Book Review

New Moon's Visibility and International Islamic Calendar for the American Region 1407H - 1421H

By Mohammad Ilyas. Penang, Malaysia: The International Islamic Calendar Programme, n.d.

The International Islamic Calendar Programme relies on calculations of the new moon's expected visibility. The term "new moon's visibility" gives a wrong connotation, because the astronomical term "new moon" refers to a moon that is completely dark and invisible. Therefore, from here on the term "crescent moon" or simply "crescent" will be used for a moon that could be visible after the new moon phase.

The problem of predicting the crescent moon's visibility has been of interest to astronomers in general for a friendly competition of sighting a young crescent moon and to Muslims for their needs associated with the Islamic calendar. The earliest astronomical criterion for visibility appeared in the Babylonian era: the moon's age after conjunction must be more than 24 hours, an arc of separation as must be more than 12° or the moon sets 48 minutes after sunset. Hindus (500-700 C.E.) developed a more elaborate system of calculations with the same $a_S >= 12°$ criterion. In the eighth to tenth centuries C.E., Muslim astronomers, notably Ya'qūb ibn Ṭāriq, Habash, al Khwarizmī, al Farghānī, and al Battānī excelled in mathematical astronomy and developed rules for predicting the crescent's visibility based on the importance of the crescent's width. A century later, al Bīrūnī recommended al Battānī's procedures. In the fifth century, al Ṣūfī and al Kashānī still quoted the early Babylonian criterion of $a_S >= 12°$.

In the late part of the nineteenth century, Schmidt recorded observations in Athens, Greece, throughout a period of twenty years. Fotheringham (1910) and Maunder (1911), who used Schmidt's data and then added some more observational data, made the first significant developments in criterion for visibility since the time of al Battānī. Bruin (1977) developed an independent physics-based criterion involving such variables as the sky's brightness, contrast, the crescent's intensity, and so on. However, his criterion was only theoretical and its validity needed to be proven by actual observations. Ilyas (1981) modified Bruin's criterion in order to remove the discrepancy in his method and the actual observational criterion of Maunder. All of these suggested criteria for calculating expected visibility have been summarized in a tabular form on page 15.

Ilyas (1984-88) mentioned his criterion with latitudes and seasons, as a_s >=f(latitude, season)(moonset lag (min.)): 41±2 at 0°, 46±4 at 30°; 49±9 at 40°; 55±5 at 50°. It is the same criterion mentioned in Ilyas's earlier book (1984), which shows that there has been no improvement. Ilyas states that he has modified his criterion (1984-88), but provides no new information. Furthermore, it is not clarified as to what a_s and f(latitude, season) are. It appears that a_s is the arc of separation, a concept that is not defined in the book (it is the difference between the right ascensions of the sun and the moon). It also appears that his criterion of a_s >=f(latitude, season) is translated into the moonset lag using different values at different latitudes for different seasons. This is good for up to mid-latitudes, but not for the higher latitudes. Ilyas recognizes that his criterion still needs perfection for which elaborate observational work is needed.

The scientific and research work needed for visibility calculations requires the collection of moon-sighting information on a global scale and its subsequent analysis according to the calculable parameters associated with the crescent moon that affect visibility. Those parameters are:

1. The angular separation of the moon from the sun as seen from the earth (this is also called elongation or arc of light).

2. The moon's topocentric altitude above the horizon. The moon's altitude above the horizon is the angle in degrees between a line that joins the centers of the moon and the earth, and a horizontal plane through the center of the earth [geocentric altitude]. But the observer is not at the center of the earth, rather he/she is on its surface. To an observer where the moon appears to be located is called "topocentric altitude," which includes the effects of atmospheric refraction, the semidiameter of the moon, and the parallax correction (for example, the correction for the observer at the surface of the earth rather than at the center of the earth).

3. The width of the crescent (or crescent thickness)

4. The distance of the moon from the earth.

5. The distance of the earth from the sun.
6. The percentage of the surface illumination of the moon.
7. The relative altitude of the observer compared to the altitude of the western horizon where the moon can be sighted.

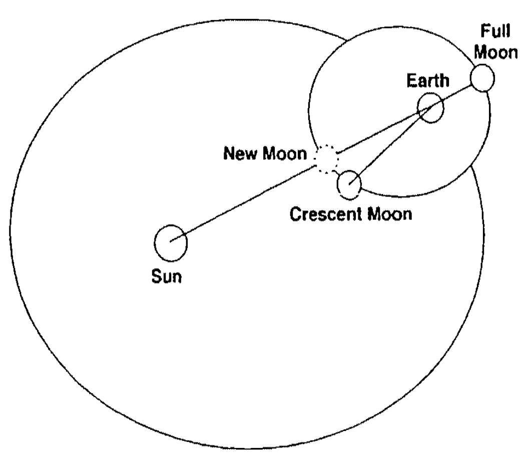
In addition to these parameters, there are some incalculable factors that affect the visibility, such as:

1. Weather conditions, such as clouds, humidity, temperature, atmospheric pollution, when that blows small dust particles.
2. The contrast of background light on the horizon due to the sun's glare and the scatter of city lights.
3. Age, eyesight, and experience of the observer.
4. Use of high-powered instruments.

These incalculable factors sometimes affect the visibility, but their effect on an otherwise visible moon is minimized when a large area is considered as one horizon (*maṭlaʿ*), because these conditions are not the same over a wide range of locations. Some of these factors on the other hand can assist the visibility.

To discuss in detail the parameters affecting visibility of the crescent that can be precisely calculated, refer to Figure one, which shows a space view of the sun, the earth, and the moon.

Figure 1



The earth revolves around the sun in an elliptical path with the sun at one focus of the ellipse, and the moon revolves around the earth in a similar way. The angle subtended by the sun, the earth, and the moon is known as the "arc of light." Until this angle becomes 7°, no sunlight reflected by the moon can come back to the earth, because the mountains on the moon's surface block it (Danjon 1932). This angle is the most important parameter for visibility and must be about 10° to 12° for the sun's light to reflect from the moon, a development that results in a thin crescent that can be sighted.

The second most important parameter is the moon's topocentric altitude above the horizon. If the moon is not above the horizon or sets a short time after sunset, it will not be visible. The third most important parameter for visibility is the crescent's size and thickness, both of which vary a great deal depending upon the arc of light, the moon's distance from the earth, and the earth's distance from the sun.

To determine whether a crescent would be sightable from any location, all of the above-mentioned parameters need to be calculated. The resulting data must then be compared with the threshold values (these can be determined by observational data) for visibility simultaneously—not individually. No one factor by itself can give any indication of sightability. If one parameter is larger than the threshold value, it may compensate for another parameter that is low. It has been determined, from observation and data collected over a period of two hundred years, that the threshold value for angular separation is about 10° to 12° and that the value for the altitude above the horizon at sunset is about 10°. Any variation from these factors must be further looked at, along with the other parameters mentioned above, to determine or predict accurately the crescent's visibility.

This kind of work has been done during the past decade by the Committee for Crescent Observation (CCO), located in Ithaca, New York. Shaukat has been involved closely with the CCO in correlating observational data with calculations of all important parameters and has been publishing visibility curves every month in *Islamic Perspective*, a monthly newsletter of the Islamic Circle of North America (ICNA), Washington, DC, chapter. This work is a definite improvement over all of the previous criteria for visibility, for it has tested visibility in the global sense and has been found to match prediction with sighting at various locations throughout the world every month during the past two years.

The tables for Islamic dates presented in this book have relied on a simple criterion of lag time between sunset and moonset at different latitudes in different seasons. This criterion, when put to the test of actual observations over the past two years, has failed a few times, as evidenced by actual sighting information collected in the United States. The following are the instances where Ilyas predicted—incorrectly—the sighting:

Crescent for	*Date of Observation*	*Result of Observations across N. America*
J'akhir 1414	Nov. 14, 1993 (SUN)	Not visible anywhere in North America
Safar 1415	July 9, 1994 (SUN)	Not visible anywhere in North America
R'akhir 1415	Sep. 6, 1994 (TUE)	Not visible anywhere in North America

The last two sentences of page 12 state:

> The criterion was successively improved upon by Ilyas[14-16] and the recent modification is to be discussed elsewhere (Table 1). In passing, it may be mentioned that the criterion takes account of

such important variables as: moon's distance from the earth; crescent's width and light intensity; brightness of the sky near western horizon at sunset; lunar mountains shadowing effect; atmospheric refraction effect; human eye's role as a detector of contrast.

The "recent modification" mentioned in the first sentence is not described anywhere if it takes into consideration the factors described in the second sentence. The second sentence is a mischaracterization of truth, because the factors mentioned are not considered in the criterion used for the Islamic dates calculated.

Chapter 2 gives global visibility maps for Ramaḍān, Shawwāl, and Dhū al Ḥijjah 1407 A.H.–1421 A.H. These maps are based on expected global visibility data tables in "A Modern Guide to Astronomical Calculations of Islamic Calendar, Times & Qiblah" in M. Ilyas (Kuala Lumpur: Berita, 1984). No improvement is evident. This work is now outdated, due to the more recent work on expected visibility, for example, by Schaefer et al. (1988-94), Yallop (1987-94), Doggett (1988), and the CCO. Therefore, the maps presented in this book contain areas designated as "visibility zone" that should not be in the visibility zone. Hence, the expected visibility tends to be nonconservative, and a calendar based on that would sometimes give Islamic dates too early.

Furthermore, Table 2 has at least two instances where Ilyas's own criterion would not give the dates shown for the beginning of the Islamic months. For Ṣafar 1416, Ilyas's table shows 28 June 1995 as the date of visibility. However, on that date the moonset lag anywhere in North America is not more than 30 minutes, and, according to his criterion, it should not be visible at any latitude. Exactly the same situation is found in the case of Jumādā al Awwal 1418 on 2 September 1997.

There are also some other problems. For example, Table 2 covers Islamic Lunation Numbers 16873 through 17053 (1 Muḥarram 1407 through Dhū al Ḥijjah 1421). However, Lunation Numbers 17024 through 17029 (Rajab 1419 through Dhū al Ḥijjah 1419) are missing. It appears that pages 247-254 are either left out from the printing or during binding. Page 55, second paragraph, last sentence states: "First Muḥamm will be IDN 1; IDN 30 will be 30 Muḥarram or R. Awwal." Instead of first R. Awwal, it should say first Ṣafar. Page 244 has a typographical error for a solar date corresponding to 26 Rabī' al Ākhir. The solar date should be 18 August 1998 instead of 1 August 1998.

It must be acknowledged that the book is an attempt in the right direction to determine the Islamic calendar for North America, but the calendar presented here is not accurate in light of actual observation and more recent research work done by others on visibility. A more organized and elaborate observational work is needed to improve the work done by Ilyas. A viable suggestion is that the Islamic Society of North America (ISNA) take the lead to organize and develop a program for scientific data collection through an observational network in North

America via a team of dedicated observers or to conduct monthly observations in several observatories for at least the next two years. I want to warn of one difficulty: The observations collected must be by designated persons, or in other cases must be screened by questions from the Muslim astronomers continuing in this effort. The same concern was expressed by Abdali (1979):

> It is worth mentioning here that man-made objects now abound in the sky, and are at times mistaken to be the crescent. What one believes to be the crescent may occasionally be a piece of jet smoke or an aeroplane flying very high in the observer's line of sight . . . . Observational data are worthless for the purpose of developing a criterion if not obtained and recorded according to strict scientific standards. The record of witness reports of crescent sighting are often lacking in this regard, and are inadmissible in formulating or validating the criteria . . .

The CCO has collected a worthwhile database that can be broadened by more observations. But the systematic collection of data is beyond the capability of individuals and requires the interest of an organization. Researchers interested in predicting the sighting of the moon can then improve their algorithms and can expand their criteria to take more parameters into account.

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