Journal of Islamic Studies and Culture
December 2023, Volume 11, pp. 1-15
ISSN: 2333-5904 (Print), 2333-5912 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jisc.v11a1
URL: https://doi.org/10.15640/jisc.v11a1

Are Islamic Legacy Calendars of the Lunar Type, Really? Measurement of the Deviation

Rafik Ouared[1]

Abstract

Background and Purpose: This study aims to demonstrate that the so-called Islamic legacy calendars are of the Gregorian-like type far from corresponding to the properties of the synodic lunar month. This unexpected result provided the first stone from which the search for a coherent definition of legacy criterion has been undertaken in this work.
Material and Methods: To this end, distributions of time lag (Δt_0), the time distance between the lunar conjunction (*LC*) and the first lunar day of the month, were processed and used to estimate the *1st−Day* rejection index (R_I) for four computerized calendar paradigms used in Lausanne city, between*1938* and *2038*. Those estimates measured the deviations from the lunar synodic properties caused by the underlying hypotheses. In addition, new synoptic figures of the projected *2023/1444H* Ramadan calendars in twelve pilot cities were computed to highlight the fundamental reason for mismatch along with specific assessment. Those figures also aimed to illustrate the competitive effects of four environmental parameters on final issues, namely: *LC*, *latitude*, *time zone* and *season*.
Results: Several results were found: R_I was ranging between 45% and 90% while the corresponding rejection thresholds were between 8h and 18h. The synoptic figures, while fully explaining the similarities and differences between the calendars in and between cities with all their respective *1st−Day* dates being summarized in "Confusion Tables", they also contributed to demonstrate that all the residual flaws of the Islamic calendars were caused by explicit and implicit assumptions of unfounded "*day reference times*" (*DRT*), as if the lunar context was assimilated to a Gregorian-like one.
Conclusion: The results were finally analyzed within the framework of the "inclusive science approach" (*ISA*) and a new proposal was made in favor of a "*single and universal*" Islamic calendar legacy definition, which conforms on the one hand, to the properties of the lunar synodic month and on the other hand, to lunar Islamic requirements.

Keywords: *DNM* (Dark New Moon), Δt_0 (Time Lag), *LC* (Lunar Conjunction), *ISA* (Inclusive Science Approach), *DRT* (Day Reference Time), *ART* (Activity Reference Time).

1. Introduction

Fundamentally, there are three natural periodical time units that can be used at human scale: daily period (24h), lunar synodic monthly period (∼708*h*) and yearly Gregorian period (∼8766*h*). The latter also corresponds to ∼365 *24h-day* equivalents, amid slightly different definitions of year lengths and technical adjustments of leap year [1,2]. These time units define the natural periodic limits of the different chronological contexts to which any system of calendar, be it solar or lunar, must subscribe first and foremost, respectively.

The idea of a Gregorian calendar [3] amounts to dividing its long natural yearly period into twelve shorter monthly periods artificially segmented and strictly proportional to unequal numbers of days (28-31). In this case, the months were not bounded by natural limits, but rather addressed by manned

[1] Institute of Inclusive Study of Lausanne, Electronic address: rafik.ouared@ik.me, rafik.ouared@gmail.com

intervention so as not to overlap. This implied the legitimacy of defining an absolute reference time, namely: "*day reference time*" (*DRT*), to fix the beginning of the day in phase with the artificial boundaries[1]. In Gregorian calendar, this referential time was set to *midnight* regardless of the activities performed during the day. This calendar, by its nature, was unique in terms of definition and application throughout the world. It is considered as a *1-fold* calendar, since months and years defined in its framework are all proportional to the periodic time lengths, respectively, the same way throughout the world.

For lunar calendars things were a way different. The durations of the synodic months are fixed by successive lunar conjunctions (*LC*s) taking place at times constantly varying between 0 and 24 hours, known with an accuracy of less than one second [4]. This implies first that the number of lunar days is not proportional to monthly time lengths. In addition, the lunar year period has not been fixed in nature, unlike the Gregorian year: it was left free to the appreciation of everyone according to own cultural and religious needs. As far as Islam is concerned, it is in the Holy Qur'an (***Surah 9, verse 36***), that the number of consecutive monthly periods forming a lunar year has been constantly fixed at *n=12*. Therefore, the construction of a genuine lunar calendar should first and foremost, strictly respects the natural synodic lunar boundaries, month by month, with no other possibility than to link the reference time to every ongoing activity, apart. In this case, and contrary to Gregorian calendar, *DRT* no longer has value. Another replaced it, namely: the "*activity reference time"* (*ART*), providing brand new inclusive definition of the lunar calendar.

Consequently, it follows that the lunar day is *two-fold* with the early and later days shifted by 24h, and the lunar month is *three-fold*, made of two combinations of three calendars in either female (30-29-30 days) or male (29-30-29 days) modes, of which both pairs of 29 and 30 days are shifted each by a day. This *X-fold* feature is sketched out in Table 1, which summarizes for instance, issues during Ramadan 2023/1444H for eight different Islamic ritual activities, at Lausanne. In this case, one can notice the exhaustive set of figures coming along with two 1st-Days of the month (March 21 and 22), two last days (April-20 and April-19) and three calendars grouped in a female mode (March-22/April-20, March-22/April-19, March-21/April-19). This configuration constantly changes with *LC*s and any other activity starting off at a different time during this period of month will check in one of the quoted outcomes. Meanwhile, the behavior of the lunar year requires deeper investments to determine the nature of related *X-fold* calendar polymorphism[2].

Activities	**ART**	**Ramadan** *1st−Day*	**Ramadan** *Last−Day*	**#Days**
Fajr Prayer	T_{Fajr}	Mar-22	Apr-20	30
Dhor Prayer	T_{Dhor}	Mar-22	Apr-19	29
Asr Prayer	T_{Asr}	Mar-22	Apr-19	29
Maghrib Prayer	$T_{Maghrib}$	Mar-21	Apr-19	30
Icha Prayer	T_{Icha}	Mar-21	Apr-19	30
Fasting	T_{Fajr}	Mar-22	Apr-20	30
Night of Fate	$T_{Maghrib}$	Mar-21	Apr-19	30
Tarawih	T_{Icha}	Mar-21	Apr-19	30

Table1– ***Three-fold*** **lunar calendar for Ramadan 2023 in Lausanne. Each row corresponds to a ritual activity defined by its *ART*. Activities in same colored type of rows share the same calendar. The colored types of rows ("*white*", "*light-gray*" and "*grey*") correspond to all possible calendars in that period.**

[1]The switch to DST in vernal equinox also changes Gregorian month boundaries by an hour, similarly.

[2]Likely to be three-fold.

As for the Islamic calendars, which are followed by the overwhelming majority of Muslims, although they are attributed a lunar-based legacy [5], the only one amongst the many other calendars used worldwide [6], they actually are at odds with respect of the true limits of the synodic lunar month, which is nevertheless the first and essential requirement to observe for any coherent formulation of this type of calendars. Indeed, it has been found that the lunar year was artificially composed in a Gregorian-like way with DRTs explicitly or implicitly fixed at sunset or earlier, as if *LC*s were always set to occur at the same time, contrary to physical reality. Those poorly constructed calendars were such that the first synodic lunar days were often rejected.

This is typically what happened on Ramadan 2023/1444H in many cities (see Figure1). In Lausanne for instance, the synodic fajr calendar for *fasting*[3] counted 30 days in a Month that lasted ~707*h*. Ramadan and Chawal *LC*s occurred on March21 at 06h23 pm (*UTC+1*) and April 20 at 06:12 am (*UTC+2*), respectively. Therefore, the first fajr day rose up on March 22 about 10 hours and 30 mins after *LC* while the last came out on April 20, less than two hours before *LC*. However, in most of the Islamic calendars the *1st−Day* on March-22 has been artificially delayed to March 23, which inevitably raised several technical questions regarding the consistency of the underlying paradigms: **a**/ why days with time lag Δt_0 smaller than 24h were rejected while in the same time, those with Δt_0>24h were taken up, senselessly? **b**/ Similarly, why the symmetry of the rule was broken up to allow forward rejection of March 22 but not backward rejection of April 20? **c**/ How could legacy calendars cope with the undefined durations induced by the broken synodic months, as if it was possible to ignore current knowledge provided by astronomy and replicate the lack of knowledge that prevailed in past centuries?

With this lot of inconsistency, it is legitimate to review the current strand of Islam-based interpretations at the light of active science. In this work, the quantitative properties of both types of calendars (synodic and Islamic) were studied and compared with the objective of demonstrating that the latter was not matching the natural synodic lunar properties. Finally, the results were exploited to discuss issues with reliable calendar legacy criteria: a brand-new definition matching both science and Islamic requirements was proposed then.

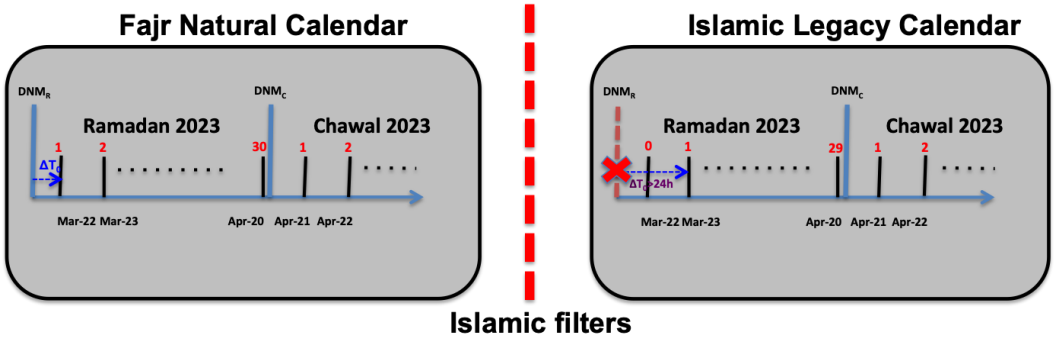


Figure 1 – **Representation of Ramadan 2023/1444H situation at Lausanne. One can see, left, the synodic *fajr* calendar not looking over the *1st−Day* (Δt_0<24h), and right, the representation of those Islamic calendars rejecting the *1st−Day* (Δt_0>24h). *DNM*$_R$ and *DNM*$_C$ (*Dark New Moon*) stand for Ramadan and Chawal *LC*s, respectively. The rejected *1st−Day* is flagged with number 0 in the right part of the figure, along with the artificial red-crossed invalidation of *DNM*$_R$.**

[3]In Islam fasting starts at dawn (Fajr).

2. Time lag distributions

Time lag Δt_0 is defined by the equation below:

$$\mathbf{\Delta t_0 = t_{15} - t_{LC}} \#(1)$$

where $\mathbf{t_{15}}$ is fajr time corresponding to solar depression 15° (solely for this study) and $\mathbf{t_{LC}}$ is the lunar conjunction time. Two Δt_0 points were considered every year between 1938 and 2038 for Ramadan and Chawal at Lausanne city, respectively, with respect to calendars *Cal1* to *Cal4,* defined in Table 2. Data were used from *timeanddate.com* platform [7].

Calendars	Definition of 1^{st} ***Fajr Day***
Cal1 (*Inclusive Fajrlendar*)	Comes right after *LC*
Cal2 (*Exclusive Sunsetlendar*)	Follows 1^{st} Sunset after *LC*
Cal3 (*Wordlwide Vislendar*)	Follows 1^{st} Sunset Computed according to Visibility Criteria encompassing the whole World (*Cloud Coverage not Included*)
Cal4 (*Local Vislendar*)	Follows 1^{st} Sunset according to Locally Computed Visibility Criteria (*Cloud Coverage not Included*)
Cal5 (*Sightlendar*)	Follows Direct Sighting at Night of Doubt (*Cloud Coverage Included*)

Table2– **Definitions of calendar paradigms. Each calendar is identified in specific grayed color row. Cal3 and Cal4 are tabulated with the same gray level as they are both computed with similar physical visibility criteria, though not within the same geographical conditions. The names associated to calendars in each second row, highlight their specific paradigm features, respectively. The reasons of which Cal1 and Cal2 are associated with the words "*inclusive*" and "*exclusive*", respectively, are discussed in the text.**

In this exercise, Cal5 was omitted for two reasons: cloud coverage was neither known nor computable, while knowledge of *LC* was not compatible with direct sighting. Since the predictions of the visibility criteria were often intrinsically divergent by 24h [8,9,10,11,12][4], one from the other, the less conservative criterion [11,13] has been selected to fix up minimum crescent age instrumental visibility threshold as defined in equations 2 and 3 below, locally for Cal4, and worldwide for Cal3, respectively:

$$\mathbf{\Delta_{vis}^{th} = t_{Maghrib} - t_{LC} \geq 11h40'} \#(2)$$

$$\mathbf{\Delta_{vis}^{th} = t_{Fajr}^{+1} - t_{LC} \geq 11h40'} \#(3)$$

where $\mathbf{t_{Fajr}^{+1}}$ is time of fajr taken locally on next day after LC while the other parameters of time are self-explicit. The set of N=208 points were distributed in ten free time intervals.

The resulting distributions are shown in Figure 2. The Rejection index $\mathbf{R_I}$ is the rate defined by the equation below:

$$\mathbf{R_I = \frac{N_{out}}{N} . 100\%} \#(4)$$

where $\mathbf{N_{out}}$ is the number of points with Δt_0>24*h*, and $\mathbf{N}$ the total number of points. One can see two results for natural *fajr* calendar *Cal*1: **a**/as expected, all time lags $\mathbf{\Delta t_0}$ are ranging between 0 and 24h, and **b**/their common distribution is uniform. Consequently, the average value of $\mathbf{\Delta t_0}$ is equal to 12*h*, there was no first-Day rejection (R_I=*0*%) and the season-free *1^{st}−Day* rejection threshold was equal to 0.

[4]For instance, under the same paradigm, Dr M. Odeh criterion implicitly pointed to March 22 as the*1^{st}−Day* of Ramadan 2023 in Paris, while both of Dr Yallop and others related visibility criteria were pointing to the next day, on March 2023.

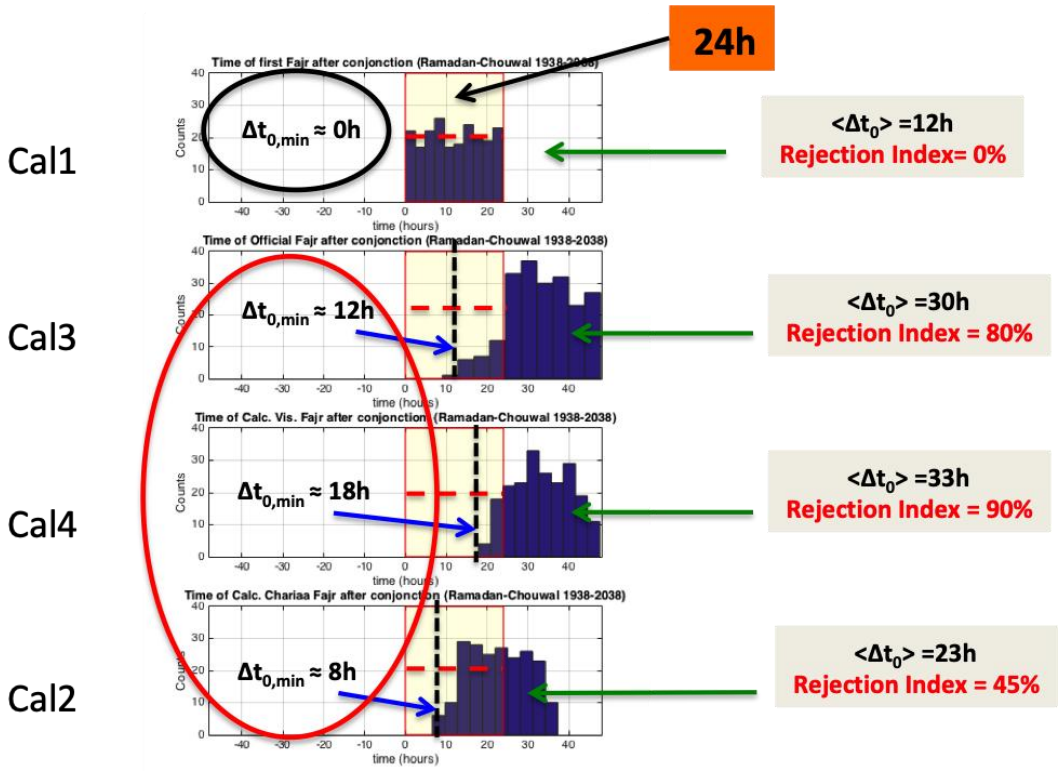


Figure 2 – **Time Lag distributions in blue color for calendars Cal1, Cal3, Cal4 and Cal2, ordered top-down, respectively. The yellow area fixes the 24h window. For each calendar, three values are computed: the average of Δt_0, the rejection indexes R_I, and the minimum time shift $\Delta t_{0,min}$ interpreted as the free-season *1st−Day* rejection threshold. The vertical black dashed lines mark the limits of the rejection thresholds for Cal2, Cal4 and Cal3, respectively.**

All the distributions for the remaining calendars were shifted by time offsets depending on the underlying paradigms, respectively. As to *Cal*2, for which *Gregorian−like DRT* was explicitly set at *sunset*, distribution was shifted by 8*h* pushing 45% (R_I) of the points outside the 24*h* time window limits. This value reflected the "*wrongness*" character of the underlying hypothesis and Δt_0 was in average equal to 23*h*. As to *Cal*4 and *Cal*3, time shift was equal to 18*h* and 12*h*, leading to larger rates of *1st−Day* rejections: 90% and 80%, respectively. The average Δt_0 for both paradigms was larger than 30*h*. By analogy with *Cal*2, the higher values of R_I indicate that *Cal*4 and *Cal*3 also undergo the same type of *DRT* assumptions, except that they are implicitly fixed in this case at times earlier than *sunset*. This latter result contradicted all the assertions that claimed that *sight-related* paradigms lined up all with a "*legal day*" starting at *sunset*. In reality, *Cal*2 was the only one calendar that met this criterion, which no one dared to follow apart from being cited in articles [14].

Time shifts in Δt_0 distributions were not only markers of synodic month violations[5]; they also were precursors of many other hidden artifacts: ***a/***the monthly periods were undefined[6], and ***b/***the forward-backward symmetry undergoing the same time lag distribution function that would normally have caused the rejection of both ending days of the month, similarly, has been broken up artificially in the backward direction to avoid unnecessary issues with non-physical calendars.

[5]Some speakers inverted causality. They claimed that thresholds were the natural cause of rejection of the first days as if the latter were coming "*ahead of time*". This statement is definitely wrong since Figure 2 shows that thresholds are themselves generated by the violation of synod month boundaries in paradigms.

[6]The usual communication of *LC* dates and times in official releases is useless and misleading for those using direct and indirect sighting paradigms.

Consequently, considering only the forward rejections of the *1st−Day* that guarantee the physical number of lunar days in the month (29,30), one can summarize the four modes of the Islamic calendar deformations in Figure 3, below:

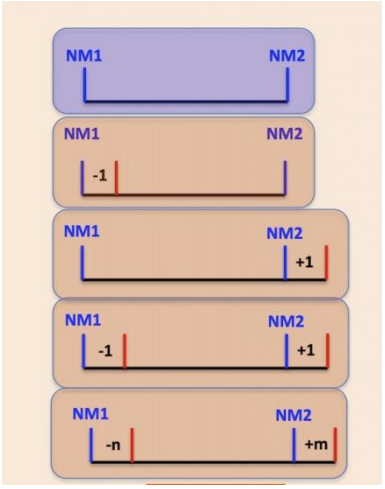


Figure 3 – **Illustration of the four Islamic calendar deformations when the forward Δt_0 rejection issue is being considered. Lunar conjunctions markups are represented in blue lines: *NM1* (*dark new moon 1*) and *NM2* (*dark new moon 2*). Top-down, in orange panels, one can observe the four modes of deformations: *Contraction* (−1 *day*), *Extension* (+1 *day*), *24h-shift* (−1 *day* on *proximal* end and +1 *day* on *distal* end), and ~1.5-day shift for direct sighting (*n, m*≥1).**

3. Comparison of calendars over 12 pilot cities

In order to visually compare the calendars locally and around the world, a synoptic figure, namely ***H24-1T,*** was computed using Matlab™ toolkit for every conjunction in different cities. In this work *twelve* pilot cities were chosen and the corresponding figures were published in [15] for every new period of Ramadan and Dhulhijja as well as the summary tables accompanying them. For instance, Figure 4 and Figure 5 show representations of *Ramadan* 2023/1444*H* calendars in cities of *Dakar* and *Antalya*.

Every figure is composed of two subfigures illustrating each the synoptic situation of *1st−Day* issues within the four calendar paradigms at corresponding *LC*s: left (**a**), for Ramadan, and right (**b**), for Chawal. Every subfigure is composed of three components: **a/** the 24*h* clock and the blue line indicating *LC* time along with an astronomical twilight area colored in *orange* hosting the time of *fajr*, **b/** four colored circular *crowns* representing each one calendar, and **c/** complementary texted information. The user guide is provided below.

Figure 4 and Figure 5 read as follows:

1. When the blue line passes through the green area in circular crown, the first day of the month is dated correctly in corresponding calendar; otherwise, it is postponed by a day if line passes through whited area. Notice that for calendar *Cal*1, *crown* is always green since paradigm never rejects first day.

2. *LC* date and time are read in the first line of the text. The synodic *1st−Day* date and time can be read in the 2*nd* line of the text. First day is the same as *LC* if blue line goes into *Area 1 (precedence of LC over fajr)*. Alternatively, if blue line goes through *Area 2 (precedence of fajr over LC), 1st−Day* comes the next day following LC**.** Both situations account for ~96% of cases which do not require the knowledge of fajr time to determine the *1st−Day*.

3. *1st−Day* is unknown if *LC* blue line goes through the orange area unless *fajr* time is known with enough precision to solve *LC-versus-fajr* precedence issue. This case accounts for ~4% of worldwide situations. The evolution curve of the *fajr* instant over a year was obtained in 2016 for the city of Lausanne with

an accuracy of *one* minute [16]. Ongoing work is out to generalize treatment of all the issues over the world.

4. The red circular segment represents the *forward* time lag Δt_0, of which the time length can be estimated right on figure and also read in the third line of the text. The blue circular segment represents *backward* time lag[7]. Its value can be read in the third line of the text, too.

5. The full whited area time lengths give the *season-dependent* Δt_0 thresholds for the respective calendars.

6. The *green-to-white* interface positions define *DRT*s: for example, in *Dakar* one can read *Maghrib* time at *7:30pm* for *Cal*2. In *Cal*4 and *Cal*3 they come earlier than sunset at *6pm* and *7:30am*, respectively, hence highlighting the *implicit* relationship between *Gregorian−like DRT*s and *indirect* sighting. Moreover, at higher latitudes, *DRT* might be undefined in *winter* season.

7. In *Dakar* (Figure 4), there was a precedence of "*Night over Day*" (*sunset* comes first after *LC*, then *fajr* follows). Therefore, the potential "*odd nights of fate*" days ranking from 21 to 29, were matching the "*even*" *fasting* days ranking from 20 to 28, between *April* 10 and 18. Adversely, in *Antalya* (Figure 5), the potential "*nights of fate*" days were ranging between *April* 11 and 19, since in this case, it was "*Day*" that preceded "*Night*" (*fajr* came first, then *sunset* followed). In Ramadan 2023, figures including the 12 pilot cities [15] showed that the 24*h*-nights over earth globe started off in Europe and ended up clockwise in both *Asia* and *Australia*, the next day[8].

Complementary to the comprehensive explanations presented in the synoptic figures, Table 3 summarizes the two subsets of pilot cities sharing the same calendars out of the possible *three* with respect of calendar *Cal*1, while the *confusion tables* (Table 4 and Table 5) summarize which cities undergo the correct first days of *Ramadan* and *Chawal* 2023 according to synod timeline, with respect of all four calendars. The correct and incorrect values are tabulated in the *lightest* and *darkest grey* columns, respectively. One can also notice that for instance, *April 21*, the *1st−Day* of *Chawal* was *correct* with respect of *Cal*2, *Cal*3 and *Cal*4 for cities belonging to the *green* group, and *wrong* for those in the *blue* group with respect of the same calendars. This is typically the reason for calling them *confusion* tables.

4. Proposal for brand new Islamic calendar legacy criterion

In the above sections, it was shown that the so-called *legacy* calendars used by Muslims nowadays were not primarily designed to comply with the inclusive synodic properties of lunar month. Instead, they were technically built as the exclusive *Gregorian* calendar was, except that *DRT*s were not set at *midnight*, and the *time* limits of a typical year have been artificially defined in a blurred way outside the frames of existing natural markups, often leading to the rejection of the first true day of the month. Unlike the *Gregorian* calendar that was legitimately designed to respect its natural context, *Islamic* calendars were not in the position of claiming lasting legacy despite some misleading statements, because they were designed without any regard for the natural lunar context on which they depended on, first and foremost.

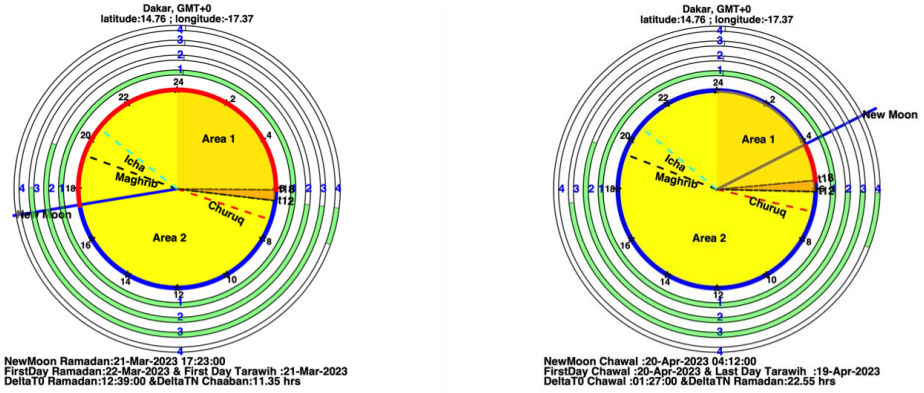
---

[7]Defined as the lifetime of last day in ending month before *LC* breaks it out.
[8]In Chawal, precedence was reversed as can be seen from Figure 4 and Figure 5.

Then, two questions remain: why should the Islamic lunar calendar endorse the properties of the synodic month, fully? As such, and given the now known *X-fold* inclusive features of synodic lunar calendars, what was the purpose of defining *legacy*?

To answer these questions, it was necessary to adopt the "*Inclusive Science Approach*" (*ISA*). In this framework, reasoning considers on the same level two sources of information, different by their nature but emanating from the same *designer*, namely, ***God Almighty***: *science evidence* when firmly and unambiguously established, and *Scriptures* encompassing the ***Holy Qur'an and Hadith***. In this approach, the role of science was not incidental. Instead, it was expected to be highly functional since it is endowed with practical capabilities that are able to adjust the constitutive *evolutionary* interpretations of Islam beyond any traditional limitations of current *hermeneutics*. Moreover, this approach was not only dictated by inference logic; it was also strongly emphasized up to *enforcement* in *Holy Qur'an* **(Surah 16, verses 51 and 52)**, potentially. As such, *ISA* was entitled to provide a powerful discriminatory method that can best rationalize *Scriptures*[9] by successive iterations, forward and backward, from one side to the other, up to reaching a convergence point in specific interpretations, the *matching truth* that can hold for shorter or longer time, up to next advances in knowledge, should they ever take place.

(b)



(a) (b)

Figure4–**Comparison of Ramadan 2023 calendars at Dakar**

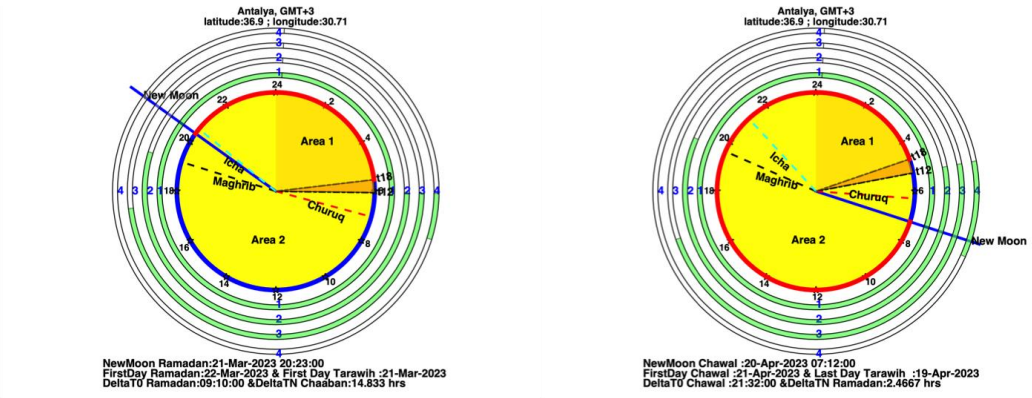
Why the properties of the lunar synodic month do matter in Islam?

To answer this question, *ISA* framework allows one to look at science first and identify the parameters out of which the calendars are fully defined. Basically, four parameters are involved: **1**/datetimes (year-month-day: hour-min-sec) of *LC* ends for every month (two parameters), **2**/*DRT* and *ART* defining the reference time of activities and days for both *lunar* and *solar* calendars, respectively, and **3**/the number of constitutive months that make a year.

The type of calendars that was needed to perform the ritual practices of Islam was quoted in the Scriptures. Indeed, ***Prophet Muhammad (PBUH)*** first ordained the observation of the lunar crescent [17] to ensure that the *sacred* months had actually begun before triggering the performance of a rite regardless of the position of the launch day, be it the 1st, the 2nd or the 3rd. We know today, that this *prophetic order*, though not strictly matching the boundaries of the synodic months, has yet provided the least erroneous[10] legitimate *Sightlendar (Cal5)* ever, in a context where the knowledge of the lunar conjunctions was missing.

[9]*God Almighty* and *Prophets* are the only "*irrational*" sources of the Scriptures that are considered in *ISA*. The authentication process goes beyond the scope of this work.

[10]The cumulative error on both ends of the month is about three days (Figure 3).



(a) (b)

Figure5–**Comparison of Ramadan 2023 calendars at Antalya**

On the other hand, ***God Almighty*** defined all the required lunar-related parameters, beyond any requirement of manned intervention: *two* in nature (*LC* datetimes), and *two* in *Scriptures* (the *number* of months in one year and *legacy ART*). In this context, all the rites would be scheduled inclusively according to their specific *X-fold* calendar, locally and around the world. The first day of Ramadan 2023, for example, was the first *fajr* day of the synodic month, and the 27th night of Ramadan started at *sunset*, the two calendars taking place at the same time inclusively, and could likewise be linked together without undergoing any *1st−Day* rejection bias.

A priori, one would say that we are in the presence of a *Lunar Calendar Paradox* (*MCP*). Indeed, Islam has defined since its birth two calendars (*X-fold* type and *Sightlendar (Cal5)*), seemingly in total opposition, one issued from ***God Almighty*** and the other by his ***Messenger***, an awkward situation, a bit! In reality, the solution to this apparent paradox arises up if we consider that both calendars actually complement each other like two sides of the same coin, the first being designed to apply as soon as science was able to work out the dates and times of lunar conjunctions with high accuracy, while the second was given, alternatively, as a temporary solution as far as the lunar conjunctions remained unknown, which has been indeed the case for more than 14 centuries, but not anymore today!

Therefore, one can see that the legitimacy of *Cal5* should logically vanish by now, in favor of true lunar calendars respecting the synod limits, month by month, whose legitimacy should prevail in the long term.

All the other paradigms developed so far, the *Sunsetlendar (Cal2)* and the two *Vislendars (Cal3 and Cal4)* were all beyond the scope of legacy in Islam because they were neither matching science nor the Islam requirements, contrary to unfounded statements made by some scholars, scientists and institutional speakers. Indeed, the very first *killing* argument is that calendars were all supposed to be lunar but they went all *Gregorian−like*, assuming *DRT*s instead of using *ART*s, as was demonstrated above. As far as *Cal2* is concerned, its underlying paradigm would be meaningful in a solar context, but not in a lunar one. As to *Cal4* and *Cal3*, the calculation of the so-called lunar visibility criteria (*not the phases*) is useless and meaningless when *LC* is being known, let alone that there are many of them to be defined and they do not converge often [8], generating a lot of confusion among the populations. The list of inconsistencies goes on to include the so-called *legacy day* hypothesis in which *DRT* is set at *sunset*, an unfounded rule generally accepted by all Muslim communities, but which actually oscillates at a much earlier time compared to its nominal value (see values of *Cal4 and Cal3 DRT*s on Figures 4 and 5).

Therefore, for all the reasons discussed above, *Cal5* should be considered as an "*old legacy*" while *Cal2, Cal3 and Cal4* should never have had any. However, it is worth mentioning that without all these development steps, it would hardly be possible to carry out this study.

Why the need of legacy given the *X-fold* feature?

In practice, the *polymorphism* of the lunar calendar does not exclude the possibility to define one single reference calendar, using an *extraordinary* main activity going over several months, for instance, without excluding and hence biasing other complementary calendars to related activities during the same synodic monthly periods.

In this case, it is possible to claim by default for the reference calendar, a *relative legacy* defined by the time of reference of a selected activity. Therefore, whenever the *1st−Day* of the month is mentioned, it should be remembered that, on the one hand, it is the "*1st−Day* ***of the synodic month starting at the same given*** **ART**", and on the other hand, for the remaining activities, "***the*** *1st−Day* ***can be the same or shifted by one day***", with all consequences on *3-fold* monthly calendar.

In Islam, it is indeed possible to select *ART* objectively, beyond the need of manned intervention. Given the numerous notifications for *fasting*[11] in Scriptures, which encompass all four sacred months, one possibility appears unambiguously above all, which is nothing other than the time of *fajr*[12].

Nevertheless, despite the ongoing issue regarding the determination of *fajr* time, which poses a problem for the full determination of the 1*st fajr* day over the world, it appears that the knowledge of *fajr* time is not always needed. It is mandatory only in ∼4% of the cities whenever *LC* occurs during *astronomical twilight*. In this case, a fair precision would be required (≤1') to resolve issues concerning precedence of *fajr* time over *LC*. To our knowledge, this level of precision was only achieved temporarily in *Lausanne* and neighboring cities thanks to an experimental development made recently [16], before it can be soon generalized around the world. In the meantime, should this limitation occur somewhere, the lack of knowledge principle would apply exceptionally to extend the ending month by one day[13].

Proposal for a single and universal definition of Islamic lunar calendar

Taking into account the considerations discussed in the previous sections, it is possible to define "*unique and universal*" lunar calendar that is adapted to the ritual practices of Islam consistently with both science evidence and the evolutionary Islam requirements.

- Claim 1: The *1st−Day* of the lunar month at a given place corresponds to the first *fajr* following the lunar conjunction, and it is locally unique.
- Claim 2: The last day of the lunar month at a given place corresponds to the last *fajr* preceding the lunar conjunction, and it is locally unique.
- Corollary 1: The lunar month calendar at a given place lists the number of days rising at *fajr* between two consecutive lunar conjunctions, and it is locally unique.

---

[11]Fasting the whole month of Ramadan, not Fasting the first day of Chawal, Fasting the day of Arafat as well as the 9th, 10th, 11th days of Muharram.

[12]How time of fajr is defined goes beyond the scope of this paper.

[13]Based on the modern extension of the interpretation of hadith [17].

- Claim 3: The annual lunar calendar at a given place defines the number of *fajr* days recorded during twelve consecutive lunar months[14], and it is locally unique.
- Corollary 2: The duration of the lunar year at a given place is defined between the 1^{st} and the 13^{th} lunar conjunction of the year, and it is universally the same.
- Corollary 3: To each lunar conjunction at a given place corresponds two 1^{st} days of the month, offset by 24h, shared by three monthly blocks of activities
- Corollary 4: Each lunar conjunction corresponds to two regions of the world whose 1^{st} days are offset by 24 hours, for any selected ART.
- Corollary 5: To each pair of consecutive lunar conjunctions at a given place corresponds three different monthly calendars related to three monthly blocks of activities.
- Corollary 6: Each pair of consecutive lunar conjunctions corresponds to three regions of the world whose monthly calendars for any given ART are different.
- Corollary 7: With each lunar conjunction, the geographical configurations in the world of the 1^{st} days and the monthly calendars change.

One can notice that though this definition proposal is "***unique and universal***", its functional application over the world is ***location wise***, not centralized, and *ART fajr* time has no other objective than providing *convenience* in handling calendars.

Therefore, within the framework of *ISA*, these claims and corollaries systematically define *Fajrlendar Cal1* as well as the inherent properties, which correspond to the fundamental requirements of science and Islam, and do not exclude the other folded calendars corresponding to other time sets of activities.

Moreover, with this definition in hand, it is now possible to resolve the outstanding issue regarding the determination of the *1st−Day* of *Muharram* in *Hijri* year 1, using calendar *Cal1*. Indeed, the date of this very day has always been set at *July 16, 622* [18]. However, one can see in the light of the above considerations, that this condition of limit is rather incomplete. Therefore, to fix it, it would be necessary on the one hand, to trace back the first *two days* of *Muharram* in year 622[15], and on the other hand, to identify the *two regions* in the world that correspond to them, respectively.

5. Discussion

The important question that should be asked at this stage concerns the methodological limitations of hermeneutics [19, 20]. Indeed, the calendar issue addressed in this work could have been solved decades ago, since the lunar conjunctions have been determined with accuracy [21]. It was then obvious that the Islamic lunar calendars had to absolutely comply with synod timeline. Instead, we have witnessed the development of new calendars, which, under the pretext of exploiting new elements of science evidence, have drifted away causing apparently more harm and bewilderment among the Muslim populations.

It is hard to believe that Muslim scientists could not have noticed that the paradigms they were developing were not quite consistent with the basic lunar requirements. The only possibility that remains is to think that their reasoning was limited by the scope of the ongoing hermeneutics, which in reality left no possibility for science to endorse its functional and corrective role of any Islamic interpretation bearing an evolutionary character over time [22]. Therefore, science has been used as a *passive* and *opportunistic alibi* for long-standing *sealed* interpretations based exclusively on *scriptural readings*.

---

[14]The 12 months imposed by Islam make it possible to close the discussion about the seasonality (***Ramdha***) of the month of Ramadan, the former being associated with a number alternating between 12 and 13 months, as in *lunisolar* calendars. This shows that semantics is impeded by some methodological limits so it must be used with great caution to interpreting Islam.

[15]There are two possible issues: {July15, 16} or {July16, 17}. More, shifting those dates by two months, as was claimed by some scholars, does not bring any added value to the solution.

Practically speaking, the usual Islam-based narration assumes explicit or implicit precedence of Islam scriptural sources (Qur'an, Hadith) interpretations over science-based evidence. Therefore, though not clearly stated, science was not used as a fundamental player to strengthen the construction of reliable and consistent timeless abstraction of Islam. The consequence of this weakness in methodology can be observed today through the many left-over long-lasting open problems, particularly critical in this modern era.

It is very clear from this study that Muslims have inherited certain perceptions of Islam that deviate greatly from reality, to the point that the extraordinary scientific advances of the 20th century and beyond could not be used wisely to curb down these biases, beyond any usual discussion about the philosophy of science in Islam [22,23] and scientism [24].

More specifically, the stumbling block dwells in the inevitable condition of observation of the lunar crescent that had been issued by ***Prophet Muhammad (PBUH)***. Hermeneutics found her locked in this pitfall and could only awkwardly negotiate the use of science to define a calendar *freed* from the frequent errors found during direct observations [21]. Therefore, it has been assumed that *indirect* observations could be less prone to errors, hence opening the field for brand new modern computations of visibility criterion. Unfortunately, not one but several of them were calculated without being able to reduce the 24-hours uncertainty that lingered in the expectations, and therefore failed to manage and reduce the state of generalized confusion.

The treatment of this one problem can be considered as a case study that blatantly identifies the limits of current hermeneutics. To solve it, it was necessary to strengthen the latter by providing a scientific arm that authorizes the use of rational experimental and theoretical processes so one could verify, correct and validate any interpretation of scriptural texts that falls within the scope of application. Surprisingly, this processing requirement has also been recommended in (***Surah 16, verses 51 and 52***), leaving no doubt about the relevance of this move as well as its discriminatory power.

Therefore, an "Inclusive *Science Approach*" (*ISA*) has been developed to give a more active role to science as well as strength in its ability to adjust and validate the interpretations of scriptural texts (*Qur'an, Hadith*), when necessary. Some unexpected discoveries have been made to detect and solve the paradox of the lunar calendar in Islam as well as the missing stone involved in the accurate determination of the time of *fajr*, on which it depends.

In this article, we have presented, for the very first time, what *ISA* is, and how *ISA* has been used to solve *MCP* thus demonstrating that science is not only intended to discover the signs of ***Allah*** or to improve well-being [24], but also to improve active understanding of both the *Holy Qur'an and the Hadiths* in order to strengthen resilience in earthly life, in the same way that Islam could be used to discover new scientific evidence as was the case when we measured the *fajr* moment, recently [16].

More, *ISA* was driven by "*No precedence*" relationship of Islam over science, and as such, was always consistent with the ***Oneness-of-GOD*** critical requirement, while other methodologies generally were not, by inadvertent omission, which was a critical flaw in the fundamental basis of the latters.

Finally, this methodology was original and effective in its way of dealing *downstream* with problems by measuring the consequences of paradigms rather than first discussing the paradigms themselves with the risk of being trapped in an infinite loop of reasoning, with no way out.

6. Conclusion

As part of the inclusive science approach, experimental analysis of time lags and the monitoring of the *H24-1T* synodic figures in 12 pilot cities, helped to establish that the lunar calendars used in the Muslim world were of the (*1-fold*) *Gregorian−like* rather than the (*X-fold*) lunar type, contrary to what Islam has ordained.

In addition, the relative notion of "*Islamic legacy*" in the lunar context has been issued and highlighted very differently from the many others that were proposed, so far.

Therefore, the inclusive *Cal1 (Fajrlendar)* appeared as the ideal proposal for a "*Legacy Islamic Calendar*" obeying a "*Single and Universal*" definition, whose application is decentralized throughout the world.

This calendar does not require periodical adjustment. It is predictable and infinitely consistent. Nevertheless, in order to definitively close the problem and overcome the *residual* uncertainty, it still remains to perform additional technical and scientific efforts to determine the worldwide generic time curve of *fajr* moment, according to the experimental principle discovered in [16].

Appendices

Cities	**UTC+X**	**Ramadan** *1st−Day*	**Chawal** *1st−Day*	**#Days**
Sydney	*+11/+10*	Mar-22	Apr-21	30
Beijing	*+8*	Mar-22	Apr-21	30
Kuala Lampur	*+8*	Mar-22	Apr-21	30
Makkah	*+3*	Mar-22	Apr-21	30
Antalya	*+3*	Mar-22	Apr-21	30
Lausanne	*+1/+2*	Mar-22	Apr-21	30
Algiers	*+1*	Mar-22	Apr-21	30
Dakar	*+0*	Mar-22	Apr-20	29
Rio de Janeiro	*-3*	Mar-22	Apr-20	29
Santiago of Chile	*-3/-4*	Mar-22	Apr-20	29
Montreal	*-4*	Mar-22	Apr-20	29
California	*-7*	Mar-22	Apr-20	29

Table 3 – **Ramadan 2023 Cal1 calendars for 12 pilot cities. In the** 2*nd* **column, *slashes* indicate how *DST* changes on and off in Chawal month for corresponding cities, respectively. The table shows which cities share one or the other of the two calendars of 30 and 29 days corresponding to the "*white*" and "*gray*" blocks respectively.**

Cities	UTC+X	Cal1	Cal2	Cal3	Cal4
Sydney	*+11*	Mar-22	Mar-23	Mar-23	Mar-23
Beijing	*+8*	Mar-22	Mar-23	Mar-23	Mar-23
Kuala Lampur	*+8*	Mar-22	Mar-23	Mar-23	Mar-23
Makkah	*+3*	Mar-22	Mar-23	Mar-23	Mar-23
Antalya	*+3*	Mar-22	Mar-23	Mar-23	Mar-23
Lausanne	*+1*	Mar-22	Mar-22	Mar-23	Mar-23
Algiers	*+1*	Mar-22	Mar-22	Mar-23	Mar-23
Dakar	*+0*	Mar-22	Mar-22	Mar-22	Mar-23
Rio de Janeiro	*-3*	Mar-22	Mar-22	Mar-22	Mar-23
Santiago of Chile	*-3*	Mar-22	Mar-22	Mar-22	Mar-23
Montreal	*-4*	Mar-22	Mar-22	Mar-22	Mar-23
California	*-7*	Mar-22	Mar-22	Mar-22	Mar-23

Table 4– **"*Confusion Table*" for Ramadan 2023 in 12 pilot cities: the last four columns give the dates of the *1st−Day* for calendars *Cal*1, *Cal*2, *Cal*3 and *Cal*4. Both the "*correct*" and "*wrong*" dates are tabulated in "*light grey*" and "*dark grey*" areas, respectively. The three groups of cities in "yellow", "green" and "blue" colored areas highlight each their similar behaviors with respect of all four calendars taken simultaneously.**

Cities	UTC+X	Cal1	Cal2	Cal3	Cal4
Sydney	*+10*	Apr-21	Apr-21	Apr-21	Apr-22
Beijing	*+8*	Apr-21	Apr-21	Apr-21	Apr-22
Kuala Lampur	*+8*	Apr-21	Apr-21	Apr-21	Apr-22
Makkah	*+3*	Apr-21	Apr-21	Apr-21	Apr-22
Antalya	*+3*	Apr-21	Apr-21	Apr-21	Apr-21
Lausanne	*+2*	Apr-21	Apr-21	Apr-21	Apr-21
Algiers	*+1*	Apr-21	Apr-21	Apr-21	Apr-21
Dakar	*+0*	Apr-20	Apr-21	Apr-21	Apr-21
Rio de Janeiro	*-3*	Apr-20	Apr-21	Apr-21	Apr-21
Santiago of Chile	*–4*	Apr-20	Apr-21	Apr-21	Apr-21
Montreal	*-4*	Apr-20	Apr-21	Apr-21	Apr-21
California	*-7*	Apr-20	Apr-21	Apr-21	Apr-21

Table 5 – **"*Confusion Table*" for Chawal 2023 in 12 pilot cities: the last four columns give the dates of the *1st−Day* for calendars *Cal*1, *Cal*2, *Cal*3 and *Cal*4. Both the "*correct*" and "*wrong*" dates are tabulated in "*light grey*" and "*dark grey*" areas, respectively. The three groups of cities in "yellow", "green" and "blue" colored areas highlight each their similar behaviors with respect of all four calendars taken simultaneously.**

Acknowledgment

The author would like to thank his dearest wife for her unwavering and lasting support without whom this work could never have been completed.

References

Britannica-Homepage, https://www.britannica.com/science/calendar/Time-determination-by-stars-Sun-and-Moon, last accessed 2023/11/06.
Wikipedia Homepage, https://en.wikipedia.org/wiki/Year, last accessed 2023/11/06.
Wikipedia Homepage, https://en.wikipedia.org/wiki/Gregorian calendar, last accessed 2023/11/06.
Wikipedia Homepage, https://en.wikipedia.org/wiki/Lunar month, last accessed 2023/11/06.
Proceedings of the first Emirates Astronomical Conference, Edited by: Nidhal Guessoum, Mohammad Odeh, Applications of Astronomical Calculations to Islamic Issues, 2008.
Wikipedia Homepage, https://en.wikipedia.org/wiki/List of calendars, last accessed 2023/11/06
Timeanddate Homepage, https://www.timeanddate.com, last accessed 2023/11/01
IMCCE Homepage, https://www.imcce.fr/newsletter/medias/2023/03/docs/Ramadan2023.pdf,
Last accessed 2023/03/01
BD Yallop, A Method for predicting the First Sighting of the New Crescent Moon, RGO NAO Technical Note N 69, 1997.
J.A.R. Caldwell and C.D. Laney, First Visibility of the Lunar Crescent, South African Astronomical Observatory, 2001.
M. Odeh, New criterion for lunar crescent visibility, Mohammad Sh. Odeh, Experimental Astronomy, 2006.
M.S. Faid, M.S.A. Mohd Nawawi, M.H. Mohd Saadon, Analysis tool for lunar crescent visibility criterion based on integrated lunar crescent database, Astronomy and Computing, Volume 45, October 2023.
Earthsky Homepage, https://earthsky.org/space/what-is-the-youngest-moon-you-can-see-with-your-eye-alone, last accessed 2023/11/07.
OUMMA Homepage, https://oumma.com/astronomie-charia-oumma-guerir-de- malaises-de-lune/, Last accessed 2023/11/07.
Youtube Homepage, Episode16: Ramadan 2023 Calendars (1444h) in 12 pilot cities, Rafik Ouared, January 2023.
Youtube Homepage, Episode 19: Imsak timetable Ramadan 2023 (1444H) for Lausanne,
Rafik Ouared, January 2023
The book of Fasting, Sahih Muslim 1081b, Book 13, Hadith 21
Wikipedia Homepage, https://en.wikipedia.org/wiki/Islamiccalendar, Last accessed 2023/11/07
A.J. Rakhmadi, M. Hidayat, The Issues and Prospect of the Global Islamic Calendar, Proceedings of the International Conference on Community Development (ICCD 2020), Ad-vances in Social Science, Education, and Humanities Research, Volume 477, pp.109-112, (2020)
The Oxford Handbook of Islamic Theology, Edited by Sabine Schmidtke, Oxford University Press, March 2016
Cahiers de l'islam Homepage, https://www.lescahiersdelislam.fr/La-visibilite-du-croissant-lunaire-et-le-Ramadan_a362.html, Last accessed 2023/11/07
Guessoum Nidhal, Islam's Quantum Question: Reconciling Muslim Tradition and Modern Science, London: I.B. Taurus, 2011
The routledge Companion to Islamic Philosophy, Edited by R.C. Taylor and L.X. Lopez-Farjeat, 2016
Mumtaz Ali Kazi, The concept of scientific knowledge in Islam, Journal of Islamic Academy of Sciences, 1:1,7-9, 1988