moon, and the length of the shadow cast by a gnomon, and celestial omens. Like all of the other texts discussed so far, at the core of all of the schemes in MUL.APIN lies the 360-day schematic calendar.

The scheme for the length of night, and by extension for the length of day, in MUL.APIN is identical to that found in tablet 14 of *Enūma Anu Enlil* with one crucial exception: the dates of the solstices and equinoxes are shifted by one month in the schematic calendar to the 15th day of Months I, IV, VII, and X. References to the length of day and night at the solstices and equinoxes appear at several places in MUL.APIN: in the list of the dates of the first appearances of stars at lines I ii 43, I iii 2 and I iii 9 (summer solstice, autumnal equinox and winter solstice only); in the shadow length scheme at lines II ii 21, II ii 25, II ii 31, and II ii 35; and in the scheme for the length of night at II ii 43, II ii 50, II iii 8, and II iii 8. Like everything we have encountered do far, these entries do not make an explicit reference to the solstice and equinox, but implicitly refer to them be singling out the dates of the longest and shortest day and equal length day and night for special treatment. For example, the shadow length scheme is presented for these four dates during the year and then a short procedure explains how it can be extended to the other months of the year.

Another part of MUL.APIN, lines II I 9—II I 21, provides additional information about the solstices and equinoxes beyond simply giving the dates when the day is longest, shortest, and of equal length of the night (Hunger & Steele, 2019: 142–145):

> DIŠ *ina* ^{iti}ŠU UD.15.KAM ^{mul}KAK.SI.SÁ IGI.LÁ-*ma* 4 MA.NA EN.NUN *u*$_4$*-mi* 2 MA.NA EN.NUN GE$_6$ ^{d}UTU *šá ina id* ^{im}SI.SÁ KI SAG-DU ^{mul}UR.GU.LA KUR-*ḫa* GUR-*ma ana id* ^{im}U$_{18}$.LU *u*$_4$*-mu* 40 NINDA.TA.ÀM *ul-ta-map-pal* UD^{meš} LUGÚD.DA^{meš} GE$_6$^{meš} GÍD.DA^{meš}

DIŠ *ina* ^{iti}DU$_6$ UD.15.KAM ^{d}UTU *ina lìb-bi* ^{mul}*zi-ba-ni-tu*$_4$ *ina* ^{d}UTU.È KUR-*ḫa u* ^{d}*sin ina* IGI MUL.MUL EGIR $^{mul\ lú}$ḪUN.GÁ GUB-*azima* 3 MA.NA EB-NUN *u*$_4$-*mi* 3 MA.NA EN.NUN GE$_6$

DIŠ *ina* ^{iti}AB UD.15.KAM ^{mul}KAK.SI.SÁ *ina li-la-a-ti* IGI.LÁ-*ma* 2 MA.NA EN.NUN *u*$_4$-*mi* 4 MA.NA EN.NUN GE$_6$ ^{d}UTU *šá ina id* ^{im}U$_{18}$.LU KI SAG.DU ^{mul}UR.GU.LA KUR-*ḫa* GUR-*ma ana id* ^{im}SI.SÁ UD 40 NINDA.TA.ÀM *un-da-na-ḫar* UD^{meš} GÍD.DA^{meš} GE$_6$^{meš} LUGÚD.DA^{meš}

DIS *ina* ^{iti}BÁR UD.15.KAM ^{d}*sin ina li-la-a-ti ina* SÀ ^{mul}*zi-ba-ni-tú ina* ^{d}UTU.È *u* ^{d}UTU *ina* ^{d}UTU.ŠÚ.A *ina* IGI MUL.MUL EGIR ^{mul}ḪUN.GÁ GUB-*ma* 3 MA.NA EN.NUN *u*$_4$-*mi* 3 MA.NA EN.NUN GE$_6$

¶ On the 15th of Month IV, the Arrow becomes visible, and 4 *mina* is the watch of the day, 2 *mina* is the watch of the night. The sun, which rises in the north with the Head of the Lion, turns and keeps moving down towards the south 40 NINDA per day. The days become shorter, the nights become longer.

¶ On the 15th day of Month VII, the sun rises within the Scales in the east, and the moon stands in front of the Stars behind the Hired Man, 3 *mina* is the watch of the day, 3 *mina* is the watch of the night.

¶ On the 15th of Month X, the Arrow becomes visible in the evening. 2 *mina* is the watch of the day, 4 *mina* is the watch of the night. The sun, which rises in the south with the Head of the Lion, turns and keeps coming up towards the north 40 NINDA per day. The days become longer, the nights become shorted.

¶ On the 15th day of Month I, the moon stands in the evening within the Scales in the east, and the sun in the west in front of the Stars behind the Hired Man. 3 *mina* is the watch of the day, 3 *mina* is the watch of the night.

In addition to giving the standard values for the length of the day and night on the dates of the solstices and equinoxes found elsewhere in MUL.APIN, each section also comments on the position of the sun as it rises on those dates. The two sections for the equinoxes state that the sun rises in the east with the constellation the Scales (Libra) at the autumnal equinox and sets in the west between the constellations the Stars (Pleiades) and the Hired Man (in Aries) at the spring equinox. The moon is said to be in the same position but at the opposite equinox, which is as we would expect since in the schematic calendar the equinox is on the 15th day of the month and so the moon and sun are in opposition. The references to east and west use the terminology *ina* ^{d}UTU.È and *ina* ^{d}UTU.ŠÚ.A which literally refer to the rising and setting sun and seem to be used to refer to the general easterly and western horizons rather than the points due east and due west. The same terminology is used elsewhere in MUL.APIN to indicate whether a planet is rising in the east or the west. For example, line II II I 61 reads (Hunger & Steele, 2019: 148–149):

DIŠ ^{mul}*dele-bat lu ina* ^{d}UTU.È *lu ina* ^{d}UTU.ŠÚ.A IGI.LÁ-*ma* 9 ITI.MEŠ *ina* AN-*e* GUB-*ma i-tab-bal*

¶ Venus becomes visible either in the east or in the west, stands in the sky for 9 months, and disappears.

Thus, the phrases "rises in the east" and "in the west" here simply indicate which horizon we are looking at.

The entries for the solstices also give the position of the rising sun stating that it is in the "north", for summer solstice, or the "south", for winter solstice. Here "north" and "south" are given in terms of wind directions, which are commonly used to roughly indicate cardinal directions (Horowitz, 1998: 195–200). In the entries for both solstices, the sun is said to rise with the Head of the Lion (Leo), but this is almost certainly a textual error: the sun will rise with the Head of the Lion at the summer solstice according to the presumed date of the solstice and the first appearance of the Head of the Lion given elsewhere in MUL.APIN, but because the rising position of stars does not change over the year, at the winter solstice the sun will be a long way from the Lion. What is important, however, is that the text states that the sun rises in the north at the summer solstice and then "turns and keeps moving down towards the south", and similarly at the winter solstice, the sun rises in the south and then "turns and keeps coming up towards the north". Thus, the dates of the solstices are associated with the most northerly and southerly rising points of the sun. The text continues by stating that something changes by "40 NINDA per day". A NINDA is a unit of distance but is also used as a unit of time. Given that the statement of a change of 40 NINDA per day directly follows the statement that the sun's rising position moves to the south/north, it would be tempting to see this change as referring to the change in azimuth of the sun's rising point. However, a close study of this passage reveals that this is not the case: the 40 NINDA per day, which is equal to 0;40 UŠ and equivalent to 0;0,40 *mina* is the daily change in the length of daylight. The passages end with the familiar statements that following the solstices, the days become shorter/longer and the nights become longer/shorter.

This section of MUL.APIN, therefore, shows that an additional, but clearly secondary, characteristic of the solstices is that the sun's rising position is to its northern and southern extremes at the summer and winter solstices respectively. By contrast, the equinoxes seem to be defined only by the equal length of day and night.

5 The Neo-Assyrian Period

All of the texts that I have discussed so far present the four dates in the schematic 360-day calendar on which the length of day is either longest, shortest, or equal to the length of night, corresponding to the summer solstice, the winter solstice, and the two equinoxes respectively. These dates are themselves schematic not reports of observations—they are placed at equal divisions of the schematic year and on the fifteenth day of a month when the moon and sun are in opposition, a situation which in reality can never happen within the same year. We have also seen that one section of MUL.APIN added a secondary characteristic to the dates of the solstices, namely the extreme northern and southern rising points of the sun. However, these early texts present no evidence of the observation of the solstices and equinoxes nor do they give names for these phenomena. This situation changes in the seventh century

BC. Among the preserved correspondence between scholarly advisors and the Neo-Assyrian kings, which contains reports of observed astronomical phenomena which are important for divination and/or for the management of the calendar, we find three reports of equinoxes and one of a solstice with what becomes standard terminology to identify these phenomena. Giver the type of text these reports are found in it is very likely that they refer to observations of these phenomena.

Let us consider the three reports of equinoxes first. The three reports are all very short giving no more than the date (month and day—the year is not usually given in these texts), a formulaic statement about the equinox, and a standard closing blessing. They are all believed to have been sent by a certain Nabû'a, who lived in the city of Assur, to the king in Nineveh (Hunger, 1992; see also the discussion in Kugler, 1909–1924: 18 and Parpola, 1983: 359–361). The report SAA 8 140 is typical:

UD.6.KÁM *šá* iti BÁR *u*$_4$*-mu ù mu-ši šit-qu-lu* 6 DANNA *u*$_4$*-mu* 6 DANNA *mu-ši* dPA dAMAR.UTU *a-na* LUGAL BE-*i-ni lik-ru-bu*

The 6th day of Month I. The day and the night were in balance: 6 *bēru* is the day, 6 *bēru* is the night. May Nabû (and) Marduk bless the king, our lord!

The other two reports are identical except that SAA 8 141 gives a date of the 15th of Month I and the date is broken away on SAA 8 142. The fact that the reports give different dates for the equinox implies that these reports are discussing equinoxes in different years and that these are not the schematic dates in the 360-day calendar given in texts such as MUL.APIN but observed dates of the actual equinox in the civil calendar.

The key phrase in this report is "the day and the night were in balance". The verb *šitqultu* is the Gt form of *šaqālu* "to weigh/balance" and is used to indicate that the subjects of the verb are equally balanced. In this case, the subjects are day and night and the text goes on to clarify that their being balanced means that they are both of the same length, namely 6 *bēru* (a *bēru* equals 30 UŠ and is equivalent to two equinoctial hours). It is clear, therefore, that the equinox is here defined by the day and the night being of equal length. As we will see, the term "in balance" becomes the standard way of referring to equinoxes in later texts.

One report, SAA 8 207, written by an unidentified scholar and sent to the king contains a reference to a solstice (Hunger, 1992). Unfortunately, the report is damaged and we do not know which month, and therefore which solstice, is being referred to. The relevant part of the report reads as follows:

[… UD].⌈15?⌉.KÁM ŠÚ [*sin* N]U IGI *šamaš* GUB

[…] the 15th?, the setting [of the moon was n]ot seen. The sun stood (still).

The phrase "the sun stands (still)" (*šamaš* GUB) is used in later texts to refer to a solstice (both winter and summer) and must refer to the same phenomenon here. The logogram GUB is used to write the verb *izuzzu* which means simply "to stand". In astronomical texts it can have a number of different meanings including being used to indicate that the moon or a planet "stands" (i.e. is visible) in the sky or to indicate that a star or constellations is in a fixed position relative to the other stars. The word must have another meaning here, however. It seems most likely that it refers to the rising point of the sun appearing to stand still for several days at its most northerly or southerly point at the solstice. Thus, this terminology for the solstice seems to give priority to the rising point of the sun rather than to the extremes in the length of day and night. This conclusion is somewhat supported by the absence of a reference to the length of day or night in this record, in contrast to the case of the equinoxes recorded in contemporary texts where the lengths of day and night were stated explicitly.

6 Observational Texts from the Late Babylonian Period

The Astronomical Diaries and related observational texts dating from the sixth to the first century BC regularly record the dates of the solstices and equinoxes using similar terminology to that found in the Neo-Assyrian texts just discussed (Sachs & Hunger, 1988: 26). Equinoxes are again denoted by the term *šitqultu* "balanced" (this is usually written logographically LÁL-*tim*, rather than syllabically as was the case in the Neo-Assyrian texts), but without the accompanying statement that day and night are both 6 *bēru* in length. Solstices are again denoted by *šamaš* GUB "the sun stood (still)".

The majority of reports of solstices and equinoxes in the Astronomical Diaries are followed by the phrase NU PAP "not watched for". Sometimes this phrase is accompanied by a reference to bad weather which prevented the sun from being seen. In these cases the date given for the phenomenon must therefore have been calculated or estimated in some way. Various schemes are attested in cuneiform texts of this period for calculating the dates of the solstices and equinoxes in the civil calendar. One scheme ties the dates of these phenomena to the 19-year intercalation cycle (Neugebauer, 1948, Slotsky, 1993, Hunger & Pingree, 1999: 151–152). According to this scheme the date of the summer solstice increases by 11 days every year except for the 19th year of the cycle where it increases by 12 days. The dates of the autumnal equinox, summer solstice, and spring equinox are calculated from the summer solstice by adding 3 months and 3 days, 6 months and 6 days, and 9 months and 9 days respectively onto the date of the summer solstice. Thus, the solstice and equinoxes are spaced evenly through the calendar year. All reports of solstices and equinoxes in the Diaries dating from the beginning of the fourth century BC onwards agree with this scheme. Almost all of these reports are denoted as "not watched for", but the dates of those without this remark are also in agreement with this scheme suggesting that during this period at least the solstices and equinoxes were always calculated rather than observed. An extension of this scheme provided calculated dates for the first appearance, acronychal rising, and the last appearance of Sirius and selected other stars (Hunger, 2014; Sachs, 1952).

7 Solstices, Equinoxes and the Zodiac

The zodiac—the division of the band through which the sun, moon, and planets move, into twelve equal length parts ("signs") each containing 30° (denoted in Babylonian texts using the linear-measure unit UŠ)—was developed in Babylonia sometime during the second half of the fifth century BC (Britton, 2010; Steele, 2007, 2018). Although no texts explicitly link the solstices and equinoxes to positions in the zodiac, an implicit connection is made in schemes which link the length of day to the position of the sun in the ecliptic. Three such schemes are currently known. All three are what can be termed "rising time schemes", which operate by assigning a certain time interval to the time it takes for a given stretch of the zodiac to rise (Neugebauer, 1953; Rochberg, 2004; Schaumberger, 1955; Steele, 2017).

The first scheme links the rising of stretches of the zodiac to the time intervals between the culmination of certain stars known as *ziqpu* stars. It is based upon an earlier calendar based scheme which associates the setting of the sun on dates in the schematic calendar with the culmination of the same stars. This calendar based version of the scheme is itself constructed from the simple function for the length of day and night given in MUL.APIN and therefore places the equinoxes and solstices, defined by the length of day, on the 15th of Months I, IV, VII, and X in the schematic 360-day calendar. This calendar-based scheme is then transferred across to the zodiac simply by equating the date in the schematic calendar with the equivalent position in the zodiac which is then taken to be the position of the sun (e.g. the equivalent of the 1st day in Month I is 1° in Aries). As a consequence, the sun is taken to be at 15° in Aries, Cancer, Libra, and Capricorn on the days of the equinoxes and solstices.

The second and third schemes are embedded within the so-called Lunar System A and Lunar System B systems of mathematical astronomy. In both systems, the length of day is computed from the sun's position using a table which is based upon different rising time schemes. In System A, the days on which day and night are equal and the days when day is longest and shortest, take place when the sun is at 10° of Aries, Cancer, Libra, and Capricorn. In System B, they take place when the sun is at 8° of Aries, Cancer, Libra, and Capricorn. A further, poorly attested lunar system, Lunar System K, places them at 12° of Aries, Cancer, Libra, and Capricorn (Ossendrijver, 2012: 115).

We therefore have four traditions for the placement of the position at which the sun is at the solstices and equinoxes: at 15°, 12°, 10°, and 8° of Aries, Cancer, Libra, and Capricorn. Despite their being incompatible, these four traditions co-existed. I take this as evidence that positions in the zodiac never became the primary definition of the solstices and equinoxes.

8 Conclusion

Main aim in this paper has been to gather the evidence for how the solstices and equinoxes were conceived by scholars in ancient Mesopotamia. This evidence clearly shows that the primary definition of the solstices and equinoxes was linked to the length of day and night: the solstices were the days on which the day was either longest or shortest, and the equinoxes were the days when day and night were of equal length. The dates of the solstices and equinoxes were considered to be equally spaced through the year, either at 3 month intervals in the 360-day schematic calendar or on dates in the real luni-solar calendar which correspond to equal divisions of the solar year (the Babylonians never distinguished between the tropical and sidereal year and so it is appropriate to talk merely of the solar year). A secondary definition of the solstice and equinoxes was therefore calendrical. In addition, solstices were also defined as the date on which the sun rose at its most northerly or southerly point on the horizon, providing a tertiary definition of the phenomenon. Equinoxes, however, do not seem to have shared this tertiary definition referring to the rising point of the sun.

Given that the primary definition of the solstices and equinoxes related to the length of day and night, it is appropriate to ask how the Babylonians were able to identify when these phenomena took place. What evidence we have of Babylonian time measurement suggests that water clocks were used to measure intervals of time in astronomical contexts. These water clocks, however, were far from accurate: studies of Babylonian timings of eclipses show that timings of more than a few hours often had errors of up to half an hour (Fermor & Steele, 2000; Steele, 2000). Thus, determining when day and night were of equal length or when the day was longest or shortest would have presented many challenges for the Babylonian astronomers and likely produced quite inaccurate results. Similarly, although the position on the horizon where the sun rises at its most northerly or southerly point can fairly easily be measured, because the sun's rising point changes very slowly around the solstices deciding when the sun had reached this point is very difficult. It is therefore not apparent how the Babylonians observed these phenomena.

Observations or solstices and equinoxes must have been made at least occasionally, however. As discussed in Sect. 5, we have four reports of solstices or equinoxes contained in repots sent to the Neo-Assyrian king, and as noted in Sect. 7, although most reports of solstices and equinoxes found in the Late Babylonian Diaries and related texts were computed according to a fairly simple scheme, at least some reports of these phenomena dating to before the fourth century BC seem to refer to observations rather than computations. Furthermore, the 19-year scheme for the dates of the solstices and equinoxes which operated after the fourth century must also have been based upon at least one observation to provide a start date for the scheme. The scheme places the solstices and equinoxes at equally spaced intervals in the solar year. However, because the sun's velocity is not constant, the solstices and equinoxes are in fact not equally spaced: in the late first millennium BC, the interval between the spring equinox and the summer solstice was about 2 days longer than that between the summer solstice and the autumnal equinox, for example. Thus, comparing solstice and equinox dates given by the Babylonian scheme with modern computation we should find differences in the accuracy of the dates of the four solstices and equinoxes. Indeed the dates of the autumnal equinoxes are consistently closer to the dates given by modern computation of the moment of the astronomical equinox than for either of the two solstices or the vernal equinox (Kugler, 1909–1924: 606). This fact might suggest that the scheme was tethered to an observed autumnal equinox in some year, although we cannot exclude the possibility that it is just chance that the dates of the autumnal equinox agree better with modern computation. Whether it was an autumnal equinox, the vernal equinox, or either of the two solstices, however, we still do not know how the date of that phenomenon was determined.

All of the reports of solstices and equinoxes in the Astronomical Diaries simply state the date on which the phenomenon took place. Interestingly, these are always recorded as daytime events, highlighting their connection with the sun; none are recorded as having taken place during the night. Short time measurements of when during the day the solstice or equinox occurred are never given. This contrasts with the situation in later Greek astronomy: the solstices and equinoxes reported in Ptolemy's *Almagest* occur both during the day and night and are usually accompanied by a statement of the approximate time of day when the phenomenon took place (Perdersen, 1974: 129). The reason, of course, is that for Greek astronomers such as Hipparchos and Ptolemy the equinoxes were defined by the sun being at one of the two points of intersection of the ecliptic and the celestial equator and the solstices as the points separated from the equinoxes by 90° on the ecliptic. For the Babylonians, defining the solstices and equinoxes in terms of the length of day and night, a time during the day when the phenomenon occurred would be meaningless. In essence the solstices and equinoxes lasted for the whole day, rather than a specific moment.

This discussion of the way in which the solstices and equinoxes were defined in Mesopotamia has hopefully provided one clear example of the importance of not assuming that astronomical concepts are not universal. Even in the case of astronomies where there is clear evidence of extensive contact, such as between Babylonian and Greek astronomy, underlying concepts can be subtly different and we must not impose our understanding of one conception onto the other culture (for a similar example, see my discussion of the differences between Greek and Babylonian concepts of the zodiac and the ecliptic in Steele, 2007).

References

Al-Rawi, F. N. H., & George, A. R. (1991–1992). Enūma Anu Enlil XIV and other early astronomical tables. *Archiv für Orientforschung, 38–39*, 52–73.

Brack-Bernsen, L. (2007). The 360-Day Year in Mesopotamia. In J. M. Steele (Ed.), *Calendars and Years: Astronomy and Time in the Ancient Near East* (pp. 83–100). Oxford: Oxbow Books.

Britton, J. P. (2007). Calendars, intercalations and year-lengths in Mesopotamian astronomy. In J. M. Steele (Ed.), *Calendars and years: astronomy and time in the ancient near east* (pp. 115–132). Oxford: Oxbow Books.

Britton, J. P. (2010). Studies in Babylonian lunar theory: part III. The introduction of the uniform zodiac. *Archive for History of Exact Sciences, 64*, 617–663.

Brown, D. (2000). *Mesopotamian planetary astronomy-astrology*. Groningen: Styx.

Brown, D., Fermor, J., & Walker, C. (1999–2000). The water clock in Mesopotamia. *Archiv für Orientforschung, 46–47*, 130–148.

Brown, D., & Zólyomi, G. (2001). "Daylight converts to night-time": An astrological-astronomical reference in Sumerian literary context. *Iraq, 63*, 149–154.

Fermor, J., & Steele, J. M. (2000). The design of Babylonian waterclocks: Astronomical and experimental evidence. *Centaurus, 42*, 210–222.

Horowitz, W. (1998). *Mesopotamian cosmic geography*. Winona Lake: Eisenbrauns.

Hunger, H. (1992). *Astrological reports to Assyrian kings*. Helsinki: Helsinki University Press.

Hunger, H. (2014). Extension of the 'Uruk Scheme'. In A. Panaino (Ed.), *Non licet stare caelestibus: Studies on astronomy and its history offered to Salvo de Meis* (pp. 45–50). Milan: Mimesis.

Hunger, H., & Reiner, E. (1975). A scheme for intercalary months from babylonia. *Wiener Zeitschrift für die Kunde des Morgenlandes, 67*, 21–28.

Hunger, H., & Pingree, D. (1989). *MUL.APIN: An astronomical compendium in cuneiform*. Horn: Berger & Söhne.

Hunger, H., & Pingree, D. (1999). *Astral sciences in Mesopotamia*. Leiden: Brill.

Hunger, H., & Steele, J. M. (2019). *The Babylonian astronomical compendium MUL.APIN*. Abingdon: Routledge.

Kugler, F. X. (1909–1924). *Sternkunde und Sterndienst in Babel. II*. Münster in Westfalen: Aschendorffsche Verlagsbuchhandlung.

Neugebauer, O. (1948). Solstices and equinoxes in Babylonian astronomy during the Seleucid period. *Journal of Cuneiform Studies, 2*, 209–222.

Neugebauer, O. (1953). The rising-times in Babylonian astronomy. *Journal of Cuneiform Studies, 7*, 100–102.

Ossendrijver, M. (2012). *Babylonian mathematical astronomy: procedure texts*. New York: Springer.

Ossendrijver, M. (2018). Babylonian scholarship and the calendar during the reign of Xerxes. In C. Waerzeggers & M. Seire (Eds.), *Xerxes and Babylonia: The cuneiform evidence* (pp. 135–164). Leuven: Peeters.

Parpola, S. (1983). *Letters from Assyrian scholars to the kings Esarhaddon and Assurbanipal. Part II. Commentary and appendices*. Neukirchen-Vluyn: Butzon & Bercker Kevalaer.

Perdersen, O. (1974). *A survey of the Almagest*. Odense: Odense University Press.

Ratzon, E. (2016). Early Mesopotamian intercalation schemes and the sidereal month. *Mediterranean Archaeology and Archaeometry, 16*, 143–151.

Rochberg, F. (2004). A Babylonian rising time scheme in non-tabular astronomical texts. In C. Burnett, J. P. Hogendijk, K. Plofker, & M. Yano (Eds.), *Studies in the history of the exact sciences in honour of David Pingree* (pp. 56–94). Leiden: Brill.

Ruggles, C. L. N. (1997). Whose equinox? *Journal for the History of Astronomy, Archaeoastronomy Supplement, 22*, S45–S50.

Sachs, A. J. (1952). Sirius dates in Babylonian astronomical texts of the Seleucid period. *Journal of Cuneiform Studies, 6*, 105–114.

Sachs, A. J., & Hunger, H. (1988). *Astronomical diaries and related texts from Babylonian. Volume I: Diaries from 652 B.C. to 262 B.C*. Vienna: Österreichische Akademie der Wissenschaften.

Schaumberger, J. (1955). Anaphora und Aufgangskalender in neuen *Ziqpu*-Texten. *Zeitschrift für Assyriologie und Vorderasiatische Archäologie, 52*, 237–251.

Slotsky, A. L. (1993). The Uruk solstice scheme revisited. In H. D. Galter (Ed.), *Die rolle der astronomie in den Kulturen Mesopotamiens* (pp. 369–365). Graz: Kult.

Steele, J. M. (2000). *Observations and predictions of eclipse times by early astronomers*. Dordrecht: Kluwer.

Steele, J. M. (2007). Celestial measurement in Babylonian astronomy. *Annals of Science, 64*, 293–325.

Steele, J. M. (2011). Making sense of time: Observational and theoretical calendars. In K. Radner & E. Robson (Eds.), *The Oxford handbook of cuneiform culture* (pp. 470–485). Oxford: Oxford University Press.

Steele, J. M. (2017). *Rising time schemes in Babylonian astronomy*. Dordrecht: Springer.

Steele, J. M. (2018). The development of the Babylonian zodiac: Some preliminary observations. *Mediterranean Archaeology and Archaeometry, 18*(4), 97–105.