

A STUDY ON ESTABLISHING AN INTERNATIONAL LUNAR CALENDAR

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Introduction

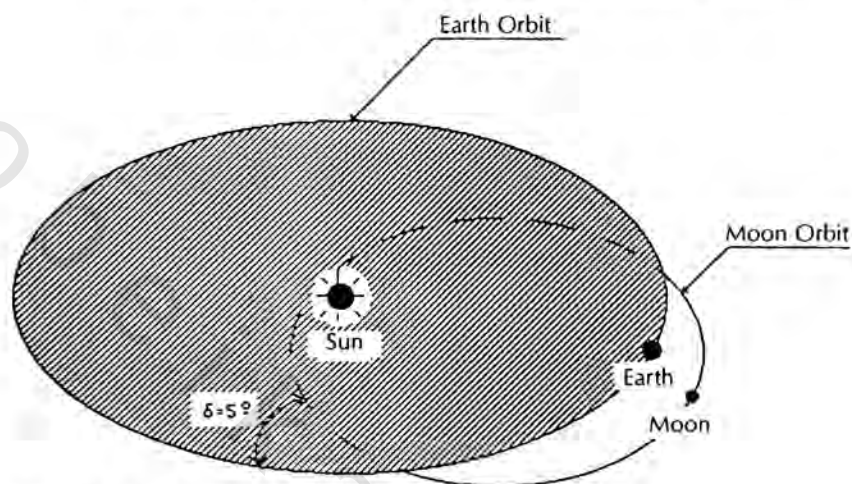
For a long time, Muslim scientists and *'ulama* from all over the world have been studying the possibility of setting a lunar calendar compatible with the principles of the Shari'ah. Many attempts were made in this direction, but none of them was taken seriously by the whole Muslim community. The most difficult thing about establishing such a lunar calendar, which is based on both the astronomy of position and its computational techniques and the constraints of the Qur'an and Sunnah, is not the technical difficulties engendered by astronomy but rather the differences that exist among people in understanding the definition of the "beginning" of the lunar month.

The technical aspects of the problem and the computational techniques will not be my focus. Instead, I will try to define the problem by describing its physical aspects, underlining the sources of confusion among the Muslim community around the world, and finally, highlighting a set of approaches that can help establish an important step toward an international lunar calendar.

Preliminaries

The moon is known to be the nearest celestial object to the earth (average distance 384,000 km), and since the earth is of a bigger mass it is expected that the moon follows an elliptical orbit around our globe (see Figure 1). But this is not exactly true. In fact, the orbit of the moon is a moving ellipse, which each month changes its position around what is

Moon's Position with Respect to the Earth and the Sun



δ : Inclination between the ecliptic and the moon orbit

Note: The drawing scales of the lunar and earth orbits are very unrealistic.

Figure 1.

called "line of nodes." However, this ellipse keeps a constant inclination angle with respect to the orbit of the earth (ecliptic, $5^\circ 8'$). The complications in the moon orbit described above are due essentially to the secondary effect of the sun's gravitation. This problem is well known among astronomers as the "three body problem." In fact, this problem becomes even more complicated if we include the effect of planetary gravitation.

At the beginning of this century an acceptable solution to the problem was found in the form of parametric series. By means of today's computers we can reach a very high degree of precision in the calculation of certain astronomical events (conjunctions, eclipses, etc). In brief, based on what was stated, we can conclude that the computation of the orbital elements of the moon is not an easy task. Nevertheless, it can be done by some experts with very high accuracy, and such calculation can be used in defining a calendar compatible with the principles of Islam.

The Lunar Calendar and the Phases of the Moon

Many civilizations throughout the ages have adopted, for simplicity, the lunar month as the basis from which to measure time. For them the day was the difference in time between sunrise and sunset, and the month was the difference in time between two identical moon phases.

Since the very beginning of the Muslim civilization, the same convention was adopted. For the *ummah*, the lunar month begins with the sighting of the new crescent, and the year is divided into twelve lunar months. Before going any further let us describe what happens to the moon's appearance (the phases of the moon) during its rotation around the earth. A good description of this phenomenon was given by Chapman as follows (see Figure 2):¹

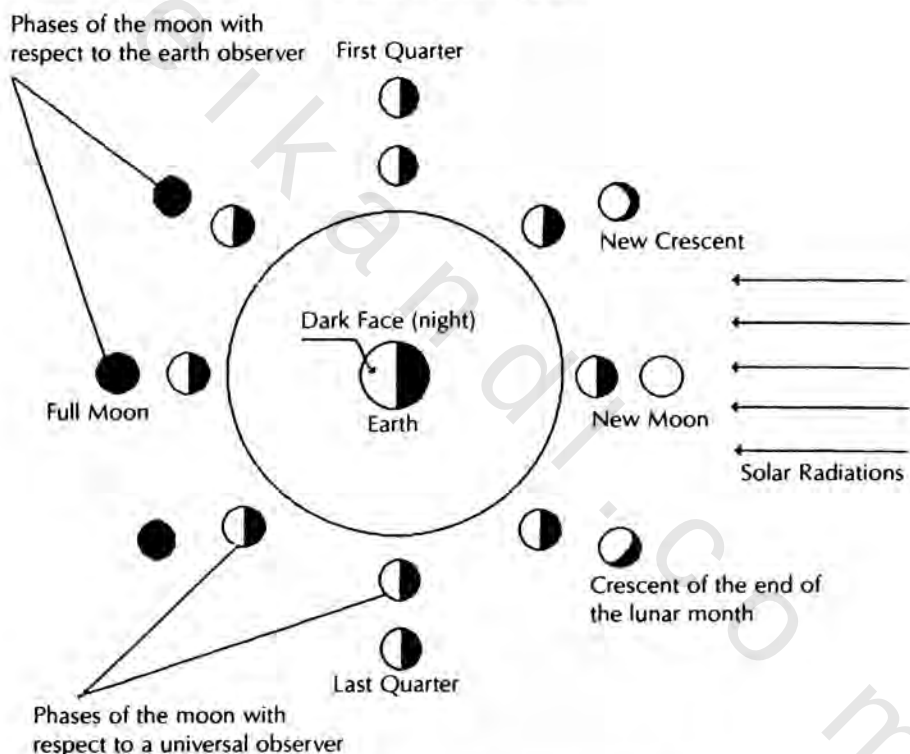
If we watch the moon regularly, we can easily discover that it changes its apparent shape from night to night; that is, it goes through a series of phases. Let's begin a series of nightly observations of the moon on an early evening when we see it as a very thin crescent, not far from the spot where the sun has just set. When we first notice the thin crescent, the red glow of sunset probably still colors the western sky. As it becomes darker, the entire circular disk of the moon is illuminated with a faint, ruddy glow. This is known as the "old moon in the new moon's arms." The moon then sets soon after the sun. The next evening the moon will appear higher in the sky and will be a thicker crescent. It sets 50 minutes later than it did the night before. The moon moves its own diameter (0.5°) eastward among the stars each hour; so it covers 13° per day, and as a result rises and sets about 50 minutes later each day.

After we have been watching the moon for a week, it will be at the phase called first quarter. Half the moon's face toward the earth is illuminated. At sunset, the moon is roughly due south, near its highest point in its daily path across the sky. During the following week, the moon passes through the gibbous phase as the face toward the earth becomes more and more fully illuminated. At the end of the second week after we first saw the crescent, the moon is full. The full moon rises at sunset, and is in the sky for the entire night. On such nights the intense light of the full moon makes the sky so bright that all but the brightest stars are hidden in the glow.

1. R. Chapman, *Discovering Astronomy* (Freeman and Company, 1978).

For the next two weeks, the moon goes through the phase inverse: full, gibbous, third quarter, and crescent, until after four weeks (actually 29 1/2 days) the moon is new. New moon is the opposite of full moon: the new moon is completely dark. During these two weeks the moon still continues to rise later and later each night. The third-quarter moon rises around midnight, six hours before the sun, and the thin crescent moon rises just before the sun on the eastern horizon.

Phases of the Moon



Note: The scale size of the Moon and the Earth is not respected for the simplicity of the picture.

Figure 2.

Sources of Confusion and Controversial Reports

After the appearance of the new ephemerides and diaries that gave the dates of conjunctions and many other periodic astronomical events, many people thought that the problem of determining the Muslim lunar calendar would be solved; instead, a great deal of confusion among people and countries took place and, hence, so many controversies were created. These controversies are mainly due to the lack of sighting coordination among Muslim countries and the adoption of different criteria for determining the new lunar month. In order to investigate some aspects of this problem, I corresponded with many people around the Muslim world, and I discussed the matter with officials during Islamic meetings. Surprisingly, I found that the bases of announcement among many Muslim countries are very different. These differences can reach as many as four solar days. The major adopted criteria are summarized below.

- *Conjunction before midnight*: If the conjunction takes place before midnight local time (even a few minutes earlier), then the following solar day is considered the beginning of the new lunar month.
- *Conjunction before sunset*: If the conjunction takes place just before local sunset (moonset after sunset), then the following solar day is considered the beginning of the lunar month even though there is no sighting of the new crescent.
- *Empirical calendar*: Some Islamic countries decide on the beginning of the lunar month by using some rough empirical methods. These methods can give, with some degree of accuracy, the solar day corresponding to the new lunar month.
- *Improper criterion of the first visibility*: This basis was adopted by some Islamic countries according to the final statements of some Islamic conferences (Istanbul, Cairo). Even though this criterion can give a close approximation to the beginning of the new lunar month, it uses some improper estimations which can cause some errors.

After examining these different criteria, we can conclude that the difference in announcing the beginning of the lunar month can be as many as one to four days. As a matter of fact, this unjustifiable difference reached four days in the Ramadan of 1985. Consequently, confusion and controversies take place instead of unity and harmony during such holy events. Such a situation is no longer acceptable and serious efforts must be taken by scientists and religious leaders to prevent future chaos.

Some Suggestions and a Set of Approaches

For a very long time it has been made clear by the *fuqaha* that according to the Qur'an and Sunnah the month begins only if the new crescent moon is sighted. Nowadays, we enjoy the magnificent development of science in all its fields, especially in astronomy. The idea here is to use this advantage to build a lunar calendar compatible with our religious principles. This is not an easy task, as some people believe, since the problem of compatibility requires some experimental results. Nowadays, it is indisputable that the date of the moon's conjunction and other orbital parameters can be computed with very high accuracy. However, this does not answer our main question in locating the place where the first visibility of the new moon is possible. It is, therefore, necessary to use experimental facts such as the minimum constraints of observability of the new moon in a place where there is sunset. During the Istanbul Conference in 1978, studies were carried out by several experts, and the following statement was issued :

There is no possible moon sighting unless three conditions are met:

1. The difference of elongation between the sun and the moon should not be less than 8° .
2. The height of the moon above the local horizon should not be less than 5° .
3. The two previous constraints must happen in a place just after sunset.

These conditions were based essentially on some experimental facts and studies done by experts in this matter (e.g., the Danjon Limit).

Although the Istanbul Conference provided a dynamic start to many research projects concerned with this matter, many Muslim countries chose not to follow its suggestions. In 1982, thorough investigations based on some experimental aspects and available data were carried out by Karray and Choras and led to the following conclusions:

- The criterion of the 8° difference in the elongation between the sun and the moon is not very proper, and adding 2° or 3° would give more accurate results.
- The 5° height of the moon above the horizon should not be generalized for all geographic latitudes. Hence, some corrections are required. Also, this constraint of lower limit visibility is corrupted by uncertainties especially in the lower latitudes and it should be taken into account, since it implies a wide range of uncertainties around the longitudes of those regions.

A major point has to be mentioned here concerning the proper meaning of sighting. If the definition of moon sighting is determined to be other than with the naked eye (requiring a *fatwa* from the '*ulama*'), then we can come up with a new solution to the problem. This suggestion was proposed in 1985 (Karray) and lengthy discussions with Muslim scientists were carried out during subsequent conferences.

Today, by means of radar we can locate the position of the moon with very high accuracy while it is still impossible to sight with the naked eye. The only condition required to detect the new moon by radar is that the observation take place just after the conjunction of the moon at local sunset. This new procedure should be studied further. Taking this suggestion one step further would be to build a radar network at the mid-latitudes. By virtue of this meaning of sighting, the lunar month can be announced one day earlier than the naked eye's first observation.

Obviously, the problem of the moon's first sighting cannot be solved unless a lot of effort toward deep understanding of the facts takes place.

Conclusion

Concerted reflection by scientific and religious communities is required to solve some of the problems and eliminate the spread of controversies which occur at every holy event. Furthermore, an official scientific committee should be formed as soon as possible in order to coordinate the efforts of Muslim scientists around the world in solving this problem. Also, a bridge of understanding between this committee and the '*ulama*' should be established so that a realistic and final solution to the problem is reached.