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## *Investigation of some astronomical phenomena in medieval Arabic chronicles*

Al-Trabulsy, Hussain Ali M.

# INVESTIGATION OF SOME ASTRONOMICAL PHENOMENA IN MEDIEVAL ARABIC CHRONICLES

BY
Hussain Ali M. al-Trabulsy

A thesis submitted to the University of Durham
for the degree of Master of science
September 1993

1 5 JUN 1994

To My

Father, Loving Memory of My Mother

And My Wife Um Ali

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## ABSTRACT

Medieval Arabic observational records of comets, meteors, meteor showers, solar and lunar eclipses are translated from the original Arabic chronicles. A comparison is made between each Arabic cometary record with East Asian observations. Specific investigation of Halley's comet has been made. The frequency of meteor showers is compared with the known prominent meteor showers. The recorded observations of different types of solar and lunar eclipses have been studied. The accuracy in the recording of the time of beginning and ending and the magnitude of the eclipse are also studied and compared with the present-day calculations. In addition, the different methods of recording of the local time of the eclipse and the magnitude are discussed.

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# 1 GENERAL INTRODUCTION

## 1.1 Applied Historical Astronomy

Every major civilization has contributed to the historical records of astronomical phenomena, but the most significant contributions have been from Europe, the Far East (China, Korea, Japan), Babylon and the Arab dominions. Undoubtedly, all ancient and medieval observations were made with the unaided eye and are thus of low precision. Nevertheless, these observations have played a major part in our understanding of the field of applied historical astronomy in its four basic areas. These are:

**(1) The study of the rotation of the Earth and the motion of the Moon.**

Halley (1695) discovered the Moon's acceleration apparently using ancient observations of eclipses preserved by Ptolemy and the Arabs. Many attempts after Halley were made to calculate this same acceleration. A gradual increase in the length of the day (LOD) can also be determined from early observations. This is mainly caused by tidal friction, which is gradually slowing down the rotation of the Earth and decreasing the orbital angular velocity of the Moon. In recent years, different techniques have been made to determine the Moon's acceleration $\dot{n}$ and they are in fairly good agreement, see table (1.1).

Recently, the most detailed study of the rotation of the Earth over the past 2700 years was made by Stephenson and Morrison (1984), using a variety of astronomical observations. They used exclusively solar and lunar eclipses throughout the pre-telescopic period, whereas occultations of stars by the Moon were used for the telescopic period (which began at AD.1610). They deduced that the mean rate of increase in the LOD between about 400 BC. and AD.948 was 2.43 ms/cy, approximately the theoretical tidal figure. For the last millennium, the LOD was found by them to have diminished to approximately 1.4 ms/cy, equivalent to a major increase in the non-tidal component. The Earth's rotational clock error $\Delta$T which was derived in both cases was as follows:

(Before AD.948)    $\Delta T = 1360 + 320t + 44.3t^2$

(Since AD.948)    $\Delta T = 25.5t^2$

where t is the time in centuries from AD.1800.

| Method | Investigator(s) | $\dot{n}$ (arcsec/cy) |
|---|---|---|
| Transits of Mercury | Morrison & Ward (1975) | $- 26 \pm 2$ |
| Numerical tidal model | Lambeck (1980) | $- 29.6 \pm 3.1$ |
| Artificial satellites | Cazenave (1982) | $- 26.1 \pm 2.9$ |
| Lunar Laser ranging | Dickey & Williams (1982) | $- 25.1 \pm 1.2$ |
| lunar occultations | Van Flandern (1982) | $-21.4 \pm 2.6$ |

Table (1.1): Independent techniques to estimate the lunar tidal acceleration.

## (2) The study of solar variability

Telescopic observations of sunspots began in the early part of the 17th century. These telescopic data are used to study the approximately ten-year solar cycle, long term trends in solar activity, (see Eddy, 1976), and intervals of weak solar activity, Eddy (1977). The best existing records for sunspots are from the Far East. Several of these records have been published in a European language, for instance by Keimatsu (1970-76), Clark and Stephenson (1978), Wittman and Xu (1987), Yau and Stephenson (1988), etc. The number of sunspots in all the pre-telescopic preserved records is only about 1% of the expected number. Despite this, they should serve as fairly useful indicators of the approximate years of maxima of the appropriate solar cycles (Yau and Stephenson, 1988). Sunspot records are the only direct indicators of the long term behaviour of solar activity. For example, analysis of both pre-telescopic (naked-eye) and telescopic sunspot observations gives a good indication of a mean period of about 10 years (Yau, 1988a). In addition, a comparison of these data with proxy indicators like $C_{14}$ and $Be_{10}$ shows a similar trend in the behaviour of the Sun over the last two millennia (Yau, 1988b).

## (3) The study of galactic Novae and Supernovae

Several Supernovae were seen in our Galaxy during the past two thousand years and were recorded. Many sightings

of ordinary novae are also on record. The positions of novae or Supernovae can often be deduced accurately using historical records of new stars. In the case of Supernovae, the observed positions can then be compared with the locations of young Supernovae remnants (SNRs) in the vicinity. Such studies could be extended, since, in general young SNRs are fairly widely spaced over the sky (Stephenson, 1979). For example, Yau (1988b) used Far Eastern observations to re-evaluate the positions of the eight well known Supernovae SN 185, 386, 393, 1006, 1054, 1181, 1572 and 1604. He also discussed the positions of 26 recorded novae and deduced their coordinates.

**(4) The study of the orbits of comets and meteoroids**

Detailed studies of the orbits of Halley's Comet have been made by many investigators, using historical records from the Far East or Babylon. The main aim of these studies was to deduce the date of perihelion passage (the nearest point to the Sun).

It is presumed that all meteor showers are of cometary origin. So, the investigation of meteor showers is important in the search for genetic associations between meteors and comets, and also in the study of the long-term perturbations of the comet's orbit.

The last three areas of study are topics in astronomy and astrophysics, whereas the first area is related to geophysics. In the present work I shall consider the following topics as they relate to Islamic history:

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1- comets with specific reference to Halley's Comet.

2- Meteors and fireballs.

3- Meteor showers.

4- Solar eclipses.

5- Lunar eclipses.

## 1.2 Pre-Islamic astronomy

With the advent of Islam, Arabs converted from Polytheism to a new religion, Islam. The pre-Islamic period is known as the age of ignorance to distinguish it from the later period. I should to like emphasize here, that the pre-Islamic Arabs were ignorant, not in the sense of having no knowledge, but that they used to worship many gods in the form of idols and not the one Almighty Allah[1] of Islam. On the contrary, they were great men of letters. The *Quran*[2], which is a marvel of literature, was a challenge for these people. The *Quran,* as a miracle of the Prophet Muhammad bears the same relation to literature as do the miracles of Jesus Christ and Prophet Moses to medicine and enchantment, respectively, for the people of their times. Because of the life in the deserts and conducting commercial caravans through the deserts from the Sabaean or Himyarite Kingdoms in the south of Arabia to Egypt and Syria in the Byzantine empire, the

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1 The proper Arabic name of the God.

2 The Holy book of Muslims and the basis of Islam. It was revealed to Prophet Muhammad in portions on a variety of occasions during the twenty three years of Muhammad's prophethood. The first revelation was at AD.610 in Mecca when he was forty years old. The word *al-Quran* in Arabic literally means the book to be read.

Arabs had to know the changing night sky throughout the year. This enabled them to fix their positions in these wide deserts. Since the Sun, the Moon , the stars and the winds are specifically mentioned in the *Quran*, it is evident that there was considerable interest in the heavens at that age in the community of Hijaz (the west part of Saudi Arabi). Moreover, the names of some famous stars are mentioned in their poetry. The Arabs divided the orbit of the Moon into 28 successive groups of stars (i.e. mansions) with the purpose of counting the lunar months, but they also linked them to prognostications of meteorological phenomena; thus the setting mansion at dawn is called *Naw'a* which was associated with rain,whereas the rising mansion was associated with the winds[3]. But the Arabs of the 9th century, connected the forecasting of weather with the Sun's motion rather than the Moon's motion so at that time, the *Naw'a* came to mean forecasting the weather for the whole solar year[4].

The constellations were known to the Arabs of pre-Islamic times as well and they might well have used them for astronomical purposes. This was assured by the *Quran* in which the word mansion and constellation are mentioned. (36.39, 15.16) as follows: *"And the Moon we have measured for her mansions (to traverse) till she returns like the old (and withered) lower part of a date-stalk". " It is we who have set out the Zodiacal signs and made them*

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3 *Al-Bairuni, al-Qanwn al-Mas'udi,* chapter 9.
4 See for example the book of *al-Anwa'a* by *al-Dainouri*

*fair-seeming to (all) beholders"*. The Arabs at that age tried to keep the lunar year roughly fixed in relation to the solar year by intercalating a lunar month every three years. We can conclude from this that before Islam the Arabs must have had a certain astronomical knowledge which is needed by any society in its daily or annual activities. However information on pre-Islamic astronomy is really vague; very few references discuss it in depth[5]

## 1.3 Islamic astronomy until AD.750

Before the end of the first half of the 7th century, Arabs conquered some parts of the Byzantine empire (i.e. Syria and Egypt) and all of the Persian empire. Al-Madinh (the city of the prophet Muhammad), the nucleus of the new Islamic government, was replaced by Damascus at the beginning of the Umaiyad empire in AD.660. Until the beginning of the Abbasid empire, there were no significant contributions in any branch of science except a work which was presented to the prince *Khalid b. Yaziyd* (the grandson of *Mu'awiyh* the founder of the Umaiyad empire). Whereupon he ordered the translation from Greek of some treatises on medicine, astrology and chemistry. Possibly this lack of interest in science was due to the occupation of the early Caliphs in creating a world empire extending from Spain and Morocco to mid-Asia.

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5 See for example C. Nallino, 1911, Arabian astronomy its history during medieval times, PP.83-140, Rome, (in Arabic).

## 1.4 Islamic astronomy after AD.750

At this time, Muslims drew extensively from the scientific heritage of antiquity, especially that of the Greeks, Romans, Persians and Indians. Baghdad, the new capital of the Abbasid empire, which was founded by the second Caliph *Abu Jafar al-Mansur* (754-775) in 762, rapidly became a cultural centre of literary and scientific activities. *Al-Mansur* was interested in astrology so when Baghdad was founded, the date and the place were chosen according to the advice of astrologers[6]. He ordered the astronomer *al-Fazari* to translate the Indian book *Siddhanta* by an astronomer of that country who came to Baghdad in 771. This book followed the method of different authors, amongst whom might be mentioned *Brahmagupta* in his book *Brahmasphutasiddhanta* which was written in AD.628 for King *Vyaghramukha*[7]. *Al-Fazari* extracted from the *Siddhanta* the elements and methods of calculation for his ephemeris *(Zij)* which became well known among Muslims at that time and remained the standard treatise for about half a century. A number of ephemerides *(aziaj,* plural of *Zij)* were produced by different authors following the Indian *Siddhanta.* So, the Indian works, especially the *Siddhanta,* had many imitations in the Muslim world up to the first half of the 5th (Islamic) century (Anawati, 1970).

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6 *Al-Bairuni, al-Aathar al-Baqeiyh,* PP.270-271
7 Nallino, Arabian astronomy, 1910, P.149

Interest further awakened when a number of treaties by Greek authors had been assembled and translated into Arabic by order of the fifth Abbasid Caliph *Harun al-Rashiyd (786-809)*. A remarkable undertaking made by his order was the translation of *al-Magest* of Ptolemy. This had tremendous success in the medieval Islamic age and enriched Muslim heritage. The first translation of *al-Magest* was made by the Barmecide *Yahya b. Khalid;* this was followed by two more accurate translations, the work of *Honin b. Ishaq* with his son *Ishaq* and *Thabit b. Qurrah.* Translations continued during the reign of the Caliph *al-Ma'amun,* in which most of the more important of the Greek treatises were rendered into Arabic. In addition to the above mentioned astronomers, many great scholars in astronomy lived in Baghdad during the 9th and 10th centuries. Among them might be mentioned *al-Sufi, al-Buzijani* and *al-Battani.*

*Al-Sufi* (903-986) collected in his book "On the fixed stars" a total of 1022 Arabic names of stars; 360 and 316 of these stars are in the northern and southern constellations respectively and 346 stars are in the Zodiacal belt. He tried also to establish accurate boundaries for the constellations. *Abu al-Wafa al-Buzijani (940-997/8)* wrote a voluminous treatise on astronomy known as *al-Magest.* The most important contribution of *al-Buzijani* is his discovery of the irregularity in the Moon's motion known as variation (change in the motion of the Moon's longitude caused by the Sun). This was

imperceptible at conjunction, opposition and quadrature, but appreciable at the intermediate points (Berry, 1961, PP.80). *al-Battani,* was known in Europe as 'Albategnius'; he lived around 853-928. He was the first to give computing methods for spherical triangles; these were further developed by later Muslims mathematicians. His major work was *al-Zij al-Sabi,* which he wrote in 912. It was translated into Latin by Nallino (1899)[8].

At the end of the 10th century, the Caliphate was in decay and powerless. Thus the role of Baghdad was taken over, first by Cairo during the Fatimid dynasty. One of the famous astronomers of that period was *Ibn Yunus* (died 1009) who wrote the excellent ephemeris, *al-Zij al-Hakimi,* the name of which relates to *al-Hakim* the Fatimid ruler, although it was clearly begun in the reign of his father *al-Aziz. Ibn Yunus* recorded observations of some thirty or so solar and lunar eclipses occurring between AD.829 and 1004 at Baghdad and Cairo (Stephenson & Said, 1989, 1992). Unfortunately, not all of his extensive work is extant (King, 1973). *Al-Hasan b. al-Haithm* (died at 1038) was one of the brilliant scientists of Cairo. He was encouraged by *al-Hakim* to leave his city, Basrh, to live in Cairo. He was a famous

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8 C.A. Nallino, *Al-Battani sive Albatenii Opus astro-nomicum,* Milano.
For more a biography of *al-Battani* and discussion of his work, see W. Hartner, *"al-Battani",* Dictionary of Scientific biography, i (New York, 1970), PP.507-516.

physicist, but he also contributed much to astronomy since he completed about 25 books and articles on this subject.

Astronomy made its appearance also in Islamic Spain (al-Andalus) in the 11th and 12th centuries. *Ibn al-Zaraqala (1029-87),* known in the West as 'Arzachel', was a famous astronomer who published his ephemerides, known as the Toletan Tables, in 1080. It contains a description of various instruments and their use especially the astrolabes[9]. Some Spanish astronomers were Jews in particular *Ibn Ezra* (1090-1167), who also wrote about the astrolabe and astrology. Arab astronomy came to an end in Cordoba (Cordova) and Seville when these cities were captured by the Spanish Christians in 1236 and 1248 respectively.

Between the end of the 10th century and AD.1258 (the time of collapsing of Baghdad), Baghdad did not contribute anything of scientific value except for the work of a few astronomers like *al-Badei al-Astrolabi* (died 1140). He was among the greatest contemporaries in the making of

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[9] It is a Greek word which means the 'measuring of stars'. The astrolabe of the Arabs is a modification of the planispheric astrolabe that was invented by Hipparchus. Muslims used it in various fields in science, art and astrology such as taking observations of celestial objects, measuring the heights of buildings or mountains and construction of horoscopes respectively. One of its chief uses was to show the exact position of Mecca from the place of the observer (*Science in the Arab-Islamic Civilization, 1989, Museum of Islamic Arts,* Kuwait, PP.12-15)

Astrolabes, and was also the most famous in the manufacture of other astronomical instruments (Sarton, 1931, Vol.II, P.204).

After the collapse of Baghdad in 1258, and the end of the rule of the Caliphs there, two magnificent schools of astronomy appeared in the East. The first one was in Maragh observatory (south of Tabriz in Iran); this was established by the great astronomer *Nasir al-Din al-Tusi* *(1201-1274)*, the consultant for the Mongol leader *Hulagu Khan*. This observatory functioned for about one century until the end of the Ilkhani dynasty. The second school appeared in the observatory of Samarkand which was founded in 1420 by the later Mongol King *Ulugh Beg (1393-1449)*. His most important work was a star catalogue. The observations in it were made with unusual precision.

Samarkand probably was the last prominent Islamic school in astronomy. After a few centuries, Islamic astronomy declined and was overtaken by European astronomy.

Numerous Islamic astronomical treatises and instruments are preserved in libraries and museums around the world. As far as I am aware, no complete survey has ever been made of this astronomical wealth. However, several medieval methods of determining the crescent and planetary visibility, the *Qibla* direction, solar and

lunar equation, etc. of considerable sophistication have been analyzed by some investigators such as Kennedy (1983), King (1986), etc.

## 1.5 Astronomical time-keeping

Most times of worship in Islam are based on celestial phenomena, i.e. the passage of the Sun across the sky at certain positions in its diurnal motion or the Moon's position with respect to the Sun. Hence, Muslims have had to determine using both calculation and instrumental measurements the hours of the day and night, the Sacred direction and Islamic dates. For any given place, such determinations were necessary in order to establish fixed rules to find the times of the prayers, the direction of Mecca and the dates of beginning or end of Fasting and Pilgrimage. This important Science of medieval astronomy was called *Ilm al-Miqat* and the person who specialized in this branch of astronomy was known as *Muwaqqit,* that is, time-keeper.

## 1.5.1 Prayer times

The obligatory five daily prayers in Islam are listed in table (1.2). In addition, there are the optional forenoon prayer *(Duha prayer)* and the occasional prayer such as Muslim festival *(Iyd)* and eclipse prayers. The times of each of the principal daily prayers are as follows:

The Dawn *(Fajr)* and nightfall *(Isha)* prayers: the former begins at the beginning of the morning astronomical twilight and the latter at the end of the evening

astronomical twilight. As a matter of fact, Muslim astronomers have adopted various values for the angle of depression of the Sun below the eastern and western horizon when morning and evening twilight begins respectively.

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| Prayer Name | Meaning |
| --- | --- |
| *Fajr* | Dawn |
| *Zuhr* | Noon |
| *Asr* | Afternoon |
| *Maghrib* | Sunset |
| *Isha* | Nightfall |

Table (1.2): Five daily prayers in Islam

I shall limit myself here to mention only the degree of depression which was adopted by some famous astronomers through out the Islamic world. In Morocco, *al-Marrakshi* in the middle of the 13th century used 20 and 16 deg. for morning and evening twilight respectively (Frank and Wiedemann, 1926). In Cairo, *Ibn Yunus* used 19 deg. for morning twilight and 17 deg. for evening twilight[10]. In Damascus, *Ibn al-Shatir* (1304 - 1375), the famous *Muwaqqit* and astronomer, used the same degree of depression as that of *Ibn Yunus.* Furthermore, a

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10 For more detail about *Ibn Yunus method* and more references see D.A. King, 1973, *Archive for History of Exact Science* 10, Heidelberg, Springer-Verlag, PP.342-394. Reprinted in D.A. King, *Islamic Mathematical Astronomy,* 1986, IX.

manuscript in Damascus of a work by *Ibn al-Shatir* gives the value 16 deg. for morning and 17 deg. for evening twilight (Khoury, 1969). From the east of the Islamic lands (Afghanistan), *al-Biruni* (973 - around 1048) used 18 deg. for both morning and evening twilights (Wiedemann, 1923)[11]. These different adopted values are summarized in table (1.3). All are close to modern limits for astronomical twilight (18 degrees). Determination of the time of these two prayers became more complicated in high latitudes during the summer months, due to the continuity of morning and evening twilight throughout the night.

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| Astronomer | M. Twilight (degrees) | E. Twilight (degrees) |
|---|---|---|
| *Al-Marrakishi* | 20 | 16 |
| *Ibn Yunus* | 19 | 17 |
| *Ibn al-Shatir* | 19 (16) | 17 (17) |
| *Al-Biruni* | 18 | 18 |

Table (1.3): Angle of solar depression as adopted by some Muslim astronomers to determine the time of *Fajr* and *Isha* prayers.

The noon (*Zuhr*) prayer begins a little after the Sun crosses the meridian. The afternoon (*Asr*) prayer begins when the length of an object's shadow equals its noon

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11 See the original Arabic source in *al-Biruni, al-Qanun al-Mas'udi* (3 volumes), Hyderabad, Deccan, 1954-1956, PP.948-950.

shadow plus the length of the object itself. The sunset (*Maghrib*) prayer begins at sunset. In principle, each prayer time lasts until the beginning of the next one except the dawn *(Fajr)* prayer which lasts until sunrise. However, the duration of any particular prayer time is a function of position (latitude) and date.

### 1.5.2 *Qibla* direction

A Muslim is supposed to face Mecca during his five daily prayers or at any other prayer wherever he (she) is. This direction is called the *Qibla*. The determination of the *Qibla* for a given place was by no means a trivial spherical astronomy problem. Medieval Muslims astronomers developed numerous alternative exact solutions to this problem using spherical trigonometry or orthogonal projections (King, 1975).

### 1.5.3 Islamic Dates

From the year of the Farewell pilgrimage of the Prophet Muhammad (AH.10 = AD.631), the lunar or Hijra[12] year became the ecclesiastical year, and the intercalation method which is mentioned above was forbidden. On average, the lunar year is 11 days shorter than the solar year. It consists of 12 months, each of 29 or 30 days length. The Islamic day begins at sunset, some 6 hours before the start of the civil day of the Western calendar. There are four methods followed by Muslims to

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12 The migration of the Prophet Muhammad from Mecca to Madinh (Yathrib) in AD.622 July 16.

organize the lunar month. The first three methods were known to the medieval Muslims whereas the last one seems to be a modern method. These are:

(1) The straightforward method of observing the crescent Moon at sunset whenever possible. If there is cloud or haze preventing visibility at the close of the 29th day of a certain month an extra day will be added. Actually, this is the original Islamic calendar since the 4th and 5th pillars of Islam (i.e. Fasting in the month of Ramadan and Pilgrimage to Mecca) are based upon this method, in addition to some optional worship.

(2) Using computation for the visibility of the crescent Moon at sunset. This method was probably transmitted to the Arabs by the Hindus (Bruin, 1977).

(3) The most simple method is based on alternate 29 and 30 day months in which the first month (Muharram) of each year has 30 days, see table (1.4). The last month (Dhu al-Hijjh) has 29 days in a normal year and 30 days in a leap year. There are 11 leap years in every 30-year cycle. The year numbered 2, 5, 7, 10, 13, 16, 18, 21, 24, 26 and 29 are leap years. A choice of Hijra era beginning on AD.622 July 16 (Freeman-Grenville, 1977) is in much better accord with crescent Moon visibility calculations at all periods (Said at el, 1989), but other authors (Ginzel, 1906; and Newton, 1967) used the previous day. This tabular method was widely used during the medieval Islamic era (Said at el, 1989).

(4) This method computes the time of the phase of the new Moon. When this phase occurs before the local midnight of

a particular month, then the next day will be the first day of the following lunar month. Otherwise the next day will be the 30th day of that particular month. This method gives a good agreement between the Islamic and Western day.

| No. | Month's name | No. of Days |
|-----|--------------|-------------|
| 1 | *Muharram* | 30 |
| 2 | *Safar* | 29 |
| 3 | *Rabi I* | 30 |
| 4 | *Rabi II* | 29 |
| 5 | *Jumada I* | 30 |
| 6 | *Jumada II* | 29 |
| 7 | *Rajab* | 30 |
| 8 | *Shaban* | 29 |
| 9 | *Ramadan* | 30 |
| 10 | *Shawwal* | 29 |
| 11 | *Dhu al-Qa'da* | 30 |
| 12 | *Dhu al-Hijjh* | 29/30 |

Table (1.4): Arabic names of the lunar months. Numbers of days are according to the tabular method.

## 1.6 Definitions of some Islamic terms

**Sunnah**

This is the traditions of the Prophet Muhammad. It includes his sayings, actions and his silent approval of others' actions. Sunnah along with the *Quran* are the first source of Islam.

## Hadith

This is the sayings of the Prophet Muhammad. The person who is a specialist in Hadith is called *Muhaddith.*

## Fiqh

The study of the rules of Islam. The person who is a specialist in Fiqh is called *Faqiyh*

## Tafseer

The interpretation of the Holy Quran. The person who is a specialist in Tafseer is called *Mufassir*

## 1.7 Format of entry of astronomical records

All of the references to celestial phenomena collected in this present work were found in Arabic historical sources rather than ephemerides *(Aziaj)* or the works of Arab astronomers. Thus, the authors of these sources are in fact historians or chroniclers and at the time, such writers dealt with recording of the events in the sky as well. Normally they tended to have a lesser knowledge than the astronomers and some of their records lacked detailed information. However, the observations which they cite are much more numerous and varied than those found in *Aziaj,* etc.

Each entry listed below begins with a serial number in chronological order followed by the Julian date. The next line gives the place of observation. When, as often happens, the place is not mentioned in the record, it

will be considered as the city where the chronicler lived. See table (1.5) for the geographical co-ordinates of these various sites. If there are more accounts than one, then the earlier one will be translated unless the later account is the more accurate. In such cases, the other accounts will only be mentioned in passing. Each reference, including volume number, is mentioned directly at the end of the text-which is placed between bold double quotation marks. Important Arabic terms which are translated are also placed in parentheses.

In this present work, the lunar date was converted to the Julian calendar by a program which was based upon the fourth method mentioned above except for eclipses where visibility of the new Moon (crescent) has been considered. It should be emphasized that unless the day of the week is specified, conversion between a lunar and solar calendar can lead to an error of one day from time to time. In cases where there is an inconsistency between the week-day and the lunar date, the adopted conversion to the Julian date will be according to the week-day. Like the Julian year, the Hijri year starts with AH. or BH. which mean after or before the Hijra respectively.

| Place | Abb. | Longitude (deg.) | Latitude (deg.) |
|---|---|---|---|
| Aleppo | A | 37.17 E | 36.23 N |
| Baghdad | B | 44.43 E | 33.33 N |
| Cairo | C | 31.25 E | 30.05 |
| Cizre | Ci | 42.18 E | 37.35 N |
| Cordoba | Co. | 04.77 W | 37.88 N |
| Damascus | D | 36.32 E | 33.50 N |
| Dubeel | Du | 43.00 E | 41.50 N |
| Granada | G | 03.58 W | 37.17 N |
| Mecca | M | 39.82 E | 21.45 N |
| Mosel | Mo. | 43.13 E | 36.35 N |
| Orontes R. | O | ~ 36.72 E | ~ 34.95 N |
| Toledo | T | 04.03 W | 39.87 N |
| Najd | N | ~ 46.72 E | ~ 24.63 N |

Table (1.5): Geographical co-ordinates of places mentioned in this work

## 2 A SHORT BIOGRAPHY OF MUSLIM CHRONICLERS CONSULTED

### 2.1 Introduction

In general, many of the chroniclers recorded major events
that occurred throughout the Islamic world together with
occasional references to very important international
events. On the other hand, some chroniclers are
essentially concerned with local affairs and they wrote a
long detailed history only about their own cities. The
usual tradition among Muslim chroniclers is that they
either started their history from the beginning of the
humanity on the Earth (i.e. from Adam) and continued
until the time of the writer, or they chronicled, the
events from the time of introduction of Islam in their
countries. The latter scheme was prevalent among
Egyptians chroniclers. In contrast, some Muslim histori-
ans wrote only about the events which happened during
their own lives.

As might be expected, natural disasters such as
earthquakes, floods, famines and droughts are often
recorded. Like the medieval European annalists, Muslim
chroniclers usually reported only major celestial events
such as eclipses, comets, meteors and meteor showers. The
latter two phenomena tend to be reported fairly
frequently. Records of less striking phenomena such as
occultations, planetary conjunction and aurorae are very
infrequent. The bright supernova of AD.1006 was carefully
observed (Stephenson and Clark,1978, PP.34-35) and

recorded by several chroniclers, but the supernova of AD.1054 which formed the Crab nebula was passed over in silence. Transits of Mercury or Venus and the appearance of sunspots were not mentioned at all in medieval Arabic chronicles. Of course, the main purpose for recording these astronomical events is purely historical. In general, the descriptions of astronomical phenomena in the chronicles lack precision; they are seldom based on the observations of astronomers, except for some which are mentioned by *Ibn al-Jawzi* and several eclipses noted by *Ibn Iyas.*

## 2.2 Names of Arabs

Tha Arabs have a confusing dual way of calling a man (or woman) either as the father of his eldest son (e.g. *Abu Ja'afar)* or the son of a famous name in his family (e.g. *Ibn al-Jawzi).* So, the man's original personal name seems at times to have been forgotten. The word *Abu,* i.e. father of (or *Um,* i.e. mother of, for a woman) has *Abi* as its genitive. The word *Ibn* means son of (or *Bint,* i.e. daughter of, for a woman).

## 2.3 Chroniclers.

(1) *Abu Ja'afar Mohammad b. Jarir al-Tabari.* Born in Tubrustan (north region of Iran, beside the Caspian sea) about AD.839 (AH.224/5). He studied at al-Rai (Tahran) and al-Kufah. He travelled to Beirout and stayed there for a long time. In 867 (AH.253), *al-Tabari* moved to

Egypt and lived in Cairo for several years, then he went back to Baghdad and spent the rest of his life there until he died in 923 (AH.310).

*al-Tabari* wrote about 26 books. His best known works are *Tafseer al-Tabari* (al-Tabari's interpretation of the holy Quran) and *Ketab Tarikh al-Rusul wl Muluk* (The book of the history of the Prophets and the kings) which is also known as *Tarikh al-U'mam* (The History of Nations). The latter is one of the best and most comprehensive of the books on history. It was written in ten volumes to cover histories of all nations from Adam to the year 915 (AH.302). It was translated into the Persian and Turkish languages, and later into French in 1874. The *Tarikh al-U'mam* has been supplemented by several later chroniclers (see chronicler no. 5). The last four volumes, which cover the period from 723 (AH.104) to 915 (AH.302), have been consulted in our work. This book is edited by M.A.F. Ibrahim and published by *Dar al-Ma'aarif*, Cairo, 1966.

(2) *Abu Zakaria Yaziyd b. Mohammad b. Iyas al-Azdi* died in 945 (AH.334); his date of birth is unknown. *Al-Azdi* was a judge in his city Mosel. Not much is known about him except that mentioned by *al-Dahabi*[1]. He was the first historian to write a book about the history of Mosel. This book, *Tarikh al-Mosel* (The history of Mosel), contains three volumes, only the second one is extant and that covers the events in Mosel from 720 (AH.101) to 839

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1 *al-Dahabi, Tazkirt al-Huffaz,* vol.3, p.109.

(AH.224). It is considered as the original source for all historical information about Mosel, as is clearly evidenced in the work of the much later chronicler, *Ibn al-Athir*. In his book, *al-Kamil*, on the history of Mosel *Ibn al-Athir* depended upon the history of *al-Azdi*[2], as did *Ibn Khaldwoon* in his book *al-Iybar*. The *Tarikh al-Mosel* is edited by A. Habibh, Cairo, 1967.

(3) *Hamzh b. Asad b. Ali Abu Ya'al al-Tamimi,* was known as *Ibn al-Qalanesi.* He was a poet, man of letters and historian. Although his family was notable in Damascus, his life is vague. He died at Damascus in 1160 (AH.555), but the year of his birth is unknown. *al-Dahabi mentioned that Ibn al-Qalanesi died at an age between 80 and 90 years,* so we can guess that he was born about 1075 (AH.468).

*Tarikh Demashq* (History of Damascus) is a short history of Damascus and surrounding areas and covers the period from 972 (AH.360) to 1160 (AH.555), the year of the author's death. This book, edited by S. Zakkar is published by *Dar Hassan,* Damascus, 1983.

(4) *Abu Marwan Hayyan b. Khalaf b. Hussain b. Hayyan al-Qurtubi,* was born in Cordoba in 987 (AH.376). He lived for more than 90 years and was a contemporary of the last Caliph of the Umaiyad daynasty in Cordoba, 1070 (AH.462). He died in 1076 October (Rabi I AH.469). *Ibn Hayyan* wrote on various subjects, but he was mainly interested in history. This is obvious from his well known book

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2 See the introduction of editor, p. 5-31.

*al-Muqtabis fi Tarikh al-Andalus* or *al-Muqtabis* in ten
volumes. Only the third and the fifth volumes are
accessible. He started writing this book when he was aged
about 20 years and completed it in 1071. He thus spent
about 64 years writing the book. *Ibn Hayyan* covered in
this book all the events which occurred in Spain
(al-Andalus) especially his city, Cordoba, from the
beginning of Islamic period in Spain at 710 (AH.91). The
third volume is edited by M.A. Makki and published in
Beirout, 1973; and the fifth volume is edited by P.
Chalmeta, in collaboration with F. Corriente, M. Subh et
al, Madrid, 1979.

(5) *Abu al-Hasan Muhammad b. Abd al-Malik al-Hamathani*
died in 1127 (AH.521). He wrote a supplement to
*al-Tabri's* history in two volumes. The first volume is
accessible and covers the period from 908 (AH.296) to 978
(AH.367). It is edited by Albert Kn'an, Catholic press,
Beirout, 1961.

(6) *Abu al-Faraj Abd al-Rahman b. Abi al-Hasan Ali b.
Mohammad al-Jawzi al-Baghdadi.* *al-Jawzi* in his name
refers to *al-Jawz* (meaning Nuts),a place in Basrah[3] and
*al-Baghdadi* relates to Baghdad. He was the most famous
man of his time in *Hadith* and *Wa'ad* (sermons). He was
also an excellent orator. He was born about 1116 (AH.510)
and died in 1200 (AH.597). He was brought up an orphan.
His father died while he was only a baby and his mother

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3 See *Ibn al-Imad, Shadharat al-Dhahab, Vol.4, pp.329.*

did not take care of him[4]. *Ibn al-Jawzi* compiled about 300 books on many Islamic sciences (like *Fiqh, Hadith and Tafseer)*, Arabic language and history. His notable book, *al-Muntazam fi Tarikh al-Muluk wa al-Umam* - in ten volumes - is very well known. It is considered as a main reference in history. *Ibn al-Jawzi* recorded in this book about 60 different astronomical events with careful description and accurate dating which usually agree closely with modern astronomical calculations. Undoubtedly, this reflects the value of this book, not only for astronomical events but also for the accuracy of historical events in general, both in description and dating. Unfortunately, only the last six volumes are available. These volumes cover the period from 870 (AH.257) to 1179 (AH.574). They have been published by Osmania Oriental publication Bureau, Hyderabad, India, 1957-1959.

(7) *Abu al-Hasan Izz al-Din Ali b. Mohammad al-Moseli* (with respect to Mosel), known as *Ibn al-Athir,* was born in al-Jazirh (The Island) which is located between Mosel (at Tigris river) and Aleppo (at Euphrates river) to the north of Baghdad[5]. He died in 1233 (AH.630). He moved to Mosel with his father and two brothers (also well known authors, one in *Hadith* and the other in literature) and settled there, but he also studied in Syria and

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4 As he said about him self in different places in his book *Said al-Khatey.*

5 Hussain Mones, Atlas of the history of Islam, 1987.

Jerusalem. For a time, he joined the Sultan *Salah al-Din,* but he finally went back to his home, Mosel, and stayed there for the rest of his life to write.

*Ibn al-Athir* became one of the most famous Islamic historians through his two books *al-Kamil fi al-Tarikh* and *Asad al-Gabah.* The former book contains 9 volumes covering the period from the beginning of creation on the earth until the year 1231 (AH.628). In this present work, I have consulted only the last six volumes which begin from the year 689 (AH.70). I have collected more than 50 astronomical events from these volumes; a number of them were possibly drawn from *Ibn al-Jawzi.* In general the description of astronomical events in *al-Kamil* does not attain the exactness of *Ibn al-Jawzi.*

(8) *Shams al-Din Abu al-Muzaffar Yusuf b. Qez'ogli*[6] *al-Baghdadi,* was born in 1185 (AH.581). He was taught and brought up by his grandfather, *Ibn al-Jawzi* who made him famous. He was known as *Sebt*[7] *Ibn al-Jawzi,* which means grandson of *Ibn al-Jawzi.* In 1203 (AH.600), he left Baghdad on his first journey to Damascus, Aleppo, Naplis, Jerusalem, Cairo, Alexandria and other cities and then continued commuting between them until 1246 (AH.644) when he went back to Baghdad, and returned the very next year to Damascus. During his stay in these cities, he formed good relations with the Aiyubid's kings of that area. He died in Damascus in 1256 (654). *Sebt Ibn al-Jawzi*

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6 It is a Turkish expression, means daughter's son (grandson)

7 The same meaning of the above Turkish expression.

inherited from his grand father eloquence and lucidity and became a famous speaker in most of the cities mentioned above, especially in Damascus[20].

*Sebt Ibn al-Jawzi* wrote 23 books among which *Mirat al-Zaman fi Tarikh al-A'ayan* (The Mirror of the age) is the most well known. As is usual of Muslim chroniclers, this book also starts from the beginning of the creation on the earth until the death of the author, i.e. 1256. Only a few volumes of this book have been edited, and the rest are still in manuscript form[21]. For the present work, I have consulted the eighth (the last volume) written in two parts which is published by Osmania Oriental Publication Bureau, India, Hyderabad, 1951. This volume begins from the events of 1102 (AH.495).

(9) *Omar b. Ahmad Ibn al-Adeem* was born at Aleppo in 1192 (AH.588). He moved to Egypt in 1259 (AH.658) when Tartars attacked his city, Aleppo, and died there in 1262 (AH.660). He wrote a long history of Aleppo in forty volumes[22]; and on the request of *al-Aziz* (the King of Aleppo) he summarized this work in three volumes known as *Zubdat al-Halab fi Tarikh Halab.*

(10) *Abd al-Rahman b. Isma'ail al-Maqdasi,* known as *Abu Shamh,* was born and died (killed) at Damascus respectively in AD.1199 and 1266 (AH.599 and 665). He was a scholar in *Hadith* of his time, and the director of *Dar*

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20 M.al-Gamidi, Ph.D thesis, vol.1, p.29-56, 1987.
21 See the last reference.
22 *Ibn Kathir,* Vol.13, *al-Bidaih wal Nihaih,* PP.236

*al-Hadith al-Ashrafiyh* (al-Ashrafiyh school of Hadith). He was also a famous historian and wrote various books on this subject; among them is *Kitab al-Rawdatian fi Akhbar al-Dawlatain* in two volumes.

(11) *Abu al-Abbas Ahmad b. Mohammad b. Idhari al-Marrakshi.* The date of his birth and other details about his life[11] are unknown. He died in 1295 (AH.694). His book *al-Bayan al-Mughrib fi Akhbar al-Andalus wa al-Maghrib,* is about the events which happened in Spain and Morocco. It is divided into four volumes. The first volume is about the events that happened in North Africa starting from the beginning of the Islamic period in Egypt around 640 (AH.20) and continuing until the 13th century. It is edited by G.S. Colin and E. Levi-Provencal, Beirout, 1948. The second and the third volumes review the events in Spain from the time of its conquest by Muslims in 710 (AH.91) to the 12th century. The editor of the second volume is unknown, but the third is edited by E. Levi-Provencal, Beirout, 1929. The fourth volume is about the history of al-Murabitin dynasty in Spain and Morocco. It is edited by I. Abbas, Beirout, 1967.

(12) *Abu Bakr b. Abdullah b. Iybak al-Dawadari.* All we know about his life is that he lived in Cairo and moved to Damascus with his father, who contributed in many diplomatic matters. Also his grandfather was the governer of Salkhad (a city in Syria to the north of Damascus,

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11 E.Levi-Provencat (editor), *al-Bayan al-Mughrib,* vol.3, 1929.

near the Jordan border)[12]. *Al-Dawadari* wrote six books, only two of which exist. In *Kanz al-Dworar,* written in nine volumes, he reviews the history from the beginning of creation until AD.1335. In this present thesis, only the last four volumes, which are accessible are used. The 6th volume is edited by S.D al-Munjid, Cairo, 1961. The 7th volume is edited by S.A. Aashur, Cairo, 1972. The 8th volume is edited by U. Haarmann, Cairo, 1971. The ninth volume is edited by H. R. Roemer, Cairo, 1960. These volumes cover the period from the beginning of Fatimid dynasty in Egypt in 971 (AH.360) to 1334 (AH.735). Neither the date of the author's birth nor that of his death is known, but we surmise that he died soon after 1335 (AH.736), the last year mentioned in his history.

(13) *Isma'ail b. Omar Ibn Kathir* was born in Damascus at 1302 (AH.701). He is a very well known author especially in *Tafseer* and history. In addition, he compiled tens of books, two of which, namely, *Tafseer Ibn Kathir* and *al-Bidaih wal Nihaih* in history made him famous. He wrote his comprehensive history book in seven volumes which cover the period from Adam to 1366 (AH.767).

(14) *Taqi al-Din Ahmad b. Ali al-Maqrizi,* was born in Cairo at 1364 (AH.766). He was originally from Balabk in Lebanon. He worked as a judge, a preacher *(Khatib)* at Amr b. al-Aas mosque in Cairo, a prayer leader *(Imam)* and a teacher of *Hadith* in the *al-Mu'aiydiyh* school. He moved to Damascus in 1413 (AH.816) and stayed there for ten

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12 Hussain Mones, Atlas of the history of Islam, 1987.

years and also he stayed in Mecca for five years from 1430 (AH.834). He spent the rest of his life in Cairo until his death in 1442 (AH.845). *al-Maqrizi* is a very distinguished historian. He is considered as the leader of historians of Egypt. Famous authors like *al-Asqalani, Ibn Taghribardi and al-Sakhawi* were his pupils.

Two of his books have been consulted in this work. These books are: *(a) Itti'az al-Hunafa bi-Akhbar al A'imma al-Fatimiyin al-khulafa* in three volumes for the events from the beginning of Fatimid period in Egypt to 971 (AH.386). (b) *al-Suluk fi Ma'rifat Duwal al-Muluk* in four volumes for the events from the end of the Fatimid period to the year of his death.

(15) *Taqi al-Din Abi Bakr b. Ahmad b. Qadi Shuhba al-Demashqi,* was born in 1377 (AH.779) in Damascus and died in 1448 (851). His book *Tarikh Ibn Qadi shuhuba* is a summary of his history of Damascus, a work which it self is no longer extant. Only the first volume of this summary has been published; it is edited by A. Darwich, Institut Francais De Damas, 1977.

(16) *Ahmad b. Ali b. Mohammad b. Hajar al-Asqalani,* was born in Cairo in 1372 (AH.773). He was originally from Asqalan, a city in Palestine near the Mediterranean sea. *Ibn Hajar al-Asqalani* was one of the scholars in *Hadith*. He compiled numerous books on different subjects related to Islam and history, but his main interest was in *Hadith*. His book *Fath al-bari sharh sahih al-Bukhari* (Explanation of sahih al-Bukhari) is one of the basic

books on *Hadith* and it made him very famous in this branch of study. *Inba al-Ghumr bi Bna al-Umr* in eight volumes is a well known book on history. In it he explains in detail the events which occurred in the lands of the Mamluki Dynasty (Egypt, al-Sham and al-Hijaz) and the surrounding countries. Unlike other chroniclers, *Ibn Hajar al-Asqalani* recorded in his history book, events starting from the year of his birth to the year 1437 (AH.840), 12 years before his death. It is published by Osmania Oriental Publication Bureau, India, Hyderabad, 1967-1975.

(17) *Jamal al-Din Abu al-Mahasin Yusuf b. Taghribardi*[13] *al-atabiki,* was born in Cairo in 1410 (AH.812)[14] and died in 1470 (AH.874). His father was the governer of Damascus and died when our author was about three years old. He was then brought up by his brother-in-law (his sister's husband). He was a prolific writer especially of history in which he excelled. The most famous of his compilations is *al-Nujum al-Zahirh fi Muluk Misr wa al-Qahirh* in 16 volumes; this covers the period from the beginning of Islamic government in Egypt 640 (AH.20) to nearly the time of author's death. This notable book was translated into the Turkish language when the Ottman Sultan, *Saleem* entered Egypt in 1517. Also, it was translated into Latin and other European languages. The first volume was

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13 *Taghribardi* is a Turkish name meaning 'God gave', see *al-Nujum al-Zahirh,* vol.11, PP.370

14 According to *Ibn al-Imad,* but *al-Sakhawi* and *Ibn Iyas* mentioned that his birth was in AH.813

published at Leiden in 1851-1855, then ten volumes were edited by William Popper and published by the University of California press in 1909-1929. *Dar al-Kutub al-Misrih* (Egyptian books store) published volumes 5 to 12, and the last volumes are published by *al-Hi'ah al-Misrih llkitab*.

(18) *Ali b. Dawood b. Ibrahim* was known as *Ibn al-Sairafi* or *al-Jwhari* after his profession as a jeweller. He lived between 1416 to 1495 (AH.819 to 900). I have consulted the first volume of his book *Nuzhat al-Nufus wa al-Abdan fi Tawarikh al-Zzaman* which covers the history of Egypt from 1382 to 1399 (AH.784 to 801). It is edited by H. Hebshi, Cairo, 1970.

(19) *Abd al-Rahman b. al-Kamal Abi Bakr b. Mohammad al-Asyuti* (with respect to Asyut city, south of Cairo) lived between 1445 to 1505 (AH.849 to 911). He wrote about 300 books. His first compilation was written when he was 17 years old. He travelled to many countries, Syria, al-Hijaz, Yemen, India, Morocco and others. His book *Husn al-Muhadara fi Akhbar Misr wa al-Qahirh* on the history of Egypt was written in two volumes. The events in this book are recorded in a very abbreviated form and most of them were cited from former chroniclers either from Baghdad or Egypt. The first edition of this book was edited by M.A.F. Ibrahim and published in Cairo in 1967-68.

(20) *Muhammad b. Ahmad Ibn Iyas* was born in Cairo in 1448 (AH.852) and died there in 1524 (AH.931). He compiled his famous book *Badai al-Zuhur fi Waqai al-Duhur* to cover the

events from the beginning of the history of Egypt until 1522 (AH.928) It is edited by M. Mustafa, Wiesbaden, 1960-1975, and published in five volumes.

(21) *Shams al-Din Mohammad b. Ali b. Mohammad,* known as *Ibn Tulun,* was born in Damascus in 1475 (AH.880). He was a pupil of *al-Suyuti;* at the same time, he was a teacher of some very well known scholars in Islam. *Ibn Tulun* was a famous grammarian, *faqiyh* and *muhaddith*[15]. He was also a historian. He wrote two books: of these *Mufakahat al-khullan fi Hawadith al-Zaman,* in two volumes (Cairo, 1962-64) covers the period from 1478 (AH.884) to 1520 (AH.926). *Al-Thaghr al-Bassam fi Dhikr man Wulliya Qada al-Sham,* in one volume, covers the events from the beginning of Islam in Damascus to about the author's death. It was published in Damascus (1956). He died in Damascus in 1546 (AH.953).

(22) *Abd al-Haiy b. Ahmad b. Mohammad al-Akari,* known as *Ibn al-Imad,* was born at Damascus in 1622 (AH.1032). He travelled to Cairo to study and stayed there for many years. Then he went back to his home, Damascus. He wrote many books. His book *Shadharat al-Dhahab fi Akhbar man Dhahab* is a well known history.

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15 *lbn al-Imad, Shadhrat al-dahab,* Vol.10, P.298

| No. | Chronicler | Period | Compilation | Place |
|---|---|---|---|---|
| 1 | Al-Tabari | 839 - 923 | Tarikh al-Tabari | Baghdad |
| 2 | Al-Azdi | 861 - 945 | Tarikh al-Mosel | Mosel |
| 3 | Ibn al-Qalanesi | 1077 - 1160 | Tarikh Damascus | Damascus |
| 4 | Ibn Hayyan | 1579 - 1076 | Al-Muqtabis | Cordoba |
| 5 | Al-Hamathani | ? - 1127 | Supplement of Tarikh al-Tabari | Baghdad |
| 6 | Ibn al-Jawzi | 1116 - 1201 | Al-Muntazam | Baghdad |
| 7 | Ibn al-Athir | 1160 - 1233 | Al-Kamil | Mosel |
| 8 | Sebt Ibn al-Jawzi | 1185 - 1256 | Mir'at al-Zaman | Baghdad & Damascus |
| 9 | Ibn al-Adeem | 1192 - 1262 | Zubdat al-Halab | Damascus |
| 10 | Abu Shamah | 1199 - 1266 | Kitab al-Rawdatain | Damascus |
| 11 | Ibn Idhari | ? - 1295 | Al-Bayan al-Mughrib | Morocco |
| 12 | Al-Dwadari | ? - 1335? | Kanz al-Durar | Cairo |
| 13 | Ibn Kathir | 1301 - 1372 | Al-Bidayh wl Nihayh | Damascus |
| 14 | Al-Maqrizi | 1367 - 1442 | 1) Itti'az al-Hunafa<br>2) Al-Suluk | Cairo |
| 15 | Ibn Qadi Shuhuba | 1377 - 1448 | Tarikh Ibn Qadi Shuhuba | Damascus |
| 16 | Al-Asqalani | 1372 - 1449 | Inba al-Ghmr | Damascus |
| 17 | Ibn Taghribardi | 1409 - 1469 | Al-Nujum al-Zahirh | Cairo |
| 18 | Al-Jawhari | 1416 - 1494 | Nuzht al-Nufus | Cairo |
| 19 | Al-Suyuti | 1445 - 1505 | Husn al-Muhadarh | Cairo |
| 20 | Ibn Iyas | 1448 - 1524 | Bada'i al-Zuhur | Cairo |
| 21 | Ibn Tulun | 1476 - 1546 | 1) Al-Thaghr al-Bassam<br>2) Mufakahat al-Khullan | Damascus |
| 22 | Ibn al-Imad | 1623 - 1679 | Shadharat al-Dhahab | Damascus |

Table (2.1): Summary of Muslim chroniclers. Numbers are according to chronological order.

# 3 INVESTIGATION OF COMETARY OBSERVATIONS

## 3.1 Introduction

For many centuries comets were regarded as atmospheric phenomena like clouds, meteors storms and thunderbolts; and they were considered as omens of important events like the birth of child, disasters or severe droughts. This impression was perhaps due to the shape and the brightness of a comet, which struck fear in the hearts of its viewers. Thus, interest in comets developed very early during the history of humanity, but there was often an aura of awe and mystery. Opinions were more astrological than astronomical. One of the earliest scientific investigations of a comet was by the Danish astronomer Tycho Brahe in AD.1577. He made careful observations of the bright comet of that year and was able to show that it had no diurnal parallax, and that it must have been be at least six times as far away as the Moon. This proved that comets are located deep in space and far away from our atmosphere, and hence there is no correlation between the changes in atmosphere and apparitions of comets.

Nowadays, despite the knowledge that comets are purely astronomical phenomena, some notions still exists that comets cause poisoning, as happened when Halley's Comet appeared in 1910, or diseases as was believed at the apparition of Kohoutek comet in 1973.

## 3.2 Records of comets in history

About two or three spectacular comets which could seen even in daylight have appeared on average each century. Using modern techniques, new comets are discovered at an average rate of five to ten every year. Many of them are discovered by amateur astronomers, while some are found by chance only on photographs taken for other purposes made with the aid of telescopes. To the naked-eye there is perhaps one bright comet every five years on average. Before the modern era with its abundant artificial light, which has indeed spoiled the darkness and the beauty of the sky, the apparition of a bright comet was very clearly seen. This aroused the curiosity of viewers. Hence these phenomena have been recorded extensively since early times in history. Most of these records are due to Chinese and Babylonian observers in ancient times and during the medieval period by Europeans, Arabs and Chinese too. Here is a brief exposition of these four sources.

### 3.2.1 Chinese records

Chinese records of celestial events not only were kept in ancient times, but they also continued until relatively recent times. However, Renaissance astronomy from Europe overtook traditional Chinese methods. The Chinese made frequent sightings of comets from about 600 BC. They recorded more than fifty comets between 613 BC. and AD.9. In addition Halley's Comet was recorded for every return

since 240 BC. except that of 164 BC. which was passed over in silence. Chinese used the words 'broom star' or 'bushy star' to describe comets. In later times, the term 'broom star' was used to denote a comet with a developed tail, while a 'bushy star' had no obvious tail (Stephenson and Walker, 1985).

### 3.2.2 Babylonians records

The period of Babylonian history was roughly parallel to that of early China. Comets were recorded among irregular phenomena such as meteors and aurorae. The earliest comet which has been found on surviving records was dated 234 BC. (Stephenson, 1986). In spite of the visibility of comets for several weeks, the changes in their positions from day to day were never recorded in any detail. The number of comets which were recorded on extant texts by Babylonians between 234 BC. and 87 was only nine. The most important record is that of the apparition of Halley's Comet in 164 BC. which fills the single gap in the history of Halley's Comet. This reflects the value of searching (Babylonians astronomical observations for Halley's Comet and other phenomena as well.

### 3.2.3 Medieval Europe

The rapid increase in recording astronomical events in Europe around AD.1000 was associated with the growth of annals in most European countries around that time. Comets were frequent among the recorded celestial events,

but accurate measurements and determinations of their position was usually lacking. Accurate measurements began at the start of the 15th century. From this time onwards every return of Halley's Comet was observed with care and accuracy. In general the date of medieval European records are exact.

## 3.2.4 Medieval Islamic

Islamic astronomy began effectively in the 8th century. It was first associated with the founding of Baghdad by the second Caliph of the Abbasid empire (AD.762) which is often called the start of golden period. Unlike Chinese historical works, the Arabic chronicles were affected heavily by discontinuity of records through various eras in Arab history. Possibly the worst affliction occurred at the end of the Abbasid empire. In 1258 the Tartars attacked Baghdad and destroyed it completely. Immense number of books were lost either by burning or being thrown into the Euphrates river.

Unfortunately, few medieval Islamic cometary records have ever been published, Some records of Halley's Comet in AD.912, 989, 1066 and 1222 have been translated briefly, as mentioned by Stephenson and Walker (1985). In addition a few cometary records found in Arabic chronicles have appeared in Schove (1984) and Kennedy (1980 and 1957).

In general, the medieval Arabic views of comets were similar to that of early opinions of the ancient Greeks

in which comets were regarded as terestrial objects rather than heavenly bodies, see for example comets number 15 and 27.

The apparition of bright comets was one of the important celestial phenomena which were recorded by three types of people; (a) astronomers, (b) astrologers and (c) chroniclers.

### 3.2.4.1 Astronomers:

Astronomical tables (*Aziaj* or *Zijes*) which were compiled by astronomers, mainly contain a complete set of tables of position and motion of regular celestial objects such as planetary mean motion, lunar and solar eclipses, transits across the meridian by the Sun, solar and lunar motion, etc. These fields of study had direct application to their lives especially for religious purposes in the determination of the direction of the *Qibla*, times of the daily five prayers or eclipse prayer, visibility of the new Moon, etc. Moreover, these works are based on the occurrence of regular celestial phenomena and their prediction by reliable mathematical rules. Appearance of comets seemed to them very difficult to predict using the standard techniques of calculation as performed by many generations of Muslims and Arabic astronomers. Thus, it is rare to find cometary tables in these *Zijes*.

Kennedy (1957), collected and analyzed eleven references in medieval Arabic sources to comets from early Abbasid times (9th century) to the 16th century. Nine of these

eleven sources are *Zijes*. The astronomers attempted to determine the longitude of the so-called *al-Kaid* comet (this means deceit) which is mentioned in a short chapter by the astrologer *Ibn Hibinta* (died after AD.929) in his book *al-Mughni fi ahkam al-Nujum* (The complete book on astrology). Some these *Zijes* have additional tables for computing the positions of several comets, based on the available observations.

### 3.2.4.2 Astrologers:

Astrologers were interested in all sorts of celestial phenomena including comets. Their interests were related to their belief that a comet is an object of ill-omen. Like astronomers, they attempted to compute the longitude and the motion of comets, but they also were concerned with such details as the shape, color, apparition, time and position of the comet with terrestrial or meteorological events *(Ibn Hibinta*, chapter on comets, 'The planets having tails' pp. 134-142).

Kennedy (1980) made studies of a Persian book with the Arabic title *Tanbihat al-Munajjimin* (Admonitions for astrologers) which was written by *Muzaffar Janabadi*, Kennedy collected from this book thirteen references to astronomical events of which eleven relate to comets; unfortunately, few of them have careful descriptions.

### 3.2.4.3 Chroniclers:

Undoubtedly, the fundamental purposes in writing chronicles was for reporting historical events and these were usually set in chronological order. The date of apparition of comets in these chronicles is usually accurately given; at the very least the year is recorded. A number of comets are well described. Sometimes, the constellation through which a comet passed is mentioned, which make the determination of the position easy. The angular size of a comet, especially the length of its tail, is estimated only by eyewitnesses who possessed little knowledge of astronomy. Hence most of these measurements are not accurate, but they still can be utilized for the purpose of calculating or improving the orbital elements. The customary unit of measurement was the cubit (*Dera'a*) or Spear (*Rumh*). Since Babylonian times, the cubit was equal to about two degrees (according to Sachs and Hunger, 1988, p.22). While the spear was larger than the cubit, to my knowledge its exact value in degrees is unknown.

Later in this chapter I have cited in full the primary records of all comets which are contained in the various chronicles which I have consulted. A special section is devoted to sightings of Halley's Comet. Between A.D.684 (the first return of p/Halley in the Islamic era) and A.D.1456, eight apparitions of Halley's Comet are

recorded by Muslim chroniclers. The returns of AD.684 and 760 are not mentioned in the sources which I have consulted and neither is that of AD.1301.

## 3.3 Searches for Halley's Comet

Comets have been observed from earliest times. Like the Moon and planets, comets remain visible for any time from days to a several weeks; this means that they slowly change their positions in the sky from night to night. Moreover, most comets appear at unpredictable times, and their orbits tend to be oriented at random in space. This leads astronomers to make extensive calculations in order to predict the next apparition of a comet or its perihelion passage (the nearest distance to the Sun). Comet Halley is the only bright periodic comet which has an extensive history covering more than two thousand years. Between 240 BC. and AD.1986, Halley's Comet made thirty returns; it has been sighted in every one of these returns and recorded.

Halley's Comet or in abbreviation p/Halley (the prefix indicating the periodic nature of the comet) was named after the English astronomer Edmond Halley (1656 - 1742). Halley saw this comet in 1682 August, and calculated its orbital parameters on the simplifing assumption that it moved in a parabolic path. He studied the old records of sightings of over twenty comets and noticed that the comets of AD.1456, 1531 and 1607 had roughly the same orbital elements as the comet of AD.1682 which he had

seen. This remarkable discovery helped Halley to decide that the comet seen in that year (AD.1682) was the same as the comets seen on the previous three occasions. He also found that the period between two sighting is about 76 years. However, significant changes of period are due to perturbations by the largest planets, Jupiter and Saturn. He concluded that the comet would return in 1758, but he died before seeing his prediction fulfilled; the comet was first sighted, before reaching perihelion, on 1758 December 25. The date of perihelion of p/Halley at this return was on 1759 March 13, and after conjunction with the Sun it remained visible until June 22.

Several years before the last apparition of 1986, many attempts were made by researchers in order to make an early prediction of the return of Halley's Comet. None of these calculations could have been made without using the extensive historical records of Halley's Comet. When it was first sighted in 1982, it was only a few arcseconds from its predicted position.

The Italian astronomer Paolo Toscanelli (1397 - 1482) made extensive observations of Halley's Comet in AD.1456. He measured the position of the comet to a fraction of a degree on almost every night. This work indeed represents the first accurate measurements of the position of p/Halley ever made in Europe. Toscanelli also observed several others comets between 1433 and 1472. These observations were sufficiently accurate to enable calculation of the orbits by later researchers. Pingre

(1783) collected the cometary sightings in Europe extending back to ancient times, and assembled them in a comprehensive catalogue. He was able to identify that the comet of AD.1456 was an earlier apparition of Halley's Comet. He also calculated approximate orbits for comets seen in AD.1301 and 837, but he failed to recognize them as Comet Halley.

There was strong competition between astronomers in the 2nd and 3rd decades of the 19th century to predict the time of perihelion passage for Halley's Comet of AD.1835. Their calculations were based on the comet's orbital period over the interval since AD.1682. One of the competitions was in France between B. Damoiseau (1820) and C. de Pontecoulant (1830). The former considered the perturbations due to the largest planets, Jupiter, Saturn and Uranus (Neptune which is similar in size to Uranus was not discovered until 1846). He derived an accurate result that the time of perihelion passage in 1835 would be November 17.15, whereas the actual time was November 16.4, but when he revised his work in 1829 he added the Earth's perturbation. His new prediction time was November 4.8, less accurate than the previous prediction. De Pontecoulant made a more accurate prediction than the last result of Damoiseau, that the perihelion passage time would be in November 12.9, too early by 3.5 days.

The 2nd competition was in Germany between O. Rosenberger and J. Lehmann (1835). The prediction by the former was November 12, too early by 4.4 days; he considered the perturbations of the seven known planets at the time. Lehmann took into account the perturbations of Jupiter, Saturn and Uranus over the interval since AD.1607. His prediction was less precise: November 27.

E. Biot (1843) demonstrated that the orbit for the comet of AD.989 closely resembled that of Comet Halley. He made an extensive translation of Chinese cometary records. These translated records were used by the French astronomer Laugier (1843 and 1846), who successfully identified the records of the apparition of Halley's Comet in AD.1378, 760 and 451. He also noted that four of the five parabolic orbital elements for the comet seen in AD.1301 were close to those of Comet Halley (Yeomans, 1990).

The English astronomer J. R. Hind (1850) made remarkable progress in investigating the history of p/Halley, yet his investigation was fairly simple. Starting with Laugier's date 1378, he stepped backwards 76 years and examined the historical records of comets which might correspond to the calculated motion of Halley's Comet. He eventually traced the history of Halley's Comet as far back as 12 BC. Hind made a few incorrect identification, and he was seriously in error for his suggested perihelion passages time in AD.1223, 912, 837, 608, 373 and 11 BC. (Yeomans, 1990). A similar attempt was made by

M. Vilyev from Russia, to go back to 622 BC. The computed dates of return of Halley's Comet before 240 BC. are 315, 391, 467, 540, and 616 BC., but there is no extant record confirming that these computed dates are for Halley's Comet except for 467 BC. A comet in that year was recorded in the chronological tables of the Chinese *Shih-Chi* (Historical record). However, there seem to be too many problems connected with this record to warrant serious consideration (Stephenson and Walker, 1985). This record may or may not relate to Halley's Comet; a decision is impossible (Stephenson, 1990).

Cowell and Crommelin (1907 and 1908) used in their computations the variation of elements technique. They included perturbation effects due to all planets except the lightest ones, Mercury and Mars (Pluto was still unknown). They (1910) restudied the comet's motion using a numerical integration technique starting with recent observations of Halley's Comet and working backwards in time; they also added the perturbation effect of Mars. They were able to correct several errors in Hind's work. Their work was fairly satisfactory, but their error became larger as they carried the motion of the comet back in time. This error became as much as 1.5 years at the return of 240 BC. Of course, the error arose not from their integration, but rather from their interpretation of the observations themselves (Yeomans, 1990).

Kiang (1972) refined the determinations of Cowell and Crommelin and showed few discordances with their results. Kiang calculated the motion of Halley's Comet backwards in time for nearly two millennia. He considered the perturbations effects by all nine planets.

Hasegawa (1979) determined perihelion passage time for Comet Halley over the interval 240 BC. to AD.1378. Yeomans and Kiang (1981) used numerical integration to extend the orbit of Halley's Comet backwards in time to 1404 BC. In the next year Brady (1982) integrated the orbit back to 2647 BC. Landgraf (1984) integrated the motion of Halley's Comet from AD.2284 to 2317 BC., using two different orbital solutions. However, in 1986, he terminated his integration before 466 BC. Except in ancient times, the differences between the results of Yeomans and Kiang, Brady and Landgraf are really very small for the date of perihelion passages, despite the use of different techniques, see figure (3.1) and table (3.1). In this thesis I have used the orbital calculations of Yeomans and Kiang (1981) in studying past records of p/Halley, see table (3.2).

## 3.4 Identification of cometary records

In medieval times, the Arabs made little distinction between the two terms planet (*Kawkab*) and star (*Najm*) both of them indicating any bright celestial object. Usually the fixed *Kawkab* means star and moving *Kawkab* means planet. A comet can have either one of these two

| Year | Month | Y & K | Brady | Landgraf |
|------|-------|-------|-------|----------|
| 684  | Oct   | 02.77 | 02.16 | 06.73    |
| 760  | May   | 20.67 | 21.78 | 20.71    |
| 837  | Feb   | 28.27 | 27.88 | 28.48    |
| 912  | Jul   | 18.67 | 16.59 | 17.48    |
| 989  | Sep   | 05.69 | 02.99 | 04.04    |
| 1066 | Mar   | 20.93 | 19.52 | 19.80    |
| 1145 | Apr   | 18.56 | 17.86 | 17.96    |
| 1222 | Sep   | 28.82 | 29.12 | 28.82    |
| 1301 | Oct   | 25.58 | 26.40 | 26.00    |
| 1378 | Nov   | 10.69 | 10.87 | 11.05    |
| 1456 | Jan   | 09.63 | 08.97 | 09.67    |

**Table (3.1):** Comparison of perihelion passage time of every return of p/Halley during the medieval Islamic period, calculated by three researchers. Y & K indicates Yeomans and Kiang.

| Year | P (E.T.) | q (AU) | e | Arg. | Node | I |
|------|----------|--------|------|--------|-------|---------|
| 684 | 10 02.77 | 0.5796 | 0.9682 | 099.13 | 43.09 | 163.413 |
| 760 | 05 20.67 | 0.5818 | 0.9679 | 099.98 | 43.97 | 163.439 |
| 837 | 02 28.27 | 0.5823 | 0.9678 | 100.08 | 44.22 | 163.443 |
| 912 | 07 18.67 | 0.5802 | 0.9681 | 100.76 | 44.93 | 163.307 |
| 989 | 09 05.69 | 0.5819 | 0.9679 | 101.47 | 45.85 | 163.395 |
| 1066 | 03 20.93 | 0.5745 | 0.9689 | 102.46 | 46.91 | 163.108 |
| 1145 | 04 18.56 | 0.5748 | 0.9688 | 103.69 | 48.34 | 162.220 |
| 1222 | 09 28.82 | 0.5742 | 0.9689 | 103.83 | 48.59 | 163.188 |
| 1301 | 10 25.58 | 0.5727 | 0.9689 | 104.48 | 49.44 | 163.072 |
| 1378 | 11 10.69 | 0.5762 | 0.9684 | 105.28 | 50.30 | 163.109 |
| 1456 | 06 09.63 | 0.5797 | 0.9770 | 105.82 | 51.15 | 162.886 |

Table (3.2): The orbital elements of each return for p/Halley during the medieval Islamic period. These elements are respectively: the time of perihelion passage (P) in ephemeris time, the perihelion distance in astronomical units (q), eccentricity (e), the argument of perihelion (Arg.), the longitude of the ascending node (Node) and the inclination (I). The angular elements are given in degrees and referred to the ecliptic (equinox 1950.0). (Yeomans, 1990, p.230)
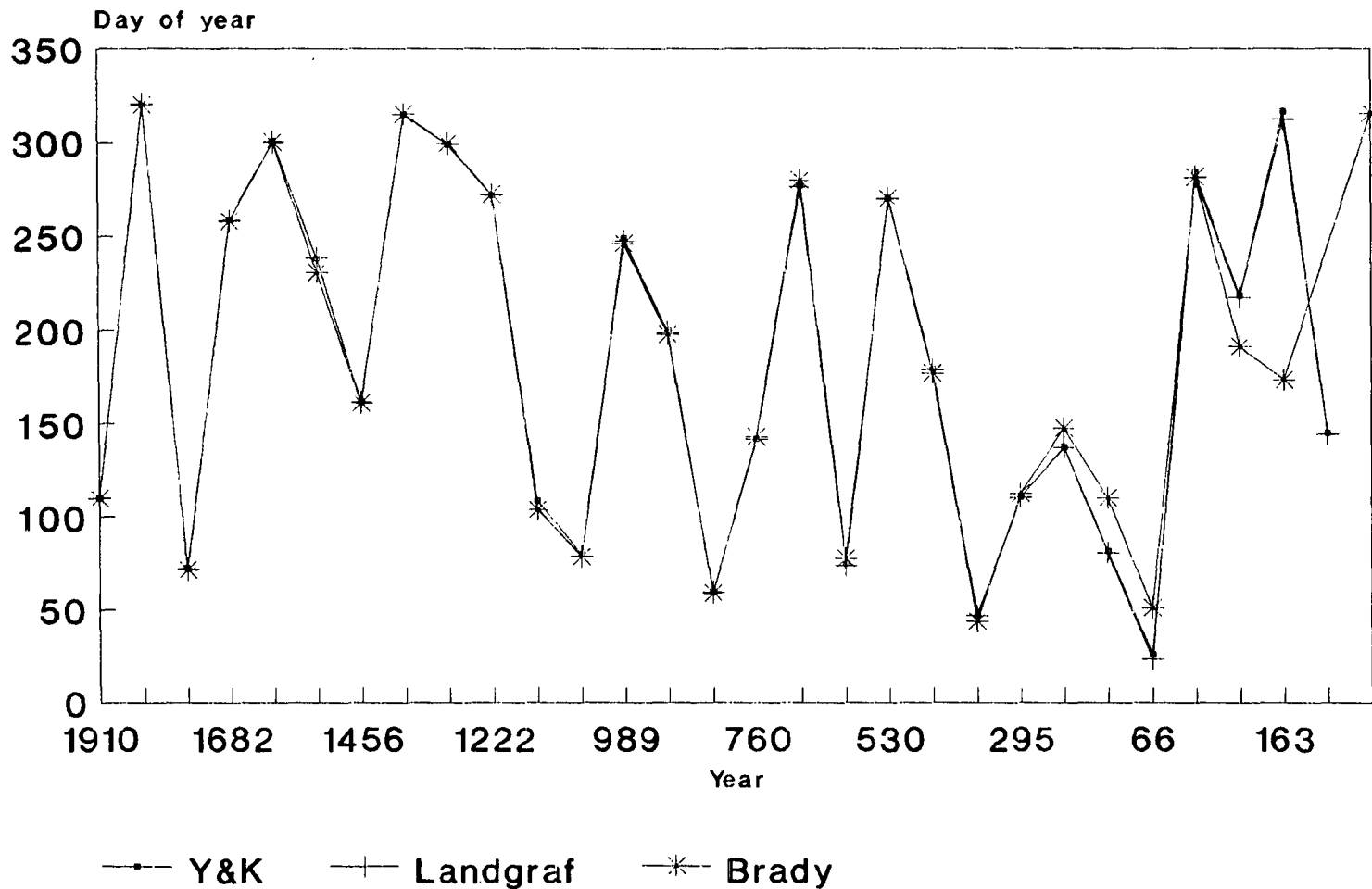
**Fig. (3.1):** The date of perihelion passage for 30 returns of p/Halley since 240 BC. until AD.1910, as calculated by Y & K, Brady and Landgraf.

| No. | Arabic Name | English meaning |
|-----|-------------|-----------------|
| 1 | *Najm/Kawkab Dhu al-Dhnab* | Star/Planet with tail |
| 2 | *Najm/Kawkab Dhu al-Dhawaba* | Star/Planet with lock of hair |
| 3 | *Najm/Kawkab Dhu al-Jummah* | Star/Planet with short hair |
| 4 | *Najm/Kawkab Dhu Shu'uba* | Star/Planet with branch |

Table (3.3): The commonly used terms for a comet in medieval Arabic chronicles and the corresponding English meaning.
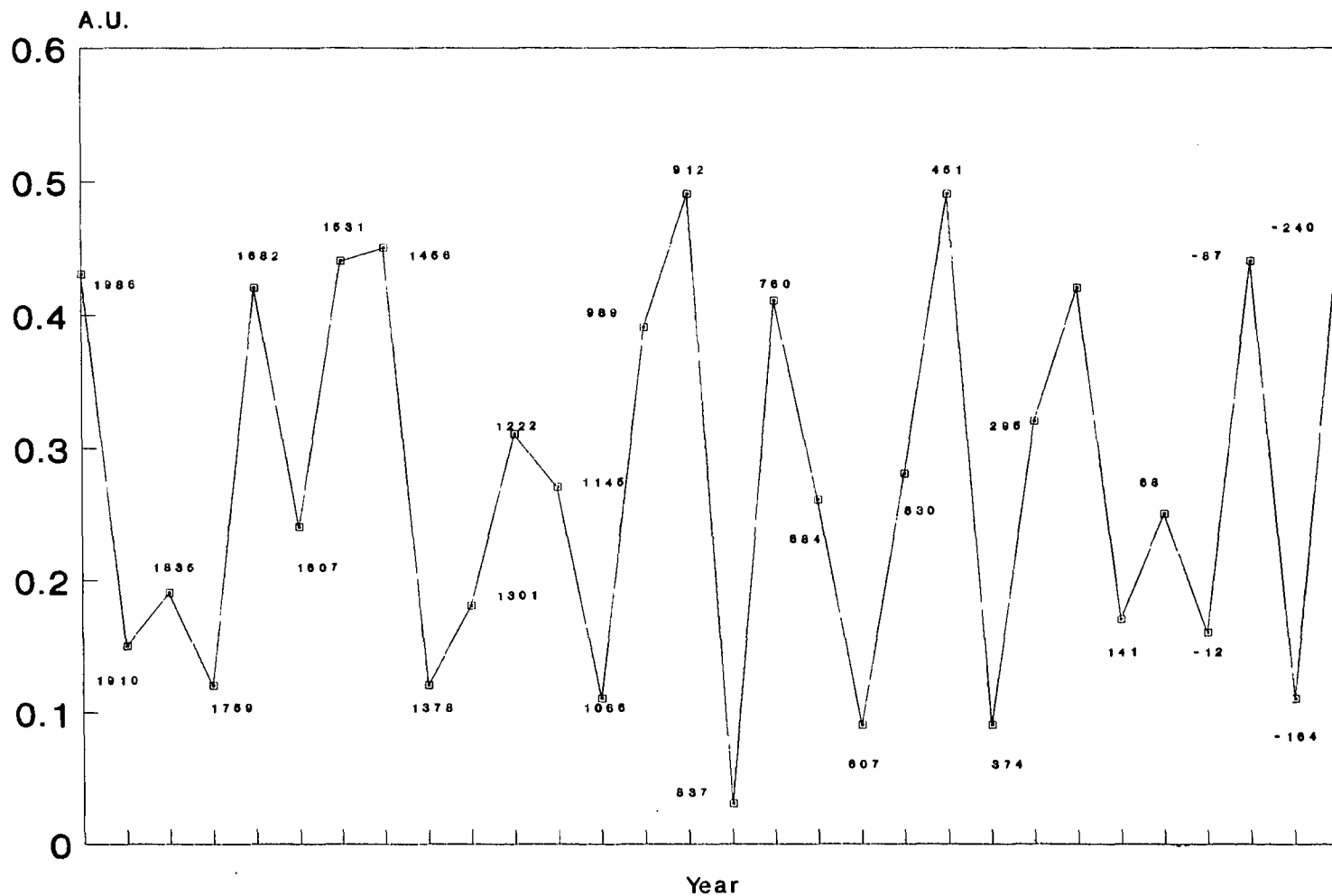
**Fig. (3.2):** The computed minimum distance of p/Halley from the Earh in every return during history. Note the remarkable apparition of AD.837. (Stephenson, 1990) and (Stephenson and Walker, 1985).

| Year | Plc. | Ref | Date of sighting | P (E.T.) | d (a.u.) |
|------|------|-----|------------------|----------|----------|
| 837 | Mo | 7 | Lasted for 40 days | 2 28.3 | 0.03 |
| 912 | B | 6 | App. Jul 8 for several days | 7 18.7 | 0.49 |
| 989 | C | 14 | lasted for 22 days | 9 05.7 | 0.39 |
| 1066 | B | 6 | ST bet. Mar 28-Apr 7 until Apr 22 | 3 20.9 | 0.11 |
| 1145 | B | 6 | App. Apr 4; to May 8; reapp. May 11 | 4 18.6 | 0.27 |
| 1222 | Mo | 7 | App. Sep 27 until Nov 5 | 9 28.8 | 0.31 |
| 1378 | C | 19 | -------- | 11 10.7 | 0.12 |
| 1456 | C | 20 | ST bet. Apr 6-May 6 for 2 months | 6 9.63 | 0.45 |

Table (3.4): Summary of observations for p/Halley in medieval Arabic chronicles. The time of perihelion passage (P) and the comet's distance from the earth (d) in astronomical units are calculated according to Yeomans and Kiang (1981). ST, App. are abbreviations for sometime and appeared respectively. There is no recorded date either for the first or the last sighting or duration of visibility for the return of AD.1378

| | Arabs Records | | Chinese Records | |
|---|---|---|---|---|
| Year | 1st sight | last sight | 1st sight | Last sight |
| 760 | ...... | ...... | May 16 | Jul 1 |
| 837 | Lasted for 40 days | | Mar 22 | Apr 28 |
| 912 | July 8 | - | Jul 19 | Jul 28 |
| 989 | Lasted for 22 days | | Aug 12 | Sep 9 |
| 1066 | May 28-Apr 7 | May 4 | Apr 3 | Jun 7 |
| 1145 | Apr 4 | - | ·Apr 26 | Jul 6 |
| 1222 | Sep 27 | Nov 5 | Sep 3 | Oct 23 |
| 1301 | ...... | ...... | Sep 15 | Oct 31 |
| 1378 | - | - | Sep 26 | Nov 10 |
| 1456 | Apr/Mar | - | May 27 | - |

Table (3.5): Comparison of observation of p/Halley between medieval Arabic and Chinese records. The sign (-) means that no date is given and the sign (...) means that the comet was not recorded .

names to which is added the description of a tail; the latter can take several forms of terminology. Table (3.3) shows the terms which are commonly used (especially the first two) to denote a comet.

## 3.5 Halley's Comet in medieval Arabic records

Halley's Comet made eleven returns during the medieval Islamic era. As noted above, only eight of them were recorded in Arabic chronicles. Table (3.4) is a summary of observations of Halley's Comet in Arabic sources. The comparison between Arabs and Chinese sighting for Halley's Comet is listed in table (3.5). For each return the computed perihelion passage date (P) in ephemeris time, E.T., and the distance from the Earth (d) in astronomical units is given. In each case I have compared the Arabic observation with records from East Asia as cited by Stephenson and Yau (1985) and Stephenson and Walker (1985).

**(1) AD.837= AH.222**
**(Computed: P = Feb 28.3; d = 0.03 AU on Apr 10)**

Mosel

In the historical period, Halley's Comet was never as close to the Earth as it was in this year, see figure (3.2). As a result the comet was extremely bright with a very clear long tail. Surprisingly, among Muslim chroniclers this apparition was recorded only in Iraq by *Ibn al-Athir*; his description is short and lacks details. Only the direction of first appearance and reappearance

after conjunction with the Sun were noted. Beyond the Arab dominions, Halley's Comet at this return was recorded in many places: China, Japan and Europe. The Chinese account is remarkable with a full description (see Stephenson and Yau, 1985; Stephenson and Walker, 1985, etc.). The Arabic record reads as follows:

" In this year (AH.222 = AD.836 Dec 13 - 837 Dec 1), a tail-like planet appeared to the left of the *Qibla*. It remained for forty nights. The first apparition was towards the west, then it reappeared towards the east. It was very long, which frightened people ". (*Ibn al-Athir, Vol.5*).

(In China: it was seen from Mar 22 to Apr 28; In Japan: Apr 12).

(2) AD.912 July 8 = 20 Dhu al-Hijjh AH.299
(Computed: P = July 18.7; d = 0.49 AU July 15)

Baghdad
In this year, three comets were seen and descriptions are recorded by Ibn al-Jawzi, Ibn al-Athir and Ibn Kathir. These comets appeared on 15 May, 28 June in the east and 8 July in the west respectively. Ibn al-Jawzi gave a good description in which he determined the date, the week-day and the position of each comet. He stated the following:

" In this year, three tailed planets appeared. One of them appeared on the night of Thursday when five nights remained of the month Ramadan (May 15); (it was) in Leo.

The second appeared on the night of Sunday when eleven days had passed in month Dhu al-Qa'da (June 28); (it was) in the east. The third, appeared on the night of Wednesday when ten nights remained of the month Dhu al-Qa'da (July 8); (it was) in Scorpius. They lasted for (several) days before disappearing ". (*Ibn al-Jawzi, Vol.6*).

According to the calculations of Yeomans and Kiang (1981), Halley's Comet would be visible during the second half of June. In mid-May the comet would be very faint and below the horizon. Consequently, the first comet which appeared on May 15 certainly was not Halley's Comet. At first sight, it seems that the first appearance and reappearance (after conjunction with the Sun) of Halley's Comet may be identified with both the second and third comets. This would mean that Halley's Comet appeared at the east on June 28 and remained for a few days then disappeared; it would reappear on July 8 in the west (as mentioned by *Ibn al-Athir*) in Scorpius. If so, then the time of conjunction should be by July 8, but this is contrary with the calculated time of conjunction, which is around July 15.

Mostlikely the third comet was Halley's comet; this appeared on 8 July and lasted for several nights then went out of sight when it was in conjunction with the Sun around July 15. Unfortunately, the date and direction of reappearance of the third comet were not recorded in Arabic chronicles, but this phase (after conjunction) was

recorded only in Japan as July 19 whereas the pre-conjunction observations was apparently omitted in Japanese records.

We conclude that in this year three different comets appeared on different dates, Halley's Comet was the third one which appeared on July 8 in Scorpius (long.=210-240), and remained for (several) days before disappearing, and reappeared on July 19 after conjunction according to records of the Japanese.

(In China: only one comet was sighted on May 15; In Japan: only one comet was seen on July 19).

(3) AD.989 = AH.379
(Computed: P = Sep 5.7; d = 0.39 AU on Aug 20)

Cairo

The calculated date of perihelion passage of Halley's Comet in this apparition was on September 5 which corresponds to 1 Jumada II AH.379. It was seen around this time for a few weeks. *al-Maqrizi* recorded a comet in the year AH.378. The duration of visibility as recorded by *al-Maqrizi* was 22 days which is almost equal to that of Halley's Comet as recorded by Chinese in the following year. Thus, it is probable that this comet was Halley's Comet but the wrong year was recorded (instead of the year AH.379). A decision is not possible. However, even if the year is correct, the record itself lacks details. The date of apparition, reapparition and the position were not stated. *Al-Maqrizi's* report reads as follow:

" In this year (AH.378 = AD.988 Apr 20 - 989 Apr 8), a planet with a lock of hair (Dhawaba) appeared. It remained for twenty two days ". (al-Magrizi,Vol.2).

(In China: AD.989 Aug 12 to Sep 9; In Korea: Oct 18; In Japan: Aug 16)

**(4) AD.1066 Mar/Apr = Jumada I AH.458**

**(Computed: P = Mar 20.9; d = 0.11 AU on Apr 23)**

Baghdad

According to calculation this comet was Halley's Comet. It was first seen some time between March 29 and April 7 and lasted until April 22; then it reappeared after two days, on April 24. It was recorded by *Ibn al-Jawzi* and *Ibn al-Athir* from Iraq. The former gave detailed information about this comet which enables us to accurately determine the date of perihelion passage in its orbit, He stated:

" In the first ten days of the month Jumada I (Mar 29 - Apr 7), a large planet appeared with a lock of hair (Dhawaba) towards the east. Its width was about three cubits and its length was many cubits; it extended towards the west, reaching mid-sky. It lasted until the night of Sunday when six days remained of this month (April 22), then it disappeared. It reappeared (after conjunction) on the night of Tuesday (i.e. after two days) at sunset (April 24); it was surrounded by its light like the Moon. The people were terrified and

agitated. When the night darkened, the tail appeared towards the south. It remained for ten days, then disappeared ". (Ibn al-Jawzi, Vol.8).

It is obvious from the careful description by Ibn al-Jawzi that the conjunction was on Monday April 23. Ibn al-Athir gives dates two or three days later, but Ibn al-Jawzi is careful to state the week-day, as well as days of the lunar month. According to Chinese observations, the comet lasted until June 7.

(In China: Apr 3 to June 7; In Korea: Apr 19; In Japan: Apr 3).

(5)   AD.1145 Apr 4 = 10 Shawwal AH.539
(Computed: P = Apr 18.6; d = 0.27 AU on May 12)

Baghdad

The apparition of Halley's Comet in this year was recorded by two chroniclers of Iraq, Ibn al-Jawzi and Ibn al-Athir. As usual, the latter gave fairly accurate dates of first appearance, disappearance at conjunction and reappearance as follows: April 4, around May 8 and around May 11 respectively. He stated that:

" On the 10th of the month Shawwal (April 4), a planet with a tail appeared at the east, opposite to the Qibla (south-west). It remained until the middle of the month Dhu al-Qa'da (around May 8), then disappeared for three

nights; then it reappeared at the west. Some (people) said that it was the same comet, but (others) stated that it was another comet ". (*Ibn al-Jawzi, Vol.10*)

It is clear from this report that conjunction was about May 10. *Ibn al-Jawzi* was a contemporary narrator for this comet from Baghdad where he lived between AD.1116 - 1200.

(In China: Apr 26 to July 9; In Japan: May 28; In Korea: May 14)

(6)  AD.1222 Sep 27 = 20 Shaban AH.619
(Computed: P = Sep 28.8; d = 0.31 AU on Sep 5)

Mosel
The first appearance of Halley's Comet in this year was on September 27 and it remained visible until October 7. It reappeared after conjunction and continued visible until November 5. This apparition was recorded by *Ibn al-Athir* as a contemporary chronicler. The record reads as follows:

" On the 20th of the month Shaban (September 27), a planet with a long and thick lock of hair (*Dhawaba*) appeared in the east at dawn. It remained for ten days, reappearing (after conjunction) at the beginning of the night in the north-west. It was moving southwards about ten cubits every night as seen by eye. It reached the south-west by way of the west. It remained in that direction until the end of the month Ramadan (around November 5), then disappeared ". (*Ibn al-Athir, Vol.9*).

The exact date of reappearing was not recorded, but it is evident that the comet reappeared at the west within a few days after October 7.

(In China: Sep 3 to Oct 23; In Japan: Sep 7; In Korea: Sep 3)

(7) AD.1378/9 = AH.780
(Computed: P = Nov 10.69; d = 0.12 AU on Oct 3)

Cairo
From Egypt al-Suyuti chronicled the return of Halley's Comet in this year in his brief book Husun al-Muhadarh. As usual, his description is short and lacks detail. Certainly, he derived his record from one of the contemporary writers, but he did not mention his source. The report is as follows:

" In this year (AH.780 = AD.1378 Apr 28 - 1379 Apr 17), a planet with a lock of hair (Dhawaba) appeared. It was seen in the beginning of the night at the north. It remained for a while ". (al-Suyuti, Vol.2).

(In China: Sep 26 to Nov 10)

(8) AD.1456 Apr/May = Jumada I AH.860
(Computed: P = June 9.63; d = 0.45 AU on June 19)

Cairo
Again, the return of Halley's Comet in this year was only recorded in Egypt by Ibn Iyas. This record is also short and lacks information. It reads as follows:

"During the month Jumada I (Apr 6-May 4), a star with a long tail appeared in the sky at the eastwards. It remained for two months. It was one of the rare planets". (*Ibn Iyas, Vol.2*).

This date is too early for Halley's Comet and it seems likely that *Ibn Iyas* has given the wrong month; this probably should be Jumada II (May 5 - June 3). In Italy, Toscanelli observed the comet from June 8 to July 8.

(In China: May 27; In Korea: June 6; In Japan: May 31 to Jul 3)

## 3.6 Other comets in medieval Arabic records

In each case I have compared the Arabic observations with records from East Asia cited by Ho Peng Yoke (1962).

### (1) AD.852 Feb/Mar = Ramadan AH.237

Iran

" During the month of Ramadan, AH.237 (Feb 26 - Mar 26) a comet appeared in the west, its tail reaching about to midheaven, the Sun then being in the sign of Aries, in the lunar mansion Butayn (delta Arietis, Allen, P.83). The comet was in conjunction with the Sun, the head of its tail (i.e. the coma) being in the lunar mansion Han'a (delta Geminorum, Allen, p.234) ". (Cited from Kennedy, 1980)

(In China: Mar/Apr; In Japan: Mar 14).

**(2) AD.858 Dec/859 Jan = Ramadan AH.244**

Iran

" In the month of Ramadan, AH.244 (858 Dec 11 - 859 Jan 9) a comet appeared in the sign of Sagittarius, in that lunar mansion Shaula (lambda Scorpii). It continued until it arrived at (the lunar mansion) Batn al-Hut (a group of stars from psi Pisces to nu Andromeda) ". (Cited from Kennedy, 1980)

(Was not recorded in East Asia)

**(3) AD.891 May 10 = 28 Muharram AH.278**

(a) Baghdad (b) Cairo

This comet was recorded by seven chroniclers, four of them from Iraq and the other three from Egypt. *al-Tabari* was a contemporary to this event; possibly most of the other chroniclers quoted from his report. All records are brief and very similar. The date of apparition was given in some records as 28 Muharram (May 10). It was said to have short hair over the shoulders (*Jummh*), which then became a lock of hair (*Dhawaba*). In other words, it had a small tail, then this tail became longer. The much later chronicler, *Ibn Iyas* from Egypt described this comet slightly differently from other chroniclers possibly based on his own interpretation. His report and the contemporary report by *al-Tabari* are as follows:

(a) " When two nights remained of the month Muharram (May 10), a planet with short hair (*Jummah*) appeared, then it became a lock of hair (*Dhawaba*) ". *(al-Tabari, Vol. 10)*.

**(b)** " In the month Muharram (Apr 13 - May 11), a tailed star appeared. It had two locks of hair. One of them flew (disappeared) from it, and the other remained for (several) days, then all of it (the comet) vanished. People regarded this as a bad omen ". (*Ibn Iyas, Vol.1*).

(In China: May 12 to July 5)

**(4) AD.905 May 19/20 = 10/11 Rajab AH.292**

(a) Baghdad (b) Mosel (c) Cairo

A comet was seen in Egypt and in Iraq on May 19 or 20. Each record is short and there are differences in date or position. Some texts use the Syriac months, which in practice corresponds exactly with the Julian months. The three records as follows:

**(a)** " The tailed planet appeared in the end of Pisces at sunset when 10 (days) had passed in the month Rajab (i.e. May 19) ". (*Ibn al-Jawzi, Vol.6*).

**(b)** " On the 20th of the month Ayar (May), a planet with a very long tail appeared in Virgo ". (*Ibn al-Athir, Vol.6*)

**(c)** " The tailed planet appeared in Virgo on the night of Sunday, when eleven nights had passed in the month Rajab, and when 19 (nights) had passed in the month Ayar (May 20) which is month Bshnes in Coptic ". (*Ibn Taghribardi, Vol.3*).

(In China: May 18 to some time between Jun 13 and 17; In Japan: May 21 to June 8).

(5) AD.906/7 = AH.294

Baghdad

This comet (tailed planet) was recorded only in Iraq as follows:

" In this year (AH.294 = AD.906 Oct 21 - 907 Oct 10), a tailed planet appeared in the west ". (*Ibn al-Jawzi, Vol.6*).

(In Japan: AD.907 Apr 7 to 15)

(6) AD.912 May 15 = 24 Ramadan AH.299

(7) AD.912 Jun 28 = 11 Dhu al-Qa'da AH.299

Baghdad

Both of these two comets were seen around the time of the second return of Halley's Comet, as recorded by *Ibn al-Jawzi* in his account which has been discussed in the previous section, number 2.

(Only the first comet was sighted in China on May 15)

(8) AD.922 Sep/Oct = Jumada II AH.310

Baghdad

A comet was seen in Iraq some time between September 24 and October 23. This is recorded briefly by *Ibn al-Jawzi* who mentioned only the month of apparition and the constellation which it passed through. He stated:

" In the month Jumada II (Sep 24 - Oct 23), a planet with a tail appeared at the east in Virgo. Its tail was about two cubits long ". (*Ibn al-Jawzi, Vol.6*).

(Was not recorded in East Asia)

**(9) AD.941 Oct 17 = 27 Muharram AH.330**

(a) Cordoba (b) Mosel (c) Balkh

This comet was recorded in Spain and Morocco by *Ibn Hayyan* and *Ibn Idhari* with similar accounts. It was also sighted and recorded in Iraq by *Ibn al-Jawzi* and *Ibn al-Athir*. The records are as follows:

(a) " In the month Muharram (Sep 24 - Oct 23), a tailed planet appeared at the western horizon in Cordoba nearly opposite to Scorpius. The first sighting was on the night of Saturday when three (nights) remained in the month Muharram; it was the night of 16th of October. It continued rising in the sky until it disappeared ". (*Ibn Idhari, Vol.2*).

(b) " In the month Muharram (Sep 24 - Oct 23), a planet with a large tail appeared in the beginning of Sagittarius and the end of Scorpius, between west and north. Its head was at the west and its tail was at the east. It was great and it spread out its tail. It appeared for thirteen days. It moved in (through) Sagittarius and Capricornus, then disappeared ". (*Ibn al-Athir, Vol.6*).

(c) " In the months of AH.330 (AD.941 Sep 26 - 942 Sep 14) a comet appeared, the tail of which stretched from the east to the west. It lasted eighteen days ". (Cited from Kennedy, 1980).

A bright comet can have a tail about 90 degrees in length. Thus, it is clear from the above descriptions of

the comet's tail and the direction of its sighting that it was a very bright comet and possibly even a daylight comet.

(In China: several different records. The record of *Liao Shih* mentions that a comet appeared on Oct 8, a date close to that noted by the Arabs).

**(10) AD.947 Aug/Sep = Safar AH.336**

Baghdad and Mosel

This comet was recorded in Baghdad and Mosel. The two records are similar. The comet appeared some time between August 20 and September 17 at the east. the text is as follows:

" In the month Safar (20 Aug-17 Sep), a tailed planet appeared at the east. Its length was about two cubits. It lasted for ten days, the it vanished " . *(Ibn al-Jawzi and Ibn al-Athir, Vol.6).*

(In China: Sep 12 to 27)

**(11) AD.975 Aug 2 = 22 Dhu al-Qa'da AH.364**

Baghdad

A comet was seen from Monday 2 to 31 August. The first sighting was at the east. This comet was seen in Iraq and also in Africa, as mentioned by *Ibn al-Athir.* Of course he meant the north of Africa where the Arabic countries are located. *Ibn al-Jawzi* recorded this comet with a fairly good description which reads as follows:

" On the night of Monday, when nine nights remained in the month Dhu al-Qa'da (Aug 2), a planet with a lock of hair (Dhawaba) appeared at the east. It had the appearance of a rectangular lock of hair about two spears in length as seen by eye (angular length). It continued to appear every night until the night when ten days remained in the month Dhu al-Hijjh (Aug 31) ". (Ibn al-Jawzi, Vol.7).

(In China: Aug 3 for 83 days; In Japan: Aug 2 for 5 days)

(12) AD.1002 Aug 5 = 23 Ramadan AH.392

Baghdad

A comet was seen in Iraq on August 5. This was recorded very briefly by Ibn al-Jawzi as follows:

" On the night of Wednesday, when eight nights remained in the month Ramadan (Aug 5), the planet with a lock of hair (Dhawaba) appeared ". (Ibn al-Jawzi,Vol.7).

(Was not recorded in East Asia).

(13) AD.1003 July = Ramadan AH.393

Mosel

Once again, some time during July, a large comet with a lock of hair appeared. This recorded by Ibn al-Athir who stated:

" In the month Ramadan, (Jul 3-31) a large planet with a lock of hair (Dhawaba), appeared ". (Ibn al-Athir, Vol.7).

There are two possibilities; either this comet and the comet of AD.1002 were the same but the wrong year was recorded by one chronicler, or there were entirely different comets appearing a year apart. Neither this comet nor the previous one is recorded in East Asia.

(In China: only one comet was seen on Dec 21 and lasted for about 30 days, i.e. until 1004 Jan 20)

## (14) AD.1029/30 = AH.420

Mosel

A comet was seen in Mosel and recorded by *al-Dwadari, Vol.8,* who obtained his information from the head of the astrologers in Mosel. See comet number (27). No descriptive details are available.

(In Japan: AD.1029 Feb 17 for 12 days)

## (15) AD.1056 Aug/Sep = Jumada II AH.448

Baghdad

In this year a comet was seen in Iraq at some time between August 24 and September 2, and it remained visible until September 27. The angular length of its tail was about ten cubits. This comet was recorded by *Ibn al-Jawzi* and *Ibn al-Athir, Vol.8.* His account reads as follows:

" In the second ten days of the month Jumada II (Aug 24 - Sep 2), a white lock of hair (*Dhawaba*) appeared at dawn; its length was about ten cubits as seen by eye, and it was one cubit wide. It lasted until the middle of the month Rajab (around Sep 27), then it disappeared. It was

said that just as this (comet) appeared in Egypt, then it was conquered. So, in Baghdad, when it had appeared, it (Baghdad) was conquered by the Egyptians ". (*Ibn al-Jawzi,Vol.8*).

Actually, Baghdad was in the hands of the Egyptians (Fatimids) just for one year from AD.1058 December 24, that is fully two years and four months after the apparition of this comet.

(In China: Aug/Sep to Sep 25; In Japan: Sep 10)

**(16) AD.1095/96 = AH.489**

Cairo

This comet was recorded only by *al-Dwadari* from Egypt in very brief detail. The date and the position were not recorded. The description reads as follows:

" In this year (AH.489 = AD.1095 Dec 30 1096 Dec 19), a star with a long tail appeared, its length was approximately twenty spears ". (*al-Dwadari, Vol.6*).

(Was not recorded in East Asia).

**(17) AD.1097 July/Aug = Shaban AH.490**

Damascus

A comet was seen in Iraq and Damascus some time between July 12 and August 10, and remained visible for 20 days. There is a short record of this comet in the history of Damascus by *Ibn al-Qalanesi* who was a contemporary chronicler, he recorded the position and duration of its appearance as follows:

" In the month Shaban (Jul 12 - Aug 10),a planet with a lock of hair (Dhawaba) appeared at the west. It remained for twenty days, then disappeared and did not reappear ". (Ibn al-Qalanesi).

From Mosel, Ibn al-Athir also recorded this comet, but probably he derived his report from the above contemporary report.

(The only comet that was recorded in East Asia around the above date was seen on the following dates: In China: Oct 6 to Oct 25; In Korea: Oct 4; In Japan: Oct 8 to Oct 25).

(18) AD.1103/4 = AH.497

Cairo

This comet was seen in Egypt some time during the lunar year AH.497. The exact date of the first sighting was not mentioned. The record is as follows:

" In this year (AH.497 = AD.1103 Oct 4 - 1104 Sep 21), a large white planet appeared in the east,like the Moon. It had a lock of hair (Dhawaba) from its east, its length was about 150 cubits (sic). It had rays and light as the clear full Moon. It had been appearing frequently for several days and nights. When it was seen with the Moon, people suspected that there were two Moons, but it was unlike the Moon in that it had a lock of hair (Dhawaba). It was one of the celestial marvels ". (al-Dwadari, Vol.6).

It is obvious that there is an exaggeration in the length of its tail. The cubit was equivalent to at least two degrees. Therefore the length of its tail would be more than 300 degrees, and this is not possible.

(Was not recorded in East Asia)

**(19) AD.1105 Dec/1106 Jan = Rabi II AH.499**

Damascus

This comet was a daylight comet seen in Damascus and recorded by the contemporary chronicler *Ibn al-Qalanesi* who stated the following in his book The history of Damascus (*Tarikh Demashq*):

"In the month Rabi II (AD.1105 Dec 9 - 1106 Jan 7), a planet with a tail appeared in the west like a rainbow from the west to mid-sky. It had been seen near to the Sun during the day, before it appeared at night. It remained for several nights, then disappeared". (*Ibn al-Qalanesi*).

From this contemporary account, *Ibn al-Athir* and *Sebt Ibn al-Jawzi* (the grandson of *Ibn al-Jawzi*) probably derived their record. The latter recorded the sixth month, Jumada II for apparition instead of the fourth month, Rabi II. Surprisingly, although this comet was a daylight object, the East Asian sources were silent. The only comet which was sighted and recorded in East Asian sources around the above date was in AD.1106 Feb 9/10. It is possible this was the same object, but there is no mention at all that the comet was a daylight object.

(In China: AD.1106 Feb 10; In Korea and Japan: 1106 Feb 9 for more than 30 days)

**(20) AD.1107/08 = AH.501**

Morocco

The apparition of this comet was only recorded in Spain or Morocco as follows:

" In this year (AH.501 = AD.1107 Aug 21 - 1108 Aug 8), a large planet with a lock of hair (*Dhawaba*) appeared on the western horizon, and lasted for many nights ". (*Ibn Idhari, Vol.1*).

(Was not recorded in East Asia).

**(21) AD.1110 May 28 = 8 Dhu al-Qa'da AH.503**

Damascus

There is a contemporary account by *Ibn al-Qalanesi* of an apparition of a comet which was first seen on May 28 and lasted until July 18. It was recorded by more than one chronicler, but the accounts are identical. The record from Damascus is as follows:

" On the 8th of the month Dhu al-Qa'da (May 28), a planet with tail appeared at the east. The tail extended to the *Qibla* (south-west). It remained until the end of the month Dhu al-Hijjh (around Jul 18), then disappeared ". (*Ibn al-Qalanesi*).

(In China: May 29; In Korea: May 31; In Japan: June 1).

## (22) AD.1143/44 = AH.538

Baghdad

There is a very brief description of a comet which appeared in this year. It was recorded in Iraq as follows:

" In this year (AH.538 = AD.1143 Jul 15 - 1144 Jul 2) the tailed planet appeared at Baghdad too. It remained for ten days ". (*Sebt Ibn al-Jawzi, Vol.8*).

The word "too" indicates that in this year an earth-quake also occurred in Baghdad. Surprisingly, the apparition of this comet was not recorded by contemporary chroniclers such as *Ibn al-Qalanesi* in Damasucus or *Ibn al-Jawzi* in Baghdad. There are two possible alternates. Either *Sebt Ibn al-Jawzi* derived his report from his grandfather, *Ibn al-Jawzi*, which related to Halley's Comet of AD.1145, but he confused the year (AH.538 instead of 539). Or he directly copied the description of this event from an unknown or lost contemporary chronicle. I prefer the latter possibility which means that a comet appeared in AD.1143/44. For instance, the recorded period of apparition of this comet and Halley's Comet of AD.1145 were different; an error in copying such details seems improbable. The occurrence of an earth-quake in this year, which is also recorded by *Ibn al-Jawzi*, and a record of a comet in Eastern Asia in AD.1144 assure the reality of this event. Finally, it is possible that *Ibn al-Qalanesi* and *Ibn al-Jawzi* were silent about this event

and did not record it.

(Was seen only in Japan some time between AD.1144 Aug 1-30)

(23) AD.1158/9 = AH.553

Mosel

A comet was seen in Mosel and recorded by *al-Dwadari, Vol.8,* who obtained his information from the head of the astrologers in Mosel. See comet number (27).

(Was not recorded in East Asia).

(24) AD.1202/03 = AH.599

Spain

This comet was seen in Spain (al-Andalus) and recorded by *Ibn Idhari* in several words; only the year of apparition was given. He stated:

" In this year (AH.599 = AD.1202 Sep 9 - 1203 Sep 7), a star with visible light and a long tail appeared. It was like the 'Galaxy bird ?', and lasted for three months ".
*(Ibn Idhari, Vol.4).*

(The only comet seen in East Asia close to the above date was recorded in Japan: some time between AD.1202 Feb 24 and Mar 25).

(25) AD.1264 July 2/3 = 7/8 Ramadan AH.662

(a) Middle Asia (b) Iran

The appearance of this comet was recorded by *Ali Shah al-Bukhari* in his astrological book *Ashjar wa Athmar* (Trees and Fruits) which was written in Persian. It was recorded also in the book *Tanbihat al-Munajjimin* which

draws on an account by the police inspector *Nakhjawani* as an eyewitness. Both records are translated by Kennedy (1980) as follows:

(a) " On 7 and 8 Ramadan, AH.662 (2 and 3 July 1264) a comet (*Dhu Dhawaba*) was found in the first part of the sign of Leo. The size of its head was that of a human head. It proceeded in the direction of Tibet and the eastern countries, Turkistan, Farghana[1], Kashgar[2], Mawara al-Nahr[3] and Khurasan[4]. Each night it became smaller, until after eighty nights and days it disappeared in the south ". (*Ali Shah al-Bukhari*).

The date of disappearance was on September 20 or 21.

(b) " *Taj al-Din Akram Nakhjawani* said that in the year AH.662 (AD.1263 Nov - 1264 Oct), in Khuzistan (the Gulf region of Iran), when he was a police inspector of the markets in the province of Shushtar, a *Dhu al-Jummah* (tailed planet) become visible and remained for a time ". (*Muzaffar Janabadi*).

(In China: July 26; In Korea: July 25 to Oct 5; In Japan: July 21 to Oct 10)

(26) AD.1270/71 = AH.669

Caucasus

A record of the apparition of this comet has been translated by Kennedy (1980) as follows:

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1 A city in western Turkistan
2 A city in east of China.
3 In mid-Asia.
4 The region between Iran and Afghanistan.

" The same *Taj al-Din* reported that in AH.669 (AD.1270 Aug - 1271 Aug), this time in Nakhjawan (in the Caucasus), a comet (*Dhu Dhawaba*) appeared in the west, (it was) motionless ". (*Ali Shah al-Bukhari*).

(Was not recorded in East Asia).

(27) AD.1285 = AH.684

Cairo

*Al-Dwadari* recorded a long account of an apparition of a bright comet. The important part of this account is as follows:

" On the middle night of the month Muharram (about March 21), a bright comet appeared in Mosel. It had three long locks of hair (*Dhawaba*) to the west ". (*al-Dwadari, Vol.8*).

He added that the head of the astrologers in Mosel, *Imad al-Din b. al-Dahhan* saw this comet and said that it had also appeared in AD.1029/30, 1096/7 and 1158/9 (see comets number 14, 16 or 17 and 23), but he (*al-Dahhan*) made some fictitious astrological comments about its three apparitions.

(Was not recorded in East Asia)

(28) AD.1298 Oct = Muharram AH.698
(29) AD.1299 Jan = Ramadan AH.698

Cairo

This comet was seen in Egypt. The date of its apparition is not clear. It recorded by *Ibn Taghribardi* with a good

description, but there is some confusion because he recorded the date of apparition using different sorts of calendars. The report reads as follows:

" In the second ten days of the month Muharram (Oct 17 - 26), a planet with a tail appeared in the sky between the end of Taurus and the beginning of Gemini. Its tail was in the northwest. It was (seen) in the last ten (days) of (the month) Kanoon II (January) which is the month Tobh in Coptic ". (*Ibn Taghribardi, Vol.8*).

The apparition of this comet was recorded using three types of calendars: Muslim, Syriac and Coptic. It is known that the Coptic month Tobh almost corresponds to January. So, it is clear that the lunar month (Muharram) is inconsistent with the other two months. I think that *Ibn Taghribardi* is referring to two comets, of which the first was seen in AD.1298 some time between October 17-26 and the other was seen in AD.1299 some time between January 21-30. This is confirmed the East Asian sources.

(In China and Korea: AD.1299 Jan 24; In Japan: AD.1298 Oct 23 and another comet in AD.1299 Jan 4)

(30) AD.1356 May = Jumada I AH.757

Cairo

" In the month Jumada I (May 2-30), a tailed planet appeared. It was large and bright ". (*al-Maqrizi, Vol.3*)

(In China: the only comet was seen from Sep 21 to Nov 4).

**(31) AD.1376/77 = AH.778**

Damascus

A comet appeared in this year (AH.778 = AD.1376 May 20 - 1377 May 9) a little before the killing of *al-Ashraf*, the King of Egypt and Syria in 1377 March 16. (see comet no.33). This was confirmed by the record of *Ibn al-Imad* who stated the following:

" In this year (AH.778 = AD.1376 May 20 - 1377 May 9), a large star appeared in Damascus. It had a long tail (*Dhawaba*). It appeared from the west. During the evening a similar one appeared in the east of Qasiuon (a place in Damascus) ". (*Ibn al-Imad, Vol.6*).

(In China: June 22 to Aug 8; In Korea: July 12; In Japan: July 10)

**(32) AD.1381 Oct/Nov = Shaban AH.783**

Damascus

There are two reports by *Ibn Qadi shuhuba* from Damascus and *Ibn Iyas* from Egypt of this comet which appeared some time between October 19 and November 16, near to the south. The former could be considered as a contemporary chronicler (AD.1377-1448). His report is as follows:

" In the month Shaban (Oct 19 - Nov 16), a star with a tail two spears long appeared in the *Qibla* direction (south-west). It appeared every night for several days ". (*Ibn Qadi Shuhuba*).

The other report is similar to the above one, and may well have been derived from it.

(In Korea: Nov 7 and lasted for 15 days).

**(33) AD.1391 June 3 = 30 Jumada II AH.793**

Damascus

A faint comet appeared this year and was seen from Egypt and Damascus at the beginning of June. It was recorded by several chroniclers; one of them, *Ibn Qadi Shuhuba* was a contemporary. He stated the following:

" At the end of month Jumada II (around Jun 3), a planet appeared in the sky; its length was three spears, but its light was faint. It was seen at the beginning of the night and set at the middle of it. It lasted in that state for (several) nights. This comet (had) itself appeared in the year AH.778 (AD.1376 May 20 - 1377 May 9) a little before the killing of *al-Ashraf* (king of Egypt and Syria from 1363 May 29 to 1377 March 16) ". (*Ibn Qadi Shuhuba*).

*Ibn Qadi Shuhuba* is suggesting that the same comet was seen in both AD.1376/77 and 1391. Finally, *Ibn Iyas, Vol.1* recorded another comet which appeared in this year in the month Jumada I (April 6 - May 5). He described the length of the tail as three cubits instead of spears.

(In China: May 23; In Korea: May 11).

**(34) AD.1402 Feb/Mar = Rajab AH.804**

(a) Cairo (b) Samarkand

A daylight comet again appeared in this year at some time between February 3 and March 4. It was seen until April 2. This comet was recorded by *Ibn Iyas* and *al-Samarqindi*, their reports are as follows:

(a) " In the month Rajab (Feb 3 - Mar 4), a large planet appeared in the sky; its light was like the Moon's light. It had a tail which extended across the sky. It was seen during the day in sunlight. It appeared every night after sunset and remained until one third of the night had passed. It lasted until the end of the month Shaban (Apr 2), then disappeared ". (*Ibn Iyas, Vol.1*).

(b) " At that time (c.1392), the Amir Timur (*Tamerlane*) set out to campaign against the *Qaysar al-Rum* (the Ottoman Sultan) *Ildirium Bayazid*. During that time a comet (*Dhu Dhawaba*) appeared ". (cited from Kennedy 1980).

Historically, Tamerlane met the Ottoman Sultan *Bayazid* in a battlefield in the plain of Ankara on AD.1402 July 20, and the battle started immediately. So, the comet was seen before this time by a few months when Tamerlane (in Samarkand) set out on his campaign against Sultan *Bayazid*. Therefore, the year AD.1392 which is mentioned by Kennedy should be corrected to AD.1402. Thus, this comet was the same comet as that noted by *Ibn Iyas*, and the revised date also agrees with the observations from Far Eastern Asia.

(In Korea and Japan: Feb 20 to Mar 19 and 20).

**(35) AD.1433 Sep/Oct = Safar AH.837**

Cairo

" In the month Safar (Sep 13 - Oct 13), a planet appeared in the sky at the west. It had a lock of hair (*Dhawaba*) about two spears length, and had illuminated rays ".
(*Ibn Iyas, Vol.2*)

(In China: Sep 15; In Korea: Oct 2 to Nov 4; In Japan: Oct 8 to Nov 1)

**(36) AD.1439 Mar/Apr = Shawwal AH.842**

Cairo

" In the month Shawwal (Mar 16 - Apr 13), a planet appeared in the sky. It had a lock of hair (*Dhawaba*) about two cubits length. It lasted for (several) days, then disappeared ". (*Ibn Iyas, Vol.2*)

(In China: Mar 25; In Korea: Apr 1 to Apr 16; In Japan: Mar 29)

**(37) AD.1472 Jan/Feb = Shaban AH.876**

Cairo                                          (

There is a contemporary account by *Ibn Iyas* of this comet which was seen at some time between Jan 11 and Feb 9 in Egypt. He stated:

" In the month Shaban (Jan 11 - Feb 9), a star with rectangular tail appeared in the sky at the west, then (later) it started appearing in the east (after conjunction) ". (*Ibn Iyas, Vol.3*)

(In China: Jan 16; In Korea: Jan 7; In Japan: Jan 2).

**(38) AD.1474 Aug/Sep = Rabi II AH.879**

Cairo

This comet appeared some time between August 13 and September 11. It was recorded briefly by *Ibn Iyas* as a contemporary writer who stated the following:

" In the month Rabi II (Aug 13 - Sep 11), a star with a long tail appeared in the sky. It was appeared after nightfall. It remained like that for a time, then disappeared ". *(Ibn Iyas, Vol.3)*

(Was not recorded in East Asia)

**(39) AD.1499/1500 = AH.905**

Damascus

" In this year (AH.876 = AD.1499 Aug 8 - 1500 Jul 26), a star with a lock of hair appeared from the east of Najd (middle region of Saudi Arabia) in Aries. Its movement was towards al-Sham (Syria) and its tail towards Yamen ". *(Ibn al-Imad, Vol.8)*.

(A comet was seen in East Asia in AD.1500 and was recorded in China: May 8 to Jul 10; In Korea: May 18 to Jul 1; In Japan: May 24)

**(40) AD.1570/71 = AH.978**

**(41) AD.1577 Nov = Shaban AH.985**

**(42) AD.1618 Nov 26 = 8 Dhu al-Hijjh AH.1027**

(a) Iran (b)Iran And Damascus (c) Iran

The author of the book *Tanbihat al-Munajjimin* (Admoni-

tions for Astrologers) *Muzaffar b. Muhammad Junabadi* recorded three comets in his book. These accounts are translated by Kennedy (1980) as follows:

**(a)** " His (the author's) father predicted the appearance of a comet. In that very year (AH.978) a comet appeared in the west ".

(Was not recorded in East Asia)

**(b)** " This menial servant (the writer), although at that time I was (only) fifteen years old, (I) informed the inhabitants of Khurasan[5] that a comet would appear. In the latter part of Shaban (1577 Nov 2-12) in the (above) mentioned year a comet did appear, in the west, of such a kind that the people were frightened and terrified. It continued for about fifty nights and days ".

This comet was also recorded by *Ibn al-Imada* as follows:

" In this year (AH.985 = AD.1577 Mar 20 - 1578 Mar 8), a star with a lock of hair (*Dhawaba*) like a tail appeared. It was very long and had a ray of light. It stayed like this appearing for nearly two months ". (*Ibn al-Imad, Vol.8*).

(In China: Nov 14; In Korea: Nov/Dec; In Japan: Nov 8)

**(c)** " On the morning of Monday, 8 Dhu al-Hijjh (1618 Nov 26) of the (above) mentioned year, a comet (*Dhu al-Dhawaba*) appeared in the east in the middle of the sign of Scorpio and lasted for about forty days ".

(In China: Nov 26 to Jan 4)

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5 The region between Iran and Afghanistan.

## 3.7 Conclusion

Among the Islamic records of Halley's Comet, only the observation of AD.1066 is of real value for improving the date of perihelion passage. Last visibility was on Sunday, Apr 23 then it disappeared. This means the morning of Sunday April 23 at roughly 5h LT. or 3.0h ET. Applying correction $\Delta$P (days) to the dates of perihelion computed by Yeomans and Kiang (1981), the following altitudes may be computed at the beginning of twilight (TWB) when the Sun was 6 degrees below the eastern horizon.

$\Delta$P = 0,   alt at TWB = -14 deg.

$\Delta$P = +2,   alt at TWB = -02 deg.

$\Delta$P = +3,   alt at TWB = +02 deg.

The reappearance was on the night of Tuesday at sunset. This means the evening of Monday April 24 at roughly 19h LT. or 17h ET. For different value of $\Delta$P, the altitude at the end of twilight (TWE) when the sun was 6 degrees below the western horizon was as follows:

$\Delta$P = +2,   alt at TWE = +7 deg.

$\Delta$P = +3,   alt at TWE = -2 deg.

For both last visibility and reappearance, a correction $\Delta$P to the computed date of perihelion of +2.5 days seems best. This is in close accord with the Chinese result of +2.3 days as deduced by Stephenson and Yau, 1985.

This means that the comet appeared later than expected at Perihelion (as according to numerical integration by Yeomans and Kiang, 1981), presumably due to the effects of non-gravitional forces. Thus the corrections to computed dates of perihelion for Halley's Comet based mainly on Chinese observations are as follows (from Stephenson and Yau, 1985):

| Year | $\Delta$P (days) |
|------|------------------|
| 837  | $0.0 \pm 0.1$ |
| 912  | ......... |
| 989  | $+4.5 \pm 1.0$ |
| 1066 | $+2.3 \pm 0.1$ |
| 1145 | $+2.7 \pm 0.5$ |
| 1222 | $+2.3 \pm 0.3$ |
| 1301 | $-1.0 \pm 0.1$ |
| 1378 | $-0.4 \pm 0.3$ |

For comets other than p/Halley, there is in general fair agreement between the dates of apparition recorded in Arab history with those noted in East Asian history. East Asian cometary records are more complete than those from the Arab world, with more sightings of individual comets. However, the Arab reports indicate the presence of significant gaps in the East Asian list, see table (3.6). The most marked of these was between AD.1095 and 1107

when Arab sources noted five comets about which east Asian history was silent. Among these five comets, was the remarkable daylight comet which was seen around 23 Dec AD.1105. This comet was not recorded in East Asia despite its brightness and clear sky during the first and last two months of the year (according to study of N. Foley, 1989, PP.22-25). I think it can be safely said that the East Asian cometary list is far from complete. This implies that statistical arguments based on the recorded century by century frequency of comets recorded in East Asia could be misleading. Undoubtedly, these deficiencies emphasize the importance of studying the cometary observations from the medieval Islamic world. In order to build up a more complete picture of cometary history, it will be necessary to combine records of comets from Arabian, East Asian, European, Babylonian and possibly other sources. As yet, existing catalogues of comets are far from complete.

| | Arabic Records | | East Asian Records | |
|---|---|---|---|---|
| Year | 1st sight | Last Sight | 1st sight | Last Sight |
| 852 | [Mar 11] | - | C: Mar/Apr<br>J: Mar 14 | ... |
| 858/9 | [Dec 25] | - | ... | ... |
| 891 | May 10 | - | C: May 12 | Jul 5 |
| 905 | May 19/20 | - | C: May 18<br>J: May 21 | Jun 13-17<br>Jun 8 |
| 906/7 | - | - | J: 907 Apr 7 | Apr 15 |
| 912 | May 15 | - | C: May 15 | ... |
| 912 | Jun 28 | - | ... | ... |
| 922 | [Oct 8] | - | ... | ... |
| 941 | Oct 17 | - | C: Oct 8 | ... |
| 947 | [Aug 3] | 10 days | C: Sep 12 | Sep 27 |
| 975 | Aug 2 | Aug 31 | C: Aug 3<br>J: Aug 2 | Oct 25<br>Aug 7 |
| 1002 | Aug 5 | - | ... | ... |
| 1003 | [Jul 17] | - | ... | ... |
| 1029/3 | - | - | ... | ... |
| 1056 | {Aug 28} | Sep 27 | C: Aug/Sep<br>J: Sep 10 | Sep 25<br>... |
| 1095/6 | - | - | ... | ... |
| 1097 | [Jul 26] | 20 days | ...<br>...<br>... | ...<br>... |
| 1103 | - | - | ... | ... |
| 1105/6 | [Dec 23] | - | ...<br>... | ... |
| 1107/8 | - | - ( | ... | ... |
| 1110 | May 28 | Jul 18 | C: May 29<br>K: May 31<br>J: Jun 1 | ...<br>...<br>... |
| 1143/4 | - | 10 days | (J: Aug 1-30)* | ... |
| 1158/9 | - | - | ... | ... |
| 1202/3 | - | 3 months | J: Feb/Mar | ... |
| 1264 | Jul 2/3 | Sep 20/21 | C: Jul 26<br>K: Jul 25<br>J: Jul 21 | ...<br>Oct 5<br>Oct 10 |
| 1270/1 | - | - | ... | ... |

* August 1144

| Year | 1st sight | Last Sight | 1st sight | Last Sight |
|---|---|---|---|---|
| 1285 | Mar 21 | – | ... | ... |
| 1298 | {Oct 22} | – | J: Oct 23 | ... |
| 1299 | Jan 25 | – | C/K: Jan 24<br>J: Jan 4 | ...<br>... |
| 1356 | [May 16] | – | ... | ... |
| 1376/7 | – | – | C: Jun 22<br>K: Jul 12<br>J: Jul 10 | Aug 8<br>...<br>... |
| 1381 | [Oct 2] | – | K: Nov 7 | Nov 22 |
| 1391 | June 3 | – | C: May 23<br>K: May 11 | ...<br>... |
| 1402 | [Feb 18] | Apr 2 | K/J: Feb 20 | Mar 19/20 |
| 1433 | [Sep 28] | – | C: Sep 15<br>K: Oct 2<br>J: Oct 8 | ...<br>Nov 4<br>Nov 1 |
| 1439 | [Mar 31] | – | C: Mar 25<br>K: Apr 1<br>J: Mar 29 | ...<br>Apr 16<br>... |
| 1472 | [Jun 26] | – | C: Jan 16<br>K: Jan 7<br>J: Jan 2 | ...<br>...<br>... |
| 1474 | [Aug 28] | – | ... | ... |
| 1499/5 | – | – | (C: May 8)*<br>(K: May 18)*<br>(J: May 24)* | (Jul 10)*<br>(Jul 1)*<br>... |
| 1570/1 | – | – | ... | ... |
| 1577 | {Nov 7} | 50 days | C: Nov 14<br>K: Nov/Dec<br>J: Nov 8 | ...<br>...<br>... |
| 1618 | Nov 26 | – | C: Nov 26 | (Jan 4)+ |

Table (3.6): A summary of the visibility dates for comets
recorded in medieval Arabic chronicles. The recorded first
and last sighting for each comet is compared to those in
East Asian records of Chinese (C), Korean (K) and Japanese
(J) origin. The date which is given between two types of
brackets [ ] and { } means respectively: the date ranges
between + 15 days and the date ranges between + 5 days. The
sign (-) means that no accurate date is given and the sign
(...) means that the comet was not recorded.

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* May and July AD.1500
+ January AD.1619

# 4 INVESTIGATION OF METEORS AND METEOR SHOWERS

## 4.1 Introduction

Sporadic meteors or shooting stars are among the
irregular astronomical phenomena. The occurrence of such
events (not the meteor showers) can not be predicted, and
most of them come from any direction. To the casual
observer, the phenomenon of meteors has some similarities
with comets and it may be hardly to distinguish between
them (see the events number 4 and 39). In reality there
are many differences. Meteors are small solid particles
which only became visible when they encounter the
atmosphere of the Earth. This means that they occurs
relatively near to the observer - at maximum distance not
more than 130 kilometers. However, most of them
disintegrate at a height of 80 kilometers. They are seen
for a short time in which they move rapidly across the
sky. On the other hand, comets are of much larger size
and can be seen when they are at many millions of
kilometers away from the Earth. They also remain visible
for several weeks or even a few months in the sky, slowly
changing their positions from day to day.

The number of meteoroids which enter the atmosphere,
forming visible meteors, over the entire earth every day
is enormous - estimated to be about 100 million.
Moreover, the meteors which are too faint to be seen are
even more numerous than the bright meteors. Nearly all of

these meteoroids are vaporized in the Earth's atmosphere; only about a few hundred of them strike the Earth yearly and are called meteorites.

As a matter of fact, meteoroids, meteors and meteorites are three different names and meaning for the same interplanetary objects. Meteoroids are solid bodies of interplanetary matter orbiting the Sun in the vicinity of the Earth. Before such a body encounters the Earth's atmosphere, it is called a meteoroid. When a smaller meteoroid encounters the Earth's atmosphere, the high friction with the air vaporizes it, then the light produced by the ionized gas surrounding the meteoroid which appears as a luminous streak is called a meteor. Such an event lasts in the night sky for several minutes, then disappears because of the effect of the winds in the atmosphere. Sometimes a meteoroid is large enough to survives its passage through the Earth's atmosphere and strikes the ground; it then is called a meteorite.

## 4.2 Individual meteors

The study of meteoroids and their debris, i.e. meteorites, is one of the ways to investigate such diverse subjects as the properties of the Earth's atmosphere and the early beginning of the solar system. The latter branch of research which uses meteorites is called meteoritics. This field has been developed in the last two decades using sophisticated laboratory experimental techniques.

Meteors sometimes are exceptional in their brightness; then they are called fireballs. They may be brighter than the full Moon and can be seen in broad daylight; at night they may light up the ground and may seen as bright as day.

The penetration depth of meteors in the Earth's atmosphere depends upon various factors; velocity, mass, angle of entry into the atmosphere, size and shape of the meteoroid. However, the atmosphere resists a meteor's motion and slows down the cosmic velocity which it had before entering the atmosphere. If the meteoroid penetrates deep into the atmosphere, a terminal velocity of no more than a few hundreds meters per second is reached. Thus unless it is very large, a meteorite impacts the ground at comparatively low velocity, typically about 100-200 meters per second. The cosmic velocity of meteoroids does not exceed 42 kilometers per second which means that they should have an elliptical (rather than parabolic) orbit around the Sun.

When a meteoroid enters the atmosphere, its velocity will depend upon its direction of motion with respect to the motion of the Earth. Since the orbital velocity of the Earth is 30 kilometers per second, the relative velocity of a meteor will range between 12 kilometers per second if it overtook the Earth (its motion in the same direction of the Earth's motion) and 72 kilometers per second if it moved against the Earth's motion.

Meteoroids with masses of one tonne or less are strongly affected by air resistance. On the other hand, meteoroids of ten tonnes are much less affected by the air resistance and will retain a fair proportion of their cosmic velocity before colliding with the ground. Figure (4.1) shows the relation between the velocity of the meteor with respect to its cosmic velocity (in this figure, the cosmic velocity is considered as 40 km per sec) versus the height of the meteor above the ground. It is obvious that under these circumstances a meteoroid with a mass of one tonne or less will not impact the Earth's surface; it will be vaporized by the high friction with the atmosphere, whereas a meteoroid with mass of ten tonnes or more will impact the ground at a velocity approaching its initial velocity. This means massive meteoroids penetrate deeper in the atmosphere than smaller ones. However, much depends on the actual initial velocity and the entrance angle.

Sometimes sound follows a meteor and is audible from the Earth. This sound is due to the explosion caused by the breaking up the meteor in the atmosphere at the end of its luminous path, or from the shock waves from the compressed air in front of the meteor which has supersonic velocity.

## 4.3 Meteor Showers

A meteor shower is a phenomenon associated with comets. It occurs when the Earth encounters swarms of particles
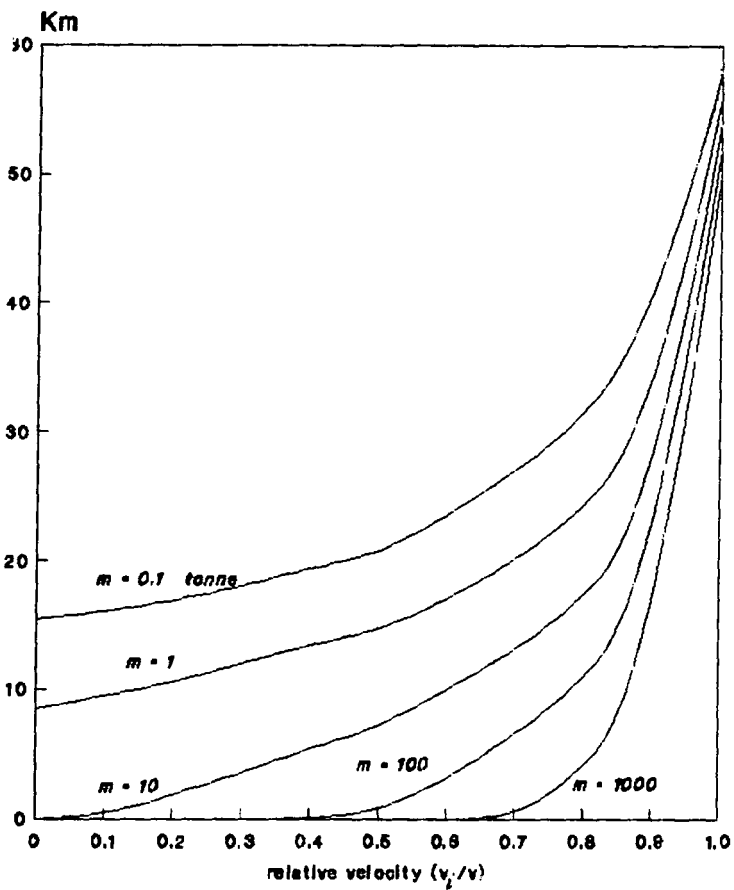
**Fig. (4.1):** Diminution of velocity of meteorites with different mass during its passage through the Earth's atmosphere. $v_t$ is the intial velocity. (Heide, 1957).
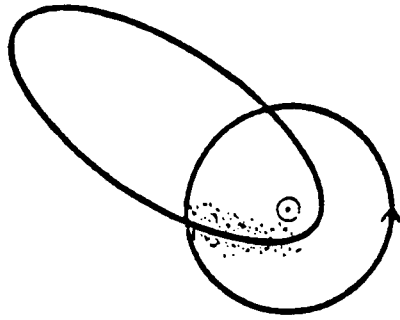
(a)
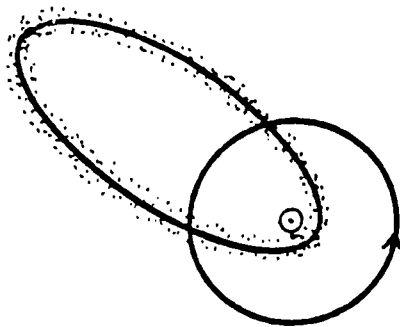


(b)

**Fig. (4.2):** (a) A compact swarm of meteoroids, (b) Over the ages, meteoroids may be spread more or less uniformly along the orbit.

which are ejected by a comet's nucleus as shown in Figure (4.2). There are several hundred meteor streams known in the solar system. About ten major meteor showers can be seen every year. In table (4.1), the most prominent meteor showers are summarized. Some spectacular meteors showers can occur at any time associated with the appearance of an unexpected bright comet.

From physical characteristics of meteors and comets they appear to have a common origin, but the strong perturbations caused by planets gradually separates the orbits of meteors and comets. In the long term the orbital elements of individual meteoroids will be completely changed, eventually, giving the impression that they have nothing in common with those of the parent comet (Kramer, 1972).

During its continued revolution around the Sun, a comet suffers a gradual diminution of mass due to solar action, causing non-gravitional forces. A meteor shower is associated with this mass-loss as solid matter ejected from the comet's nucleus.

The majority of meteor showers belong to the Jupiter family. This massive planet strongly influences meteor streams, so it changes the spatial density and the structure of the streams, and also alters the visibility conditions of meteor showers (Kazimirchak et al., 1972).

| Meteor Shower | Date of Max (1992) | Velocity (km/sec) | Associated comet | Comet's period (yr) |
|---|---|---|---|---|
| Quadrantid | Jan 4 | 43 | - | 7.0 |
| Lyrid | Apr 21 | 48 | 1861 I | 415.0 |
| η Aquarid | May 4 | 59 | Halley | 76.0 |
| δ Aquarid | Jul 30 | 43 | - | 3.6 |
| Perseid | Aug 13 | 61 | 1862 III | 105.0 |
| Draconid | Oct 9 | 24 | Giacobini-Zinner | 6.6 |
| Orionid | Oct 20 | 66 | Halley | 76.0 |
| Taurid | Oct 31 | 30 | Encke | 3.3 |
| Andromedid | Nov 14 | 16 | Biela | 6.6 |
| Leonid | Nov 16 | 72 | 1866 I | 33.0 |
| Geminid | Dec 13 | 37 | Phaethon | 1.6 |

table (4.1): The prominent annular meteor showers.

Interest in meteor showers started after discovery of the phenomenon of the radiant point (the apparent point of origin in the sky) in 1833 by Denison Olmsted when he observed the radiant of the Leonid meteor shower. From that date a number of researchers began to search for information about recorded meteors in the past. The most extensive investigation was made by the French sinologue E.Biot (1848) who compiled a catalogue of observations of

fireballs. Biot's main source was the great Chinese historical encyclopedia, the *Wen-hsien T'ung-k'ao*, of *Ma Tuan-lin* a historian of the premongol period, in the 13th century. This catalogue contains information covering more than 1500 fireballs during many centuries. The positions of fireballs in Biot's catalogue are described relative to the stars; in addition a description of some of their physical properties is given. Of course, most of the fireball observations cited by Biot were made in China in the vicinity of latitude 35 degrees north, where the majority of Chinese capitals were situated. Astapovic and Terenteva (1968) attempted to determine the radiants of meteor showers by a detailed processing of fireball observations recorded in Biot's catalogue.

## 4.4 Meteors and Meteor Showers in the Medieval Islamic Period

The main, or maybe the only medieval Islamic source of meteors and meteor showers is chronicles. Like comets, it is very rare to find a description of meteors in the treatises of Muslims and Arab astronomers. The reason for not recording these phenomena by astronomers may be the same reason for neglecting comets. To those astronomers, meteors and meteor showers were completely irregular phenomena and did not appear to have any direct or indirect application to their lives. So, possibly because of this reason they ignored these phenomena. The word

"swoop down" (*Inqidhad*) is frequently used to describe both a meteoroid when it encounters the Earth's atmosphere and the luminous trail (light) formed.

## 4.4.1 Records of individual meteors

More than forty sightings of individual meteors are known to be recorded in Islamic medieval history, see table (4.2); about thirty of these are recorded over only two centuries- the 10th and 11th centuries.

All of these meteors can be identified as fireballs, with intense light accompanying them. In several cases, loud sound issued, described as thunder or a hum or a buzz (*Daweiy*). In these cases break up into more than one fragment is often mentioned. Surprisingly, about 27 of these fireballs are recorded by either *Ibn al-Jawzi* or *Ibn al-Athir* or both. Even the other chroniclers who recorded the same events derived their reports from these writers. The place of observations of the event is rarely recorded, but it may simply be considered as the city or town where the chronicler lived.

**(1) AD.775 Aug 28 =  27 Shawwal AH.158**

Baghdad

" In this year (AH.158), a planet swooped down when three nights remained in the month Shawwal (Aug 28) after morning twilight. Its trail was clear until sunrise ".
*(al-Tabari, Vol.8)*

**(2) AD.916 Mar 28 = 22 Ramadan AH.303**

Baghdad

" On the night of Friday when eight nights remained in the month of Ramadan (Mar 28), a large planet swooped down. Its light lasted for an hour, like a firebrand ". *(Ibn al-Jawzi, Vol.6)*

**(3) AD.920 Mar/Apr = Dhu al-Qa'da AH.307**

Baghdad

" In the month Dhu al-Qa'da (Mar 24 - Apr 21), a large planet with prevailing light swooped down. It broke up into three pieces. A mighty thunder sound was heard when it swooped down; there were no clouds ". *(Ibn al-Jawzi, Vol.6)*.

This event is also recorded in the same words by the later writers *Ibn al-Athir, Vol.6; Ibn Kathir, Vol.11* and *al-Suyuti, Vol.2*. However, *Ibn al-Athir* stated only the year of occurrence.

**(4) AD.922 Sep/Oct = Jumada II AH.310**

Mosel

" In the month Jumada II (Sep 24 - Oct 23), a large planet with a tail swooped down at the east in Virgo. Its tail was about two cubits long ". *(Ibn al-Athir, Vol.6)*.

*Ibn al-Jawzi, Vol.6,* recorded this event in the same words as the above account, but without mentioning the swooping down which means this object might have been a comet. So, his report is discussed in the previous chapter.

**(5) AD.925 Apr 25 = 29 Muharram AH.313**

Baghdad

" When one night remained in the month Muharram (Apr 25), a planet swooped down before sunset from the south to the north. The ground was illuminated by the intense light from it (the meteor). It had a sound like a loud thunder sound ". *(Ibn al-Jawzi, Vol.6)*.

This same event and description was also recorded by the same chroniclers of the meteor number (3) in which *Ibn al-Athir* mentioned only the year of occurrence.

**(6) AD.927 May 13 = 9 Rabi I AH.315**

Baghdad

" On Sunday when eight (days) had passed of the month Rabi I (May 13), a large planet swooped down; it had an intense light. (This occurred) when two hours remained of the day (i.e. two hours before sunset) ". *(Ibn al-Jawzi, Vol.6)*.

*Ibn al-Athir, Vol.6,* also chronicled this meteor, but he mentioned that the meteor had a strong sound instead of intense light.

**(7) AD.930 Jan 2 = 29 Dhu al-Qa'da AH.317**

Mosel

" At the end of the month Dhu al-Qa'da (around Jan 2), a large planet swooped down; it had a very intense light ". *(Ibn al-Athir, Vol.6)*.

**(8)  AD.970 Oct/Nov = Dhu al-Hijjh AH.359**

Baghdad

" In the month Dhu al-Hijjh (Oct 4 - Nov 2), a large planet swooped down at the beginning of the night. The ground was illuminated by it until it became like the rays of the Sun. Like a loud thunder sound was heard when it was swooping " . (*Ibn al-Jawzi, Vol.7*).

Three late writers: *Ibn Kathir, Vol.11; Ibn Taghribardi, Vol.4 and al-Suyuti, Vol.2* chronicled this event in very similar words to the above report; they probably cited from it.

**(9)  AD.971 Nov 29 = 9 Safar AH.361**

Baghdad

" On the night of Wednesday the 9th of the month Safar (Nov 29), a large planet swooped down. It had a hum like the hum of thunder ".(*Ibn al-Jawzi, Vol.7*).
It is recorded also by *Ibn al-Athir, Vol.7.*

**(10)  AD.983 Jul 28 = 16 Safar AH.373**

Baghdad                                              (

" On the night of Wednesday the 16th of the month Safar (Jul 28), a planet with an intense light swooped down; after that a hum like thunder was heard ".  *(Ibn al-jawzi, Vol.7).*

The recorded lunar date should corresponded to Saturday. So, there is mistake either in the day of the month or the week-day.

**(11) AD.983 Aug/Sep = Rabi I AH.373**

Mosel

" In the month Rabi I (Aug 12 - Sep 9), a large planet swooped down. The ground was illuminated by it; a hum like loud thunder was heard from it ". (*Ibn al-Athir, Vol.7*).

**(12)  AD.999 Mar 11 = 21 Rabi I AH.389**

Baghdad

" On Sunday when ten (nights) remained in the month Rabi I (Mar 11), a large planet swooped down at forenoon ". (*Ibn al-Jawzi, Vol.7*).

It was chronicled also in Mosel by *Ibn al-Athir, Vol.7*, but he reported only the month of occurrence.

**(13)  AD.1002 Sep 12 = 3 Dhu al-Qa'da AH.392**

Damascus

" *Ibn al-Jawzi* said: on the night of Monday the 3rd. of the month Dhu al-Qa'da (Sep 12), a planet swooped down. Its light was like the full Moon. Then (its) rays vanished, but its body remained wavering about two times two cubits (presumably he means the apparent area) as seen by eye; then it disappeared after one hour ". (*Ibn Kathir, Vol.11*).

As clear from the text that *Ibn Kathir* quoted his report from *Ibn al-Jawzi*, but this report is not extant in *Ibn al-Jawzi's* book, *al-Muntazam.* It was recorded also by *al-Suyuti, Vol.2.*

**(14) AD.1003 Aug/Sep = Dhu al-Qa'da AH.393**

Mosel

"(Also) in the month Dhu al-Qa'da (Aug 31-Sep 28), a large planet swooped down like the light of the full Moon. Its light vanished, but its body remained wavering". (*Ibn al-Athir, Vol.7*).

This event might be the same as the last one, but *Ibn al-Athir* who probably cited his account from *Ibn al-Jawzi* may have copied the wrong year. In addition, he did not mention the exact date or the week-day.

**(15) AD.1008 Mar 2 = 3 Rajab AH.399**

Baghdad

" On Wednesday, the beginning of the month Rajab (Mar 2), a planet swooped down at sunset. It had intense light. It broke up into three pieces; each one went in a different direction ". (*Ibn al-Jawzi, Vol.7*).

**(16) AD.1010 Oct 4 = 24 Safar AH.401**

Baghdad

" On Thursday when seven (days) remained in the month Safar (Oct 4), a planet swooped down in the afternoon from the westwards of the Caliphate's house to the eastwards. None had ever been seen larger than it ". (*Ibn al-Jawzi, Vol.7*).

It was recorded also by the later writer *Ibn al-Athir, Vol.7,* but in very brief description.

**(17) AD.1012 Sep 16 = 27 Safar AH.403**

Baghdad

" On the night of Wednesday when three (nights) remained in the month Safar (Sep 16), a planet with large body swooped down at nightfall from the right of the *Qibla* direction (i.e. south-west). Its light covered the ground. People regarded this as a great event ". (*Ibn al-Jawzi, Vol.7*).

(18)  AD.1013 Mar/Apr = Ramadan AH.403

Baghdad

" In the month Ramadan (Mar 15 - Apr 13), a planet swooped down from the east to the west. Its light overcame the Moon's light. It broke up into pieces and remained for a long hour ". (*Ibn al-Jawzi, Vol.7*).
This event was recorded also by *al-Suyuti, Vol.2*.

(19)  AD.1014 Mar/Apr = Ramadan AH.404

Mosel

The same description as in the last account is recorded by *Ibn al-Athir, Vol.7*, but he noted the following year (AH.404) instead of the year AH.403. It is not clear which date is correct.

(20)  AD.1023/24 = AH.414

Cairo

" In this year (AH.414 = AD.1023 Mar 25 - 1024 Mar 12), a large planet swooped down. It had a hum like thunder. Fear struck the hearts (of people) ". (*Ibn al-Dwadari, Vol.6*).

(21) AD.1026 Oct/Nov = Ramadan AH.417

Baghdad

" In the month Ramadan (Oct 14 - Nov 12), a large planet with intense light swooped down. It had a hum like a thunder ". (*Ibn al-Jawzi, Vol.7*).

It was recorded also by *Ibn al-Athir, Vol.7* and *Ibn Kathir, Vol.12.*

(22) AD.1029 Aug 4 = 20 Rajab AH.420

(23) AD.1029 Aug 6 = 22 Rajab AH.420 ...

(24) AD.1029 Aug 12 = 28 Rajab AH.420

Baghdad

During the last ten days of the month Rajab (Aug 3-13), a number of meteors appeared in the sky of Baghdad. *Ibn al-Jawzi, Vol.8* recorded them as follows:

(a) " In the darkness of the night of Tuesday when 10 (nights) remained in the month Rajab (Aug 4), a large planet swooped down and it illuminated the ground. It had a hum like thunder's hum. It broke up into four pieces ".

(b) " On the night of Thursday (after two nights, Aug 6), a smaller planet (than the previous one) swooped down ".

(c) " On the night of Wednesday when two nights remained in the month Rajab (Aug 12), a larger and brighter (planet) than the first one swooped down ".

(25) AD.1032 Sep 9 = 2 Shawwal AH.423

Baghdad

" On the night of Monday the 2nd of the month Shawwal (Sep 9), a planet swooped down and illuminated the ground. The people were terrified ". (*Ibn al-Jawzi, Vol.8*).

(26) AD.1034 Oct 9 = 24 Dhu al-Qa'da AH.425

Baghdad

" On the night of Wednesday when seven (nights) remained
in the month Dhu al-Qa'da (Oct 9), a large meteor
(*Shihab*) swooped down ". (*Ibn al-Jawzi, Vol.8*).

(27) AD.1034 Oct 11 = 26 Dhu al-Qa'da AH.425

Baghdad

" On the night of Friday (After two nights from the
previous event, Oct 11), during the darkness of night, a
meteor (*Shihab*) swooped down. It was like the brightest
thunderbolt. Its light even covered the ground and it
overcame the light of lamps (torches). It terrified all
the observers. The duration between swooping down and
vanishing was longer than usual ". (*Ibn al-Jawzi, Vol.8*).
The later chroniclers *Ibn al-Athir, Vol.8 of* Mosel and
*al-Suyuti, Vol.2,* of Egypt, also recorded this meteor.

(28) AD.1036 May 22 = 22 Rajab AH.427

Baghdad

" On Saturday when eight (days) remained in the month
Rajab (May 22) at forenoon, a planet swooped down; its
light overcame the Sun's light. Its end (trail) was like
a dragon with a dark blue color ". (*Ibn al-Jawzi, Vol.8*).
It is recorded also by *Ibn al-Athir, Vol.8*

(29) AD.1051 Jun 19 = 7 Safar AH.443

Baghdad

" On Wednesday the 7th of the month Safar (Jun 19) in the afternoon, a planet appeared in Baghdad. Its light overcame the Sun's light. It had a tail about two cubits long. It moved slowly, then swooped down while people were watching it ". *(Ibn al-Athir, Vol.8)*

**(30) AD.1055 Jul 20 = 23 Rabi II AH.447**

Baghdad

" in the end of the day, on Thursday when eight (days) remained in the month Rabi II (Jul 20), a large planet swooped down and broke up into three pieces ". *(Ibn al-Jawzi, Vol.8)*.

**(31) AD.1060 Jul 5 = 3 Jumada II AH.452**

Baghdad

" On Wednesday, the 3rd of the month Jumada II (Jul 5), a large planet swooped down at sunrise from the west to the east. It lasted a long time ". *(Ibn al-Jawzi, Vol.8)*.

The 3rd of the month Jumada II was corresponded to Monday. So, either the recorded week-day or the day of the month is incorrect. The above Julian date is given according to the week-day. *Ibn al-Athir, Vol.8*, reported the same event, but he noted that the time of swooping was at dawn.

**(32) AD.1063 Apr 27 = 26 Rabi II AH.455**

Baghdad

" On the night of Monday when five nights remained in the month Rabi II (Apr 27), a large planet swooped down. It

had an intense light ". (*Ibn al-Jawzi, Vol.8*).

*Ibn al-Athir* recorded this meteor, but mentioned only the month of occurrence.

**(33) AD.1063/64 = AH.456**

Mosel

" In this year (AH.456 = AD.1063 Dec 23 - 1064 Dec 10), a large planet swooped down. Its light was brighter than the Moon's light. A loud hum was heard from it, then it disappeared ". (*Ibn al-Athir, Vol.8*) .

**(34) AD.1065 Aug 8 = 3 Ramadan AH.457**

Baghdad

" On the night of Tuesday the 3rd of the month Ramadan (Aug 8), a large planet swooped down. Its light spread out like the (light of the) Moon, then it broke up into pieces; an awful hum was heard ". (*Ibn al-Jawzi, Vol.8*).

**(35) AD.1084 Jun 26 = 20 Safar AH.477**

Baghdad

" On the night of Tuesday when ten (nights) remained in the month Safar (Jun 26), a planet swooped down from the east to the west. Its size and light were as big as the full Moon. It moved slowly a long distance (in the sky) for about one hour. It was unique among the swooping planets ". (*Ibn al-Jawzi, Vol.9*).

It was recorded also by *Ibn al-Athir, Vol.8*, but he mentioned the month of occurrence.

**(36) AD.1121 Jun/Jul = Rabi II AH.515**
Mosel

" In the month Rabi II (Jun 17 - Jul 16), a planet swooped down at nightfall. It had a very bright light. When it swooped down, columns separated from it (i.e. the meteoroid broke into pieces, then each individual piece had its own trail). A loud sound of destruction, like an earth-quake was heard ". (*Ibn al-Athir, Vol.8*).

(37) AD.1176/77 = AH.572

Mosel

" In this year (AH.572 = AD.1176 Jul 9 - 1177 Jun 27), a planet swooped down, and it illuminated the ground with intense light. A loud sound was heard. Its trail lasted in the sky for an hour, then it disappeared ". (*Ibn al-Athir, Vol.9*).

(38) AD.1193 = AH.589

Mosel

" In this year (AH.589 = AD.1193 Jan 5 - Dec 25), two large planets swooped down after dawn; and a loud sound of destruction was heard. Their light overcame the light of the Moon and the light of the day ". (*Ibn al-Athir, Vol.9*).

(39) AD.1387 Jul 3/4 = 18/19 Jumada II AH.789

(a)Damascus (b)Cairo

An object was seen on 3rd July and recorded by several chroniclers from Egypt and Damascus. *Ibn Qadi Shuhuba* stated the following:

(a) " On the night of the 19th of the month Jumada II (July 4), a large planet appeared towards the north, then

it extended and three meteors (Shuhub) appeared from it. One of them had a tail one cubit in length. They had an intense light. They extended towards the west, then towards the Qibla (south-west). This was one hour after the Isha prayer as noted in Egyptian history ".

Al-Jawhari from Cairo stated the following:

(b) " On the night of the 18th of the month Jumada II (July 3), a large planet appeared in the sky towards the north. It extended towards the west. It had three branches (Shu'uba), one of them had a long tail of one spear length. It (the object) had a light brighter than the Moon's light. After that, it moved from the west to the south, then people heard a noise (followed by) an awful sound ". (al-Jawhari, Vol.1).

This object was evidently a meteor, as indicated by the sound which it made. Moreover, Ibn Qadi Shuhuba specifically mentioned that "three meteors appeared".

(40) AD.1430 Mar/Apr = Rajab AH.833

Cairo

" In the month Rajab (Mar 25-Apr 22), a large planet with a lock of hair (Dhawaba) of two spears length appeared in the sky. It appeared at sunset between the east and Qibla direction (south-east). It expelled sparks from east to west. People were astonished at this (event) ". (Ibn Iyas , Vol.2).

```
-------------------------------------------------------
    Julian Date         Place          Reference
-------------------------------------------------------

    775 Aug 28          B              1
    916 Mar 29          B              6
  [920 Apr 8]           B              6,7,13,19
  [922 Oct 9]           Mo             7

    925 Apr 25          B              6 ?
    927 May 13          B              6,7
    930 Jan 2           Mo             7
  [970 Oct 19]          B              6,13,17,19

    971 Nov 29          B              6,7
  [983 Jul 28]          B              6
    983 Aug 27          Mo             7
    999 Mar 11          B & Mo         6,7

   1002 Sep 12          D              13,19
 [1003 Sep 15]          Mo             7 ?
   1008 Mar 2           B              6
   1010 Oct 4           B              6,7

   1012 Sep 17          B              6
 [1013 Mar 30]          B              6
   1014 Mar 30          Mo             7
   1023/24              C              12

 [1026 Oct 29]          B              7,6,13 ?
   1029 Aug 4           B              6
   1029 Aug 6           B              6
   1029 Aug 12          B              6

   1032 Sep 9           B              6
   1034 Oct 9           B              6
   1034 Oct 11          B              6,7,19
   1036 May 22          B              6,7

   1051 Jun 18          B              7
   1055 Jul 20          B              6
   1060 Jul 3           B              6,7
   1063 Apr 27          B              6,7

   1063/64              Mo             7
   1065 Aug 7           B              6
   1084 Jun 27          B              6
 [1121 Jul 2]           Mo             7

   1176/77              Mo             7
   1193                 Mo             7
   1387 Jul 3           D              15
   1387 Jul 4           C              18
 [1430 Apr 9]           C              20
-------------------------------------------------------
```

Table (4.2): A summary for known recorded meteors
(fireballs) during the medieval Islamic era. For
abbreviation of cities and references see tables
(1.5) and (2.1). The bracket [ ] means that the
date ranges between + 15 days.

## 4.4.2 Records of Meteor Showers

Meteor showers in Arabic chronicles are described by several different expressions, which in the end lead to the same meaning. In the following table (4.3), a list of these modes of expression and their meanings in English are given. Table (4.4) is a summary of the recorded meteor showers during the medieval Islamic dominions.

---

| No. | Arabic Name | English meaning |
|-----|-------------|-----------------|
| 1 | *Inqidhad al-Kawakib* | Planets swooping |
| 2 | *Tanathur al-Kawabib* | Planets scattering |
| 3 | *Inqidhat al-Nujum* | Stars swooping |
| 4 | *Tanathur al-Nujum* | Stars scattering |
| 5 | *Tasaqut al-Nujum* | Stars falling |
| 6 | *Tatayor al-Nujum* | Stars flying |
| 7 | *Majat al-Nujum* | Stars wavering |
| 8 | *al-Ramy bi al-Nujum* | stars striking |

---

Table (4.2): Eight expressions which are exclusively used by chroniclers for describing meteors showers.

W. Rada and F.R. Stephenson (1992), [This reference will subsequently be abbreviated to RS] presented for the first time a detailed catalogue of medieval Arabic observations of meteor showers. In this present section,

I have re-translated some of the entries in RS catalogue.
Three new meteor showers of AD.915, 1029 and 1377 have
been added.

(1) AD.571 Mar 4 = 2 Rabi I -AH.53

Mecce

" When the prophet Muhammad was born, 50 years before the
start of the year known as the Elephant year, which was
Monday the 2nd day of Rabi I (Mar 4)... the planets were
shooting and the devils were struck by them. When the
Quraish (the tribe to which the prophet Muhammad
belonged) saw it, they did not recognize that it was the
planets shooting and instead they said that it was the
last day ". (Translated by RS from *al-Ya'qubi, Tarikh
al-Ya'qubi, Vol.2*).

(2) AD.609 Dec 29 = -AH.13

Mecce

" Prophet Muhammad received his first divine revelation
when he was forty years and one day old (that was on
Monday 12 Rabi I). That year was also the year of the
planetary conjunction in Aquarius ... On the prophet's
revelation, the devils were struck by meteors from the
sky ". (Translated by RS from *al-Ya'qubi, Tarikh
al-Ya'qubi, Vol.2*).

(3) AD.762/3 = AH.145
Cairo

" In this year (AH.145 = AD.762 Mar 31 - 763 Mar 19),
planets scattered from the beginning of the night until
morning, people were terrified ". (al-Suyuti, Vol.2).

**(4) AD.764/5 = AH.147**

Mosel

" In this year (147 = AD.764 Mar 8 - 765 Feb 24), planets
scattered ". (al-Azdi).

This meteor shower was recorded also by Ibn al-Athir,
Vol.5. Certainly, he derived his report from the first
historian of his city (Mosel), namely al-Azdi.

**(5) AD.839 Apr/May = Jumada II AD. AH.224**

Cordoba?

" In this year (AH.224) striking by stars occurred in the
month Jumada II (Apr 18 - May 16) and the planets
scattered from the Qibla (south-east) to Jawf
(north-west) and from north-east to south-west in
al-Andalus (Spain) ". (Ibn Idhari, Vol.2).

**(6) AD.855 Oct 16 = 2 Jumada II AH.241**

Baghdad

" On the night of Thursday when one night had passed in
the month Jumada II (Oct 16), planets swooped down and
scattered in Baghdad ". (al-Tabari, Vol.9).

**(7) AD.902 Aug 15 = 9 Ramadan AH.289**

Baghdad

" When eight nights had passed in the month Ramadan (Aug
15), planets swooped down all over the sky at dawn and
continued like that until sunrise ". (Ibn al-Jawzi,

*Vol.9).*

As usual, *Ibn Kathir, Vol.11,* cited this event from the above chronicler.

**(8) AD.902 Oct 14 = 8 Dhu al-Qa'da AH.289**

Cordoba?

" In this year (AH.289), stars fell down on the 8th of Dhu al-Qa'da (Oct 14), so that the year was called the year of the stars' ". *(Ibn Idhari, Vol.1).*

**(9) AD.902/3 = AH.290**

Cairo

" At the beginning of this year (AH.290 = AD.902 Dec 3 - 903 Nov 21), stars sprinkled all over the atmosphere in Egypt. People were afraid, and (the phenomenon) continued to increase. Not long afterwards in the same year, people were suffering thirst due to drought ". (Translated by RS from *al-Baghdadi*).

**(10) AD.913 Feb 3 = 24 Jumada II AH.300**

Baghdad

" When seven (nights) remained ¿in the month Jumada II (Feb 3), stars scattered strangely towards Khurasan (the region between Iran and Afghanistan) ". *(Ibn al-Jawzi, Vol.6).*

It was recorded also by *Ibn al-Athir,Vol.6; Ibn Kathir,Vol.11* and *Ibn Taghribardi, Vol.3.* The second author gave the week-day as the night of Wednesday.

**(11) AD.915 Jun 25 = 10 Dhu al-Hijjh AH.302**
Mosel

" On the night of *al-Adha* (the 2nd festival of Muslims, i.e. the 10th of the month Dhu al-Hijjh = Jun 25), three large planets swooped down; two at the beginning of the night and one at the end of the night. In addition, many small planets (swooped down) ". (*Ibn al-Athir, Vol.6*).

(12) AD.934 Oct 12 = 1 Dhu al-Qa'da AH.322

Cordoba

" In the beginning of the month Dhu al-Qa'da (around Oct 12), groups of stars in mid-sky were striking from east to west and from west to east. They were fascinating to the observer ". (*Ibn Hayyan, Vol.5*).

(13) AD.935 May 13 = 6 Jumada II AH.323

Baghdad

" In this year (AH.323), stars were shooting in such a manner as had never been seen at all before. That was on Thursday night the 6th of the month Jumada II ". (Translated by RS from *al-Mas'udi, Muruj al-Dhahab, Vol.4*).

(14) AD.935 Oct 13/14 = 13 Dhu al-Qa'da AH.323

(a)Cordoba and (b)Baghdad

(a) " When twelve night had passed in the month Dhu al-Qa'da (Oct 14), stars were striking extensively in the atmosphere. Most of them were directed from mid-sky to the western horizon. Among them, a great star lost its lustre; it appeared from the east like a column. It competed with the Moon and was nearly splitting it as seen by the observer's eye ". (*Ibn Hayyan, Vol.5*).

(b) " At dawn of Wednesday when twelve nights had passed in the month Dhu al-Qa'da (Oct 14), the stars swooped down in Baghdad from the beginning of the night until the end of it. Also the same happened in al-Kufh. The swooping was on a huge scale and nothing like it had happened before ". (*Ibn al-Jawzi, Vol.6*).

This marvellous event was recorded by several other chroniclers such as: *Ibn al-Athir, Vol.6; Ibn Taghribardi, Vol.3; Ibn Kathir, Vol.12* and *al-Suyuti, Vol.2* .All of these records closely resemble the two above accounts.

(15) AD.952/3 = AH.341

Cairo

" In this year (AH.341 = AD.952 May 27 - 953 May 15), stars scattered in the sky and appeared like locusts for most of the night. It was a terrible thing such as no one remembered ". (*al-Suyuti, Vol.2*).

(16) AD.1026 Aug/Sep = Rajab AH.417

Baghdad

" During the month Rajab (Aug 16 - Sep 13), a large number of shooting stars were observed. They had a loud sound and intense light ".(*Ibn al-Jawzi, Vol.8*).

(17) AD.1029 Jul/Aug = Rajab AH.420

Damascus

" In the month Rajab (Jul 15 - Aug 12), many planets swooped down with intense light and loud sound ". (*Ibn Kathir, Vol.12)*

**(18) AD.1060 Jan 22 = 16 Dhu al-Hijjh AH.451**

Baghdad

" On Saturday in the middle of the month Dhu al-Hijjh (Jan 22), a large number of swooping planets appeared in the atmosphere at nearly an hour before sunrise. The swooping was on a huge scale and was associated with a loud thunder sound ". (*Ibn al-Jawzi, Vol.8*).

**(19) AD.1065 Jul 24 = 26 Shaban AH.458**

Baghdad

" On the night of Sunday, when four (nights) remained in the month Shaban (Jul 24), two planets swooped down; one of them had a light like the light of the Moon. After about one hour, they were followed by more than ten small planets which (swooped down) towards the west ". (*Ibn al-Jawzi, Vol.8*).

**(20) AD.1197/8 = AH.594**

Cairo

" At the beginning of this year (AH.594 = AD.1197 Nov 12 - 1198 Oct 31), planets sprinkled ". (Translated by RS from *al-Baghdadi*).

**(21) AD.1202 Oct 18/19 = 29 Muharram AH.599**
Baghdad

" On the night of Saturday, the end of the month Muharram (around Oct 8), the stars wavered in the sky towards the east and west and scattered like locusts spreading left and right. This continued until dawn. Such an event had not happened before except at the revelation of the

prophet Muhammad (see meteor shower no. 2) and (also) the year AH.241 (see meteor shower no. 6) ". (*Sebt Ibn al-Jawzi, Vol.8*).

This meteor shower was recorded in much the same words by several other chroniclers such as: *Ibn Kathir, Vol.12; Ibn Taghribardi, Vol.6; al-Dwadari, Vol.7* and *al-Suyuti, Vol.2.*

(22) AD.1377 Jun 27 = 21 Safar AH.779

Cairo

"On the 27th of the month Tamouz (June), a number of stars were falling at night. People were afraid of this". (*Ibn Iyas., Vol.1*).

(23) AD.1497 Jul 27 = 26 Dhu al-Qa'da AH.902

Damascus

" On Thursday the 26th of the month Dhu al-Qa'da (Jul 27) in the evening, the clouds were agitated from the east of Damascus and moved towards the west until it became dark. People began to expect the fall of rain due to the high humidity and heat and this continued to the end of the night when star shooting developed and the sky began to clear of clouds. There were around 20 shooting stars in an hour ". (translated by RS from *Ibn Tulun, Vol.1*).

(24) AD.1832 Nov 13 = 19 Jumada II AH.1248

Najd (middle region of Saudi Arabia)

" On Tuesday night, the 19th of Jumada II, in the year

AH.1248 (AD.1832 Nov 13) , the stars scattered late in the night and continued until sunrise ". (Translated by RS from *Ibn Issa*).

## 4.5 Conclusion

Twenty four meteor showers have been assembled in this work. Although the number of data is insufficient to draw significant conclusions, the records illustrate a preponderance of meteors showers which occurred between 14 to 18 October during AD.850 to 1200, three meteors showers in July and August and two showers in May while only one shower is recorded at other months, see table (4.4). As is clear from the histogram in Figure (4.3) which shows the monthly frequency of meteors showers and the prominent meteor showers in table (4.1), it can be safely said that the frequency of meteor showers in October is due to the Leonids shower. This meteor shower has a 1992 date of maximum of November 16. The reason for the shift in the date of maximum is partly because of the difference in length between the sidereal and tropical years. This causes about 1.4 day per century delay in the date of maximum. However, this difference is almost doubled as a result of planetary perturbations (Kidger, 1992). Thus the meteor shower of AD.1832 Nov 13 has an equivalent 1993 date of maximum of Nov. 17 which also relates to the Leonid shower as well. The AD.915 meteor shower corresponds to a present day date of maximum July 26, close to July 30 the current date of the annual Delta Aquarids.

| Julian Year | Place | Reference |
| --- | --- | --- |
| 571 Mar 4 | M | RS |
| 609 Dec 29 | M | RS |
| 762/3 | C | 19 |
| 764/5 | Mo | 2,7,17 |
| | | |
| 839 Apr/May | Co? | 11 |
| 855 Oct 17 | B | 1 |
| 902 Aug 15 | B | 6,13 |
| 902 Oct 14 | Co? | 11 |
| | | |
| 902/3 | C | RS |
| 913 Feb 3 | B | 6,7.13.17 |
| 915 Jun 25 | Mo | 7 |
| 934 Oct 12 | Co | 4 |
| | | |
| 935 May 13 | B | RS |
| 935 Oct 14 | B | 6 |
| 935 Oct 14 | Co | 4 |
| 952/3 | C | 19 |
| 1026 Aug/Sep | B | 6 |
| | | |
| 1029 Aug/Sep | D | 13 |
| 1060 Jan 21 | B | 6 |
| 1065 Jul 24 | B | 6 |
| 1197/8 | C | RS |
| | | |
| 1202 Oct 18 | B | 8,13,17,12,19 |
| 1377 Jun 27 | C | 20 |
| 1497 Jul 27 | D | 21 |
| 1832 Nov 13 | N | RS |

Table (4.4): Summary of meteor showers as recorded in medieval Arabic chronicles. RS refers to Rada and Stephenson, 1992.
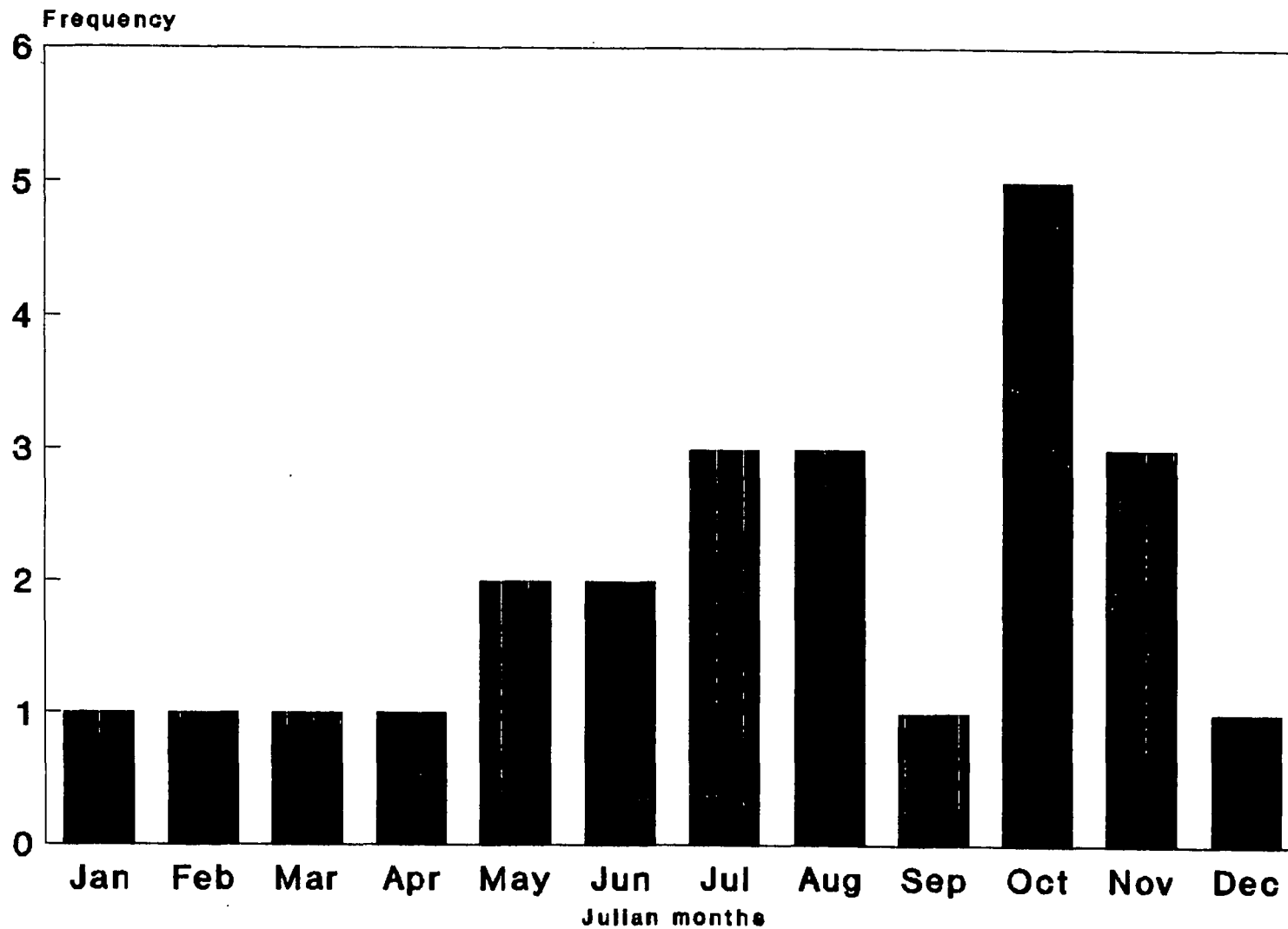
Fig. (4.3): The monthly frequency of meteor showers during the medieval Islamic period.

# 5 INVESTIGATION OF SOLAR ECLIPSES OBSERVATIONS

## 5.1 Introduction

The first use of solar eclipse observations for an astronomical determination was made by Hipparchus. in 135 BC. to find the lunar parallax. About 18 centuries after Hipparchus., Halley (1695) was the first analyst to use ancient eclipses, and he discovered the so-called secular acceleration of the Moon's longitude. He gives little information about the method but it may be inferred that he used the ancient observations to test the theory of the Moon's motion. From the available theoretical expressions for the lunar motion he computed the conditions for a small set of ancient eclipses - probably those preserved by Ptolemy and the medieval Arabians. He found that the Moon's apparent orbital motion was being accelerated. This problem was investigated by many researchers after Halley, beginning with Dunthorne (1749). Most of them used long term observations of eclipses whether of the Sun or Moon.

Many solar and lunar eclipse times are recorded by Muslims astronomers, but these not be considered in this thesis. For details, see Stephenson and said (1991). Recently, Said, Stephenson and Rada (to be denoted as SSR), 1989, made an extensive search of Arabic chronicles for references to eclipses of the Sun. The recorded medieval solar eclipses in this chapter are based on their work; I have not been able to discover any further

records. SSR uncovered observations of about 30 solar eclipses ranging in date from AD.833 to 1513. They gave full translations and also provided a chronological and astronomical commentary. The few lunar eclipses which they noted relate to instances when a chronicler reported observations of solar and lunar eclipses which occurred at approximately the same time.

## 5.2 Total solar eclipse

A total solar eclipse is a spectacular, awe inspiring event. The Moon's umbra never is sufficiently large to cover the whole Earth, but in this type of eclipse the umbra sweeps across the Earth from west to east producing the so called path of totality which is seldom greater than 270 kilometers wide at any one moment. Inside this path the Sun would be completely obscured by the Moon for as long as 7.5 minutes at maximum. The average frequency of occurrence of total eclipses is extremely rare at any one location, only three times in a millennium. A feature of such an event is the fall of light intensity during the last few seconds, which is remarkably sudden.

Total solar eclipses play an important role in the investigation of the lunar motion and changes in the Earth's rate of rotation in order to determine the Earth's rotation clock error T at different period in history (Stephenson and Morrison 1983 and 1984, Stephenson and Said 1988, Stephenson and Lieske 1989, etc.).

In the Arabic chronicles consulted, seven records (including two for the eclipse of AD.1176) of total solar eclipses have been uncovered. Most descriptions of darkness in these records are accompanied by the appearance of stars while in one case there is also a report of birds falling from the sky. These eclipses are as follow:

1) In AD.833 : darkness appeared, there is no indication that the stars were seen or any other effects caused by sudden darkness.

2) In AD.912 : The stars appeared and darkness covered the horizon. Because this eclipse occurred some 15 minutes before sunset, this eclipse was less spectacular than if would have been at mid-day.

3) In AD.993 : The Earth was in darkness and stars appeared. No one could see the palms of his hand on account of the darkness.

4) In AD.1061 : The birds fell whilst flying on account of the darkness. In another record, the birds returned to their nests and the stars were seen.

5) In AD.1176 : In both records from Cizre and the Orontes river, the stars appeared and the Earth was in darkness.

6) In AD.1241 : The stars appeared and it became like a dark night so that some people lit lamps as a result of darkness.

According to computation based on the formula for T due to Stephenson and Morrison (1984), there was a total eclipse in AD.939 at Toledo in Spain. This is recorded by *Ibn Hayyan* who quoted his report from *al-Razi* but he did not mention that the Sun was totally obscured.

There is a erroneous description of totality for the eclipse of AD.1491; the record from Cairo says that this eclipse was total, but the calculated magnitude was not more than 0.4. However, there are two further inaccurate description of eclipses that were stated to have been total and accompanied by darkness. These eclipses are as follow: (1) In AD.1433, the computed magnitude at Cairo was 0.88 but the chronicler stated that there was darkness and that some stars appeared. (2) In AD.1463, also from Cairo, the computed magnitude was 0.85 and the eclipse was described as total and accompanied by darkness. As well as these in AD.1513, at Damascus the computed magnitude was 0.98 whereas the record mentions that the lamps were lit as account of darkness. By this late date, T was so small (less than 5 minutes) the eclipse magnitudes can be computed with high precision.

## 5.3 Annular solar eclipse

Because the Moon's orbit around the Earth is slightly elliptical, its distance from us continually changes. When the Moon is in the more distant half of its circuit, an annular eclipse occurs. In this type of eclipse the Moon's disk fails to cover the Sun's disk completely, so

that the Moon is seen surrounded by a ring of bright sunlight. Because of the intensity of daylight, an annular eclipse may be scarcely noticed by the casual observer unless more than about 98 per cent of the Sun's disk is covered by the Moon.

Among the solar eclipses recorded in Arabic chronicles, there are two which should have been annular according to calculations: in AD.1376 and 1473. Both of them were recognized as partial eclipse rather than annular. They were seen at Cairo and recorded by *Ibn Iyas* who was contemporary to the second eclipse and possibly observed it.

## 5.4 Partial solar eclipse

From within the penumbra, the Sun's surface appears only partially covered by the Moon. This type of eclipse is much more frequent than the other two types. It occurs about once every 2.5 years on the average at any given location. As mentioned above, it is rare to observe a partial eclipse if less than about 80 per cent of the Sun is covered by the Moon. In fact, the casual bystander easily notices a thin solar crescent of a solar eclipse only when its magnitude is 0.99. By then it becomes possible to gaze directly at the Sun without discomfort. In the medieval Islamic period, five partial solar eclipses whose magnitude may be calculated as less than 0.51 were recorded. The eclipse of AD.1467 in Cairo was remarkable since it could be observed despite its very

small magnitude, 0.12. Possibly the occurrence of this eclipse was expected from the calculations of astronomers, then careful observation was made. Undoubtedly, that such a small diminution of the Sun was noticed suggests a special watch for eclipses around this time, unless thin cloud or haze, etc. enabled the Sun to be easily viewed (Said et. al. 1989). The method of reflection in water was used among Muslims and Arabs astronomers for observing the Sun to reduce its brightness . Moreover, detection of the eclipse of AD.1004 of magnitude 0.3 in Spain suggests a careful watch too.

## 5.5 Recording of magnitude and local time

It has long been customary to estimate the magnitude of an eclipse as a fraction of the diameter of the solar or lunar disk which is obscured at greatest phase. Like the ancient Babylonians and afterwards the Greeks, Arabs sometimes used the method of fingers or digits in measuring the magnitude (Stephenson and Said, 1991). Of course, the determination of the magnitude of an eclipse would appear to have been made directly without any instrumental aid, see figure (5.1). For example, the magnitudes of the solar eclipses of AD.1377, 1398, 1431, 1433 and 1438 were estimated very approximately, see table (5.2). The estimate local time of onset of an eclipse may be inaccurate for two main reasons:

(1) The eclipse was not noticed until it was already well advanced, especially for solar eclipses. Thus, the onset of an eclipse would be delayed, possibly by a significant of an hour. Most local times of onset recorded by chroniclers prove to be fairly approximate; timing errors are typically in the region of an hour (Said and Stephenson, 1991), especially if the eclipse estimate is relative to sunrise or sunset and sometimes with respect to midday or midnight. The eclipse of AD.993 which was recorded by *al-Maqrizi*, contains a serious error in recording the time of ending. According to calculation, the eclipse should ended at 10.20 am not at the end of the day (see table 5.1). Such large error is exceptional.

2) Sometimes the occurrence of eclipses is expressed relative to the prayer times either the five compulsory prayers or the optional forenoon (*Duha*) prayer, see table (5.3). But (as we explained in the first chapter) each prayer is to be performed within a certain interval of time rather than at an exact moment so that eclipse time expressed in this way are usually rough. In general the observations expressed in this way are in adequate accord with computation, see table (5.4)

*Ibn Iyas* usually recorded the duration of solar and lunar eclipses in degrees in which 15 degrees = 1 hour, see table (5.3). The recorded duration of eclipse using this method are fairly good comparing to computation, see table (5.4). (Lunar eclipse will be discussed in the following chapter).

```
--------------------------------------------------------------------
        Recorded Solar Eclipse          Computed Solar Eclipse
--------------------------------------------------------------------

 Julian Date    Plc.   Ref.      Begin     Max.     End      Mag.
--------------------------------------------------------------------

 0833 Sep 17    Co?    11        08.45     09.55    11.15    Total
 0882 Aug 17    B      1,6,7,19  18.20     -        -        -
 0903 Jun 27    Co     4         18.00     18.50    -        0.93
 0912 Jun 17    Co     4,11      18.20     19.10    -        Total
 0939 Jul 19    T?     4         06.15     07.15    08.20    Total

 0939 Jul 19    Co?    4         06.10     07.10    08.15    0.995
 0993 Aug 20    C      14        07.45     09.00    10.20    0.96
 1004 Jan 24    Co?    11        12.55     13.55    14.50    0.30
 1061 Jun 20    B      6,7,19    06.35     07.40    08.50    Total
 1174 Nov 26    B      6         07.30     08.45    10.15    0.91

 1176 Apr 11    Ci     7         06.35     07.35    08.40    Total
 1176 Apr 11    B      6         06.40     07.40    08.45    0.92
 1176 Apr 11    O      10        06.10     07.05    08.10    Total
 1178 Sep 13    B      6         14.35     15.40    16.50    0.82
 1241 Oct 06    C      14        13.50     15.05    16.15    Total

 1376 Jul 17    C      20        07.15     08.50    10.25    0.95
 1377 Jan 10    C      16        13.00     14.20    15.25    0.88
 1386 Jan 01    C      14,20     11.10     12.35    14.00    0.80
 1386 Jan 01    D      15        11.45     13.05    14.30    0.84

 1398 Nov 09    C      16        -         -        07.35    -
 1399 Oct 29    C      14,20     14.15     15.30    16.35    0.50
 1399 Oct 29    D      16        14.40     15.50    16.55    0.55
 1419 Mar 26    C      14,16,20  10.15     12.05    13.55    0.88
 1431 Feb 12    G?     14,16,20  12.45     13.50    15.05    0.90

 1433 Jun 17    A      16,22     17.30     18.25    19.15    0.995
 1433 Jun 17    C      14,20     17.15     18.20    19.00    0.88
 1438 Sep 19    C      14,20     12.50     14.20    15.35    0.52
 1463 May 18    C      20        10.40     12.30    14.20    0.85
 1467 Mar 06    C      20        06.45     07.15    07.45    0.12

 1473 Apr 27    C      20        06.00     07.10    08.30    0.93
 1491 May 08    C      20        16.00     17.00    18.05    0.40
 1502 Oct 01    C      20        08.10     09.30    11.00    0.55
 1513 Mar 07    D      21        14.15     15.35    16.45    0.975
 1513 Mar 07    C      20        13.45     15.05    16.25    0.91
--------------------------------------------------------------------
```

Table (5.1): Summary of all the observed solar eclipses in Arabic chronicles are compared with the calculated local circumstances. A sign (-) indicates that the Sun rose or set eclipsed. The abbreviated name of the place and the number of reference are according to our two tables (1.5) and (2.1). All times are in hours and decimals.

| Julian Date | Plc. | Rcorded Mag. | Comp. Mag. |
|---|---|---|---|
| 0833 Sep 17 | Co? | Great eclipse, with darkness | Total |
| 0912 Jun 17 | Co | Total, stars seen | Total |
| 0939 Jul 19 | T? | Total, except slight portion | Total |
| 0993 Aug 20 | C | Total, stars seen | 0.96 |
| 1061 Jun 20 | B | Total, with darkness | Total |
| 1176 Apr 11 | Ci | Total, with darkness, stars seen | Total |
| 1176 Apr 11 | O | Darkness, stars seen | Total |
| 1241 Oct 06 | C | Total, with darkness, stars seen | Total |
| 1377 Jan 10 | C | More than 0.5 eclipsed | 0.88 |
| 1398 Nov 09 | C | About 0.5 eclipsed, hardly noticed | - |
| 1431 Feb 12 | G? | 7/8 eclipsed | 0.90 |
| 1433 Jun 17 | C | 2/3 eclipsed, dark and stars seen | 0.88 |
| 1438 Sep 19 | C | About 2/3 eclipsed | 0.52 |
| 1463 May 18 | C | Total, with darkness | 0.85 |
| 1473 Apr 27 | C | Generally eclipsed, darkness | 0.93 |
| 1491 May 08 | C | Total | 0.40 |
| 1513 Mar 07 | D | Darkness | 0.975 |
| 1513 Mar 07 | C | Largely eclipsed | 0.91 |

Table (5.2): Comparison between recorded and computed magnitude of solar eclipses in medieval Arabic chronicles. In 1398 the Sun did not rise at Cairo until after the maximum phase had passed.
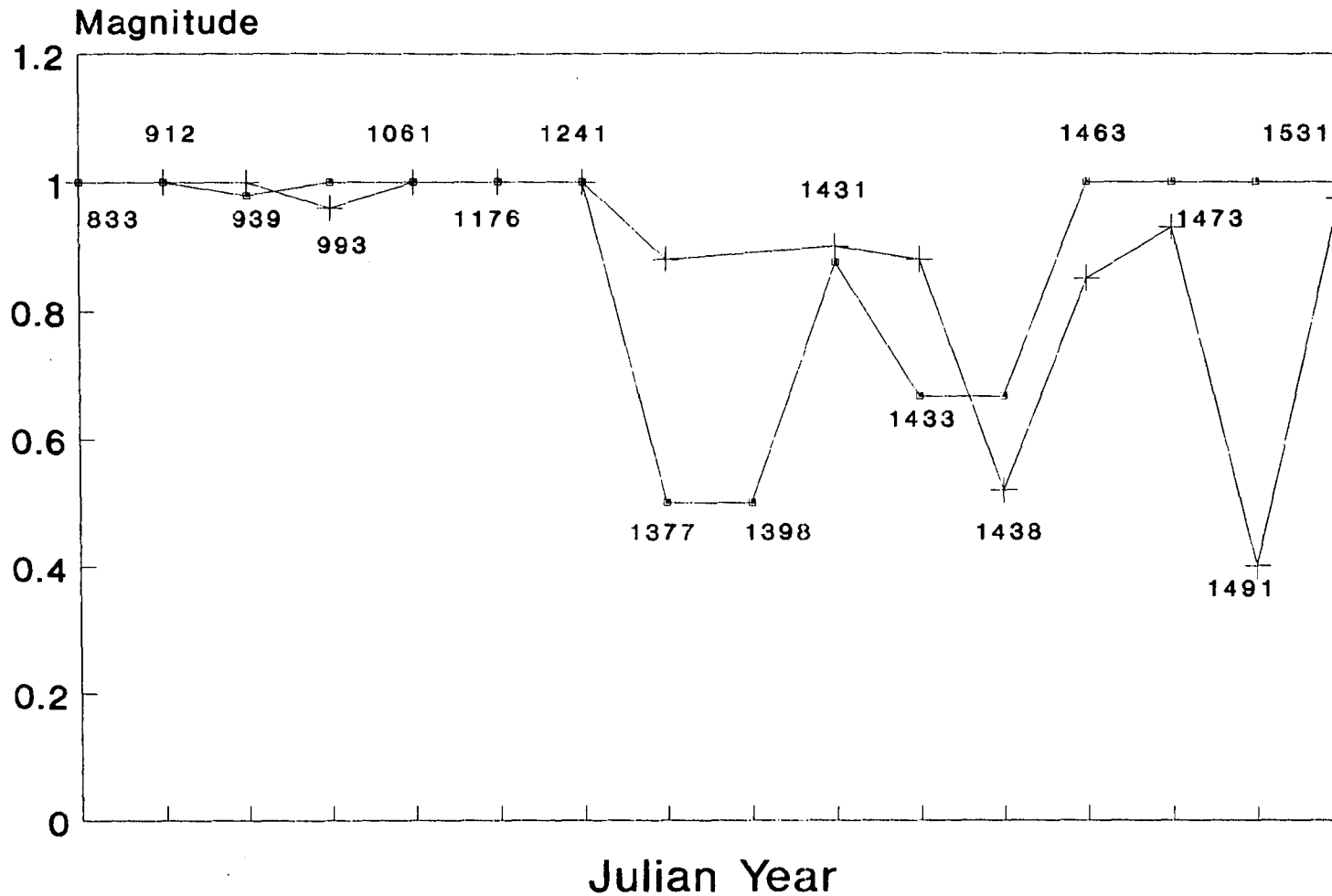
**Fig. (5.1):** Comparison between observed computed magnitude of solar eclipses as recorded in Arabic chronicles and the computed one.

```
-------------------------------------------------------------------------
  Julian Date    Plc.        Recorded Local Time
-------------------------------------------------------------------------

   833 Sep 17    Co?    Eclipsed before Zawal (i.e. noon)
   882 Aug 17    B      From time of SS; set eclipsed
   912 Jun 17    Co     Cleared 0.5h before SS
   939 Jul 19    T?     During forenoon
   939 Jul 19    Co?    From late forenoon

   993 Aug 20    C      Cleared at end of day
  1004 Jan 24    Co?    Began at 7th hour
  1061 Jun 20    B      From 2h after daybreak; for 4h and fraction
  1174 Nov 26    B      From SR to late forenoon
  1176 Apr 11    B      In forenoon for 1h

  1178 Sep 13    B      From afternoon to near SS
  1241 Oct 06    C      Lasted for 1h
  1376 Jul 17    C      After Zuhr prayer for about 40 deg
  1377 Jan 10    C      From Zuhr to after Asr prayer
  1386 Jan 01    C      Before MD to Asr prayer

  1386 Jan 01    D      After zawal
  1398 Nov 09    C      At SR for 1h
  1399 Oct 29    C      Before Asr prayer
  1419 Mar 26    C      Just before Zawal
  1431 Feb 12    G?     After MD

  1433 Jun 17    A      After Asr prayer to SS
  1433 Jun 17    C      Lasted for more than 1h after Asr prayer to S.
  1438 Sep 19    C      After MD
  1463 May 18    C      Lastd for 40 deg
  1467 Mar 06    C      Lasted for 30 deg

  1473 Apr 27    C      Lasted for 30 deg
  1491 May 08    C      Lasted for 30 deg
  1502 Oct 01    C      From SR for 1h
  1513 Mar 07    D      In afternoon for 13 deg
  1513 Mar 07    C      Lasted for 14 deg, about 1h; before Asr praye
-------------------------------------------------------------------------
```

Table (5.3): Description of the observed local time for solar
eclipses in medieval Arabic chronicles. SS, SR and MD are
abbreviated for sunset, sunrise and midday respectively.

137

| Julian Date | Plc. | Observed Local Time (Reduced) | Computed Local Time Beg. | End | Duration |
|---|---|---|---|---|---|
| 0833 Sep 17 | Co? | Beg <12.5 h | 08.45 | 11.15 | 2.7 |
| 0882 Aug 17 | B | Beg <18.75 h | 18.20 | - | - |
| 0912 Jun 17 | Co | End 19.5 h | 18.20 | - | - |
| 0939 Jul 19 | T? | Beg ~8.5 h | 06.15 | 08.20 | 2.05 |
| 0939 Jul 19 | Co? | Beg ~8.55 h | 06.10 | 08.15 | 2.05 |
| 0993 Aug 20 | C | End 18.6 h | 07.45 | 10.20 | 2.75 |
| 1004 Jan 24 | Co? | Beg 13.2 h | 12.55 | 14.50 | 1.95 |
| 1061 Jun 20 | B | 5.15 for 4 h | 06.35 | 08.50 | 2.15 |
| 1174 Nov 26 | B | 6.8 to 10.0 h | 07.30 | 10.15 | 2.85 |
| 1176 Apr 11 | B | ~9.1 for 1 h | 06.35 | 08.40 | 2.05 |
| 1178 Sep 13 | B | >12.0 to 8.25 h | 14.35 | 16.50 | 2.15 |
| 1241 Oct 06 | C | Lasted for 1 h | 13.50 | 16.15 | 2.65 |
| 1376 Jul 17 | C | >12.0 for 2.7 h | 07.15 | 10.25 | 3.1 |
| 1377 Jan 10 | C | 12.0 to >14.9 h | 13.00 | 15.25 | 2.25 |
| 1386 Jan 01 | C | <12.0 to 14.75 h | 11.10 | 14.00 | 2.9 |
| 1386 Jan 01 | D | Beg >11.25 h | 11.45 | 14.30 | 2.85 |
| 1398 Nov 09 | C | Beg 6.2 h | - | 07.35 | - |
| 1399 Oct 29 | C | Beg <14.7 h | 14.15 | 16.35 | 2.2 |
| 1419 Mar 26 | C | Beg <12.0 h | 10.15 | 13.55 | 3.4 |
| 1431 Feb 12 | G? | >12.0 h | 12.45 | 15.05 | 2.6 |
| 1433 Jun 17 | A | >15.0 to 18.4 h | 17.30 | 19.15 | 1.85 |
| 1433 Jun 17 | C | >16.45 to 19.0 h | 17.15 | 19.00 | 1.85 |
| 1438 Sep 19 | C | Beg 12.0 h | 12.50 | 15.35 | 2.85 |
| 1463 May 18 | C | Lasted for 2.7 h | 10.40 | 14.20 | 3.8 |
| 1467 Mar 06 | C | Lasted for 2.0 h | 06.45 | 07.45 | 1.0 |
| 1473 Apr 27 | C | Lasted for 2 h | 06.00 | 08.30 | 2.7 |
| 1491 May 08 | C | Lasted for 2 h | 16.00 | 18.05 | 2.05 |
| 1502 Oct 01 | C | Beg 5.75 for 1 h | 08.10 | 11.00 | 2.9 |
| 1513 Mar 07 | D | ~11.35 for 0.87 h | 14.15 | 16.45 | 2.3 |
| 1513 Mar 07 | C | <14.4 for 0.93 h | 13.45 | 16.25 | 2.8 |

Table (5.4): Comparison between computed and observed local times of solar eclipses in medieval Arabic chronicles. The signs > and < here mean after and before respectively. The time of forenoon is calculated as the average of the time of sunrise and the time of transit (*Zawal*).

## 5.6 Discussion of individual solar eclipses

In each case the computed date is given in the heading. After the text is cited, observation is compared with computation. All times are given in hours and decimals.

**(1) AD.833 Sep 17 = 28 Shaban AH.218**

Cordoba?

" In this year (AH.218) there was the great solar eclipse in which the Sun was obscured and darkness appeared. That was before the Sun reached the meridian at the end of the month Ramadan " (*Ibn Idhari, Vol.2*).

There is an error in the recorded month; the eclipse actually occurred in the previous month, Shaban. It was a total eclipse, which according to computation lasted for about three minutes, and reached its height at 9.55 am. The full duration was 2.7 hours, the eclipse beginning at 8.45 am.

**(2) AD.882 Aug 17 = 28 Muharram AH.269**

Baghdad

"In the month Muharram in this year (AH.269), the Sun was eclipsed at the time of sunset on Friday, when two nights remained of the month Muharram, and set eclipsed". (*al-Tabari, Vol.9*).

Three similar accounts mentioning only the month are given by *Ibn al-Jawzi, Vol.5; Ibn al-Athir, Vol.6* and *al-suyuti, Vol.2*. According to computation, this eclipse occurred on 28 of the month Muharram. The Sun would begin to be eclipsed at 18.2 pm, only 15 minutes before sunset.

**(3) AD.903 June 27 = 28 Rajab AH.290**

Cordoba

" In this year (AH.290), the Sun was eclipsed in Cordoba and its vicinity on Wednesday, when one night remained in the month Dhu al-Hijjh ". *(Ibn Hayyan, Vol.3)*.

The month and the week-day are wrong. No such eclipse occurred on or near this day. The calculated date of the only solar eclipse which was large in Spain for several years around this time is AD.903 June 27. This was equivalent to Monday, 28 Rajab AH.290. Hence only the year is correct. The eclipse began at 18.00, and the Sun set eclipsed. The maximum magnitude was 0.93.

**(4) AD.912 June 17 = 28 Shawwal AH.299**

Cordoba

" In this year (AH.299), the Sun was eclipsed and it disappeared totally on Wednesday when one night remained in the month Shawwal. The stars appeared and darkness covered the horizon. Thinking it was sunset, most of the people went for the sunset *(Maghrib)* prayer. afterwards, the darkness cleared and the Sun appeared for half an hour and then set ". *(Ibn Hayyan, Vol.3)*.

A similar account was given by *Ibn Idhari, Vol.2*. The Sun would be totally obscured for about two minutes at 19.10, only 15 minutes before sunset, in close accord to observation.

**(5) AD.939 July 19 = 28 Ramadan AH.327**

(a)Toledo? (b)Cordoba?

This solar eclipse is recorded by the chronicler of Spain (al-Andalus), *Ibn Hayyan* in the fifth volume of his chronicle *al-Muqtabis*. He quoted his reports from *al-Razi* (AD.888-926) and *al-Mas'udi* (AD.900-956). Both records are as follows:

(a) " During the forenoon of that day (i.e. Friday), the Sun was eclipsed totally and its disk became dark except for a slight portion of it as seen by the eye " (quoted from *al-Razi*).

(b) " At the end of the month Ramadan, the Sun was eclipsed on Friday in the late forenoon (great *Duha*), when two nights remained in the month Ramadan " (quoted from *al-Mas'udi*).

Both texts are agree that the eclipse occurred on the last Friday in the month Ramadan, but they differ by one day in the day of the month. Computation shows that the eclipse began in Toledo at 6.15 am, and became completely obscured for 3.75 minutes. So, *al-Razi* had mistaken the magnitude of the eclipse unless there is an error in the place of observation. The beginning of eclipse was rather early in the day for late forenoon (great *Duha*) as mentioned in the second account.

(6) AD.993 Aug 20 = 28 Jumada II AH.383

Alexandria

" In this year (AH.383) the Sun was eclipsed totally at the end of the month Jumada II. It was so dark that stars

appeared and people could not see palms of their hands. The eclipse cleared at the end of the day ". (al-Maqrizi, Vol.1).

At Cairo, the computed magnitude of the eclipse was 0.96 at 9.00 am, but from the vicinity of Alexandria the Sun would be completely obscured, which would caused the intense darkness as mentioned in the text. The chronicler made serious error in stating that the eclipse ended at the end of the day-i.e. about 18.55. According to calculation the Sun should have cleared at 10.20 am., much earlier than the recorded time. In Egypt, this eclipse would only be total at the vicinity of Alexandria and the record of al-Maqrizi (from Cairo) possibly relates to an observation from that place.

(7) AD.1004 Jan 24 = 28 Rabi I AH.394

Cordoba?

" In this year (AH.394), there was a solar eclipse at the 7th hour, on Monday, when one night remained in the month Rabi I ". (Ibn Idhari, Vol.3).

This eclipse lasted for nearly two hours, it began at 12.55 pm in Cordoba. So, the time of eclipse the 7th hour (if after sunrise) is approximately correct. Although the magnitude was small -0.3- Ibn Idhari stated that the eclipse was noticed throughout Spain (al-Andalus).

(8) AD.1061 Jun 20 = 28/29 Jumada I AH.453

Baghdad

" On Wednesday, when two nights remained in the month Jumada I, two hours after daybreak, the Sun was eclipsed totally. There was darkness and the birds fell whilst flying. The astrologers claimed that one-sixth of the Sun should have remained but nothing of it did so. The Sun reappeared after four hours and a fraction (of an hour). The eclipse was not in the whole of the Sun (not total) in places other than Baghdad and its provinces ". *(Ibn al-Jawzi,Vol.8)*.

This account also recorded by *Ibn al-Athir* of Mosel, Vol.8 and *al-Suyuti* of Cairo, Vol.2. In Baghdad, the eclipse began at 6.35 am, and it became total at 7.4 am, two hours and 50 minutes after sunrise. The time of mid-eclipse in the text is not accurate . The duration of totality was about 3.75 minutes.

(9) AD.1174 Nov 26 = 28 Rabi II AH.570

Baghdad

" The Sun was eclipsed at sunrise on Tuesday the 28th of Rabi II. It remained like this until late forenoon (great *Duha*) ". *(Ibn al-Jawzi, Vol.10)*. 

This eclipse was almost total at magnitude 0.91 at 8.45 am. It lasted about two hours and a half.

(10) AD.1176 Apr 11 = 28/29 Ramadan AH.571

(a) Cizre, (b) Baghdad and (c) Orontes river.

(a) "At forenoon of Friday the 29th of the month Ramadan, the Sun was eclipsed totally and the Earth was in

darkness so that it was like a dark night and the stars appeared. That was at Jazirat (Island of) Ibn Umar". *(Ibn al-Athir, Vol.9)*.

Although *Ibn al-Athir* was an eyewitness of this eclipse, he had mistaken the day of the week which was actually Sunday. This eclipse lasted for about 3 minutes. The Sun was completely obscured.

(b) "In the forenoon of Friday the 27th of the month Ramadan, the Sun was eclipsed for an hour then reappeared". *(Ibn al-Jawzi, Vol.10)*.

In this text, both the day of the week and the month are incorrect. The eclipse was almost total. The magnitude was 0.92 at 7.40 am. The calculated full duration is about two hours, but *Ibn al-Jawzi* may be referring only to its more obvious phases.

(c) " (In the year AH.570) in the last days of the month Shawwal, I remember we crossed the river Orontes *(al-Asi)* on our return (from Hama to Damascus). The Sun was eclipsed and it became dark in the day time. People were frightened and stars appeared ". *{Abu Shamh, Vol.1)*.

*Abu Shamh* quoted this report from *al-Katib al-Asfahani* who accompanied the Sultan Saladin in his campaigns from Hamah to Damascus. He had mistaken both the year and month which were actually AH.571, the month Ramadan. the eclipse would be total for rather more than two minutes at 7.05 am. The total duration of the eclipse was 2 hours.

(11) AD.1178 Sep 13 = 28 Rabi I AH.574

Baghdad

" The Sun was eclipsed on Wednesday the 29th of Rabi I in the afternoon and stayed like this until near sunset ". (Ibn al-Jawzi, Vol.10).

The time of the ending of the eclipse is not accurate. From the calculation the eclipse would end more than an hour before sunset, 16.5. The magnitude was 0.82 at 15.4.

(12) AD.1241 Oct 6 = 28 Rabi I AH.639

Cairo

" On Sunday. 29th of Rabi I, The whole body of the Sun was eclipsed. There was darkness and the stars appeared and the people lit lamps in the daytime ". (al-Maqrizi, al-Suluk, Vol.1).

The correct day of the week was given, but the eclipse occurred on the 28th of Rabi I not on the 29th as al-Maqrizi mentioned. The eclipse was completely total at 15.05, and lasted for about 3 minutes. A more detailed description is to be found in a contemporary work, the Synaxarium Alexandrinum (I. Forget, editor, Louvain, 1963) a Coptic religious year book. The duration of darkness as mentioned in that book was " one hour -from the middle of the 8th to the middle of the 9th- hour"; this is much exaggerated.

(13) AD.1376 July 17 = 28/29 Safar AH.778

Cairo

" On Saturday, the 28th of Safar, the Sun was eclipsed after the noon (Zuhr) prayer and continued eclipsed for about 40 degrees (2h 40m) ". (Ibn Iyas., Vol.1).

From calculation, this eclipse would be fully annular in Cairo at magnitude 0.95 and lasted for about four minutes. The time of eclipse in the text is incorrect; it began at 7.15 am, not afternoon, and ended at 10.25 am.

(14) AD.1377 Jan 10 = 28 Shaban AH.778

Cairo

" In the month Shaban this year (AH.778), both the Sun and the Moon were eclipsed (for lunar eclipse see next chapter). The Sun was eclipsed by more than half between the noon (Zuhr) and the afternoon (Asr) prayers on Saturday the 28th and continued (eclipsed) until after the afternoon Asr) prayer. The people prayed the solar eclipse prayer but not the lunar one ". (al-Asqalani, Vol.1).

The time of the beginning and the ending of the eclipse in the above account are fairly accurate. At Cairo the eclipse began at 13.00, and ended at 15.25. So, the full duration was 2.25 hours. The magnitude of this eclipse was 0.88 at 14.2.

(15) AD.1386 Jan 1 = 28 Dhu al-Qa'da AH.787
(a)Cairo and (b)Damascus

(a) "On the 28th of the month Dhu al-Qa'da, the Sun was eclipsed from before middy to the afternoon (Asr) prayer". (al-Maqrizi, al-Suluk, Vol.3).

This eclipse was also recorded by the later chronicler *Ibn Iyas.* who omitted the day and mentioned the previous month, Shawwal. Also he stated that the eclipse occurred between after *Zuhr* and *Maghrib* prayer. The full duration of this eclipse in Cairo was about 3 hours, and the magnitude was 0.8 at 12.35 pm.

(b) " In the month Dhu al-Qa'da, the Sun was eclipsed after it reached the meridian ". *(Ibn Qadi Shuhuba, Vol.1).*

The recorded time of the beginning of the eclipse is in tolerable accord with the calculation. The eclipse began at 11.45 am, and ended at 14.30. It reached maximum obscuration, 0.84, at 13.05.

(16) AD.1398 Nov 9 = 28 Safar AH.801

Cairo

" On the month Safar, the Sun was eclipsed at sunrise and most of the people did not notice this because about half of it was eclipsed. It cleared quickly and according to what the astronomers said, the eclipse lasted for one hour. No eclipse prayer was performed because few people noticed it ". *(al-Asqalani, Vol.4).*

According to computation, the Sun did not rise at Cairo until after the maximum had passed. The obscuration ended at 7.35 am.

(17) AD.1399 Oct 29 = 28 Safar AH.802

(a) Cairo and (b) Damascus

(a) " On Wednesday the 28th of the month Safar, the Sun was eclipsed before the afternoon (Asr) prayer ". (al-Maqrizi, al-Suluk, Vol.3).

The same report is given by Ibn Iyas., Vol.1; presumably he derived his report from al-Maqrizi. The week-day is correct according to the crescent visibility. At Cairo 50 per cent of the Sun was obscured at 15.30.

(b) " On the 28th of the month Safar, the Sun was eclipsed and the eclipse prayer was held in Damascus after the afternoon (Asr) prayer ". (al-Asqalani, Vol.4).

The magnitude of the eclipse was 0.55 and the full duration was approximately as same as that of Cairo.

(18) AD.1419 Mar 26 = 28/29 Safar AH.822

Cairo

" On the 29th of the month Safar, the Sun was eclipsed just before it reached the meridian ". (al-Maqrizi, al-Suluk, Vol.4).

This is an eyewitness account by al-Maqrizi, also there is another record by al-Asqalani who himself led the people in the eclipse prayer and delivered two addresses (khutba) but he wrongly mentioned the following month Rabi I. The later chronicler, Ibn Iyas. recorded this event from the above account. The magnitude was 0.88 at 12.05 pm, the eclipse began at 10.15 am, and ended at 13.55.

(19) AD.1431 Feb 12 = 28 Jumada I AH.834

Cordoba?

" The news arrived from Spain (al-Andalus) of the occurrence of an eclipse there covering all of the Sun's body except one-eighth of it. That was after midday on the 28th of the month (Jumada II) ". *(al-Maqrizi, al-Suluk, Vol.4).*

There are another two similar accounts about this eclipse by *al-asqalani, Vol.8* and *Ibn Iyas., Vol.2.* The correct month of occurrence is Jumada I (as mentioned by *al-Asqalani*) rather than the following month. It started at 12.45 pm, and ended at 15.05. The calculated magnitude, 0.9, is in good agreement with the recorded one.

(20) AD.1433 Jun 17 = 28 Shawwal AH.836

(a)Aleppo and (b)Cairo

(a) " On the 28th of the month Shawwal, the Sun was eclipsed after the afternoon (*Asr*) prayer and continued until the time of sunset. It cleared up after the conclusion of the eclipse prayer ". *(al-Asqalani, Vol.8)*

This eclipse was recorded also by the much later chronicler *Ibn al-Imad, Vol.7.* The date of this eclipse as recorded in the text is correct. The magnitude of it was 0.99, almost total, at 18.25, and the end of occurred at 19.15 when the altitude of the Sun was only about 0.5 degree above the visible horizon. This confirms the report of *Ibn al-Imad* "It cleared completely just before sunset".

(b) " On Wednesday the 28th of the month Shawwal, the Sun was eclipsed by about two-thirds in Cancer, more than one hour after the afternoon (Asr) prayer. The eclipse cleared at sunset. During the eclipse there was darkness and some stars appeared ". (al-Maqrizi, al-Suluk, Vol.4)

Ibn Iyas , Vol.2. reported this eclipse briefly. The eclipse began at 17.15 for 1.85 hour, reaching its maximum magnitude - 0.88 - at 18.20. The description that the stars appeared is exaggerated because the obscured part of the Sun disk was not large. The stars might well have appeared in the first eclipse at Aleppo since the magnitude was so great.

(21) AD.1438 Sep 19 = 28 Rabi I AH.842

Cairo

" On Friday the 28th of the month Rabi I , The Sun was eclipsed by about two- thirds after midday. The Earth and objects on it became yellowish until it cleared ". (al-Maqrizi, al-Suluk, Vol.4)

This was also chronicled by Ibn Iyas., Vol.2, who mentioned that "people prayed ⟨the eclipse prayer at al-Azhar (mosque) and other mosques". The computed magnitude is 0.52 at 14.20. It began at 12.50 pm, and ended at 15.35.

(22) AD.1463 May 18 = 28 Shaban AH.867

Cairo

" In the month Shaban, the Sun was eclipsed totally and there was darkness. The eclipse lasted for about 40 degrees ". (Ibn Iyas , Vol.2).

From calculation the day of occurrence was 28th of the month Shaban. This eclipse was generally annular on the Earth's surface, and it was partial in Cairo of magnitude 0.85 at 12.30 pm. The chronicler described this eclipse wrongly as a total one.

**(23) AD.1467 Mar 6 = 28/29 Rajab AH.871**

Cairo

" In the month Rajab, the Sun was eclipsed and continued in eclipse for about thirty degrees ". (Ibn Iyas , Vol.2).

The eclipse started at 6.45 am, and ended one hour later. So, the given duration in the text is incorrect. The magnitude was 0.12 at 7.15 am, a very small phase.

**(24) AD.1473 Apr 27 = 28/29 Dhu al-Qa'da AH.877**

Cairo

" In this month (Dhu al-Qa'da), the Sun was eclipsed generally and there was darkness. It continued eclipsed for about thirty degrees ". (Ibn Iyas , Vol.3).

This eclipse was annular according to calculation at magnitude of 0.93 at 7.10 am. It began at 6.00 am, and lasted for 2.5 hours. more than the recorded one which was 30 degrees, i.e. two hours. The term "generally"

could indicate that all of the central part of the Sun was covered or possibly that the eclipse was seen at a variety of locations (Said and Stephenson, 1991).

(25) AD.1491 May 8 = 28 Jumada II AH.896

Cairo

" In the month Jumada II, the Sun was eclipsed totally. It stayed eclipsed for about 30 degrees ". (Ibn Iyas , Vol.3).

This was a partial eclipse - not total as mentioned in the text - as seen from Cairo of magnitude 0.4 at 17.00. The full duration for the eclipse was very close to computed one in which the eclipse began at 16.00 and ended at 18.05.

(26) AD.1502 Oct 1 = 28 Rabi I AH.908

Cairo

" In the month Rabi II, the Sun was eclipsed at sunrise and stayed like this for an hour until it cleared ". (Ibn Iyas , Vol.4).

The recorded month is incorrect, it should be the preceding month Rabi I. The beginning of the eclipse is not accurate too, for the calculated beginning is 8.10 am, about two hours after sunrise. The maximum phase of 0.55 was at 9.30 am, and the full duration of the eclipse was 2.9 hours.

(27) AD.1513 Mar 7 = 28 Dhu al-Hijjh

(a)Damascus and (b)Cairo

(a) " In the afternoon time of Monday the 29th of Dhu al-Hijjh, the Sun was eclipsed for 13 degrees. There was darkness and some shopkeepers lit the lamps in their shops. In the mean time there were clouds ". *(Ibn Tulun, Mufakahat al-Khullan, Vol.1)*.

The day of the week is correct, but the date 29th should be the previous one. The calculated beginning is 14.15 for two and a half hours, much greater than the recorded duration which is 13 degrees i.e. 52 minutes.

(b) " On Monday the 28th of the month Dhu al-Hijjh, the Sun was largely eclipsed for 14 degrees before the afternoon *(Asr)* prayer, and it stayed eclipsed for about an hour ". *(Ibn Iyas , Vol.4)*.

The recorded date is correct, but the chronicler had mistaken in the recording the full duration which is 14 degrees i.e. 56 minutes, whereas the calculated duration is 2.8 hours, much larger than that asserted by *Ibn Iyas*. The maximum phase was 0.91 at 15.05.

## 5.7 Conclusion

It is obvious from the above translated records that in general the agreement between observations and calculations is fairly good both for the magnitudes and the time of occurrence. There are two records with serious error in dating the eclipse: AD.903 (about 5 months later than the computed) and AD.1176 of Orontes river in which the year and the month are incorrect. However, the week-day is usually in exact accord with the calculated one. About

20% of the recorded solar eclipses are of value in the study of the rotation of the Earth and the determination of the Earth's rotational clock error T. These clearly affirm that the Sun was completely obscured at carefully specified location - namely AD.912, 1061, 1176 and 1241.

# 6 INVESTIGATION OF LUNAR ECLIPSES OBSERVATIONS

## 6.1 Introduction

Lunar eclipses occur at full Moon. The Moon enters the shadow of the Earth on average once or twice in each year either partially when a part of the Moon enters the umbra or totally when the Moon is completely immersed in it. Penumbral eclipses are usually unnoticed even by astronomers. A lunar eclipse may be observed by anyone who can see the Moon at the time. So, this phenomenon tends to be visible more often than a solar eclipse.

The full duration of a lunar eclipse may be as much as about four hours (from the time of starting to enter umbra until it leaves it) if it passes through the centre of the shadow. Thus, it is not unusual for the Moon to be seen to set or rise whilst eclipsed, as occurred in both AD.882 and 951, for example.

## 6.2 Description of lunar eclipses in Arabic chronicles.

About 60 lunar eclipses are recorded in the accessible Arabic chronicles. In this chapter each eclipse is discussed individually while a summary is given in table (6.1). Most of the accounts are short. As for solar eclipses, chroniclers often estimated the local times of lunar eclipses relative to the Islamic prayer times or relative to midnight. In table (6.3) the recorded local times of lunar eclipses are summarized, and the reduced times are compared with computed ones in table (6.4).

*Ibn Iyas* (1448-1524) himself recorded 19 lunar eclipses which occurred during his life. As was his habit for solar eclipses, he recorded the durations of lunar eclipses in degrees with fair precision, see figure (6.1).

The usual color for the totally eclipsed Moon is coppery red. This is due to Sun light refracted by the Earth's atmosphere. Red light more easily penetrates the Earth's atmosphere because of its longer wavelength. However, the darkness of a lunar eclipse depends upon weather conditions of the Earth's atmosphere and whether there is any volcanic dust in the stratosphere. There is no indication of a reddish color during any total lunar eclipse in Arabic chronicles, except that of AD.1256 which was recorded by *Ibn Taghribardi*; on that occasion the Moon became very reddish. In contrast, darkness is sometimes said to have occurred during total a lunar eclipse, see table (6.2).

The magnitude of a total lunar eclipse can range from 1 up to maximum of about 1.87; this is of course due to large shadow cone which is formed by the Earth. In table (6.1) eleven of the eclipses were partial according to computation. However, only two of them were actually recorded by the chroniclers as partial; these are as follows:

(1) AD.1422 " the Moon was almost fully eclipsed " this is closely supported by calculations which indicate a magnitude of 0.99.

| Recorded Lunar Eclipse | | | Computed Lunar Eclipse | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Julian Date | Plc. | Ref. | Beg. | Max. | End | Mag. |
| 867 Nov 15 | D | 13 | 17.7 | 18.4 | 21.1 | 1.22 |
| 882 Aug 03 | B | 1,6,7,19 | 03.3 | 05.1 | - | 1.43 |
| 893 Dec 26 | Du | 1,6,7 | 21.3 | 23.0 | 24.7 | 1.26 |
| 936 Mar 11 | Mo | 7 | 01.7 | 03.6 | 05.5 | 1.06 |
| 936 Sep 04 | Mo | 7 | 02.9 | 04.7 | - | 1.13 |
| 939 Dec 29 | Mo | 7 | 04.7 | 06.5 | - | 1.20 |
| 940 Dec 17 | B | 5 | 15.9 | 17.7 | 19.4 | 1.23 |
| 951 May 24 | Mo | 7 | - | 20.8 | 22.6 | 1.85 |
| 962 Apr 23 | Mo | 7 | 18.7 | 20.7 | 22.7 | 1.47 |
| 965 Feb 19 | B | 6 | - | 18.3 | 20.1 | 1.12 |
| 966 Aug 04 | B | 6,7 | 03.3 | 05.2 | | 1.20 |
| 969 Jun 03 | Mo | 7 | 02.3 | 04.2 | - | 1.80 |
| 1117 Jun 16 | Mo | 7 | 01.9 | 03.7 | 04.8 | 1.22 |
| 1178 Aug 30 | B | 6,7 | 03.7 | 05.1 | - | 0.47 |
| 1226 Feb 14 | Mo | 7 | 02.5 | 04.5 | - | 1.76 |
| 1256 Jul 09 | C | 17 | 08.1 | 09.0 | 09.8 | 0.20 |
| 1309 Aug 22 | C | 14 | 22.1 | 00.0 | 02.0 | 1.67 |
| 1324 May 10 | C | 14 | - | 19.5 | 21.3 | 1.17 |
| 1371 Oct 25 | C | 16 | 20.1 | 21.9 | 23.6 | 1.16 |
| 1376 Jul 31 | C | 20 | 15.4 | 17.1 | 18.9 | 0.66 |
| 1377 Dec 16 | C | 16,19,20 | - | 17.6 | 19.6 | 1.27 |
| 1386 Jan 16 | C | 18,20 | 04.3 | 06.1 | - | 0.86 |
| 1396 Jun 21 | C | 16 | 22.1 | 23.9 | 01.8 | 1.72 |
| 1399 Apr 21 | C | 20 | 20.1 | 21.9 | 23.7 | 1.12 |
| 1399 Apr 21 | D | 16 | 20.5 | 22.2 | 23.9 | 1.12 |
| 1400 Oct 04 | D | 16 | .... | - | 19.1 | - |
| 1403 Aug 03 | C | 16,20 | 22.8 | 00.6 | 02.4 | 1.57 |
| 1406 Jun 02 | C | 16,20 | 01.2 | 02.8 | 04.4 | 0.77 |
| 1407 May 22 | C | 20 | 01.3 | 03.4 | - | 1.50 |
| 1414 Dec 27 | C | 16 | 17.1 | 18.6 | 20.1 | 1.15 |
| 1421 Feb 17 | C | 20 | 19.9 | 21.8 | 23.7 | 1.42 |
| 1422 Aug 02 | C | 16 | 23.8 | 01.3 | 02.9 | 0.99 |
| 1425 Nov 26 | C | 20 | 21.9 | 23.7 | 01.4 | 1.21 |
| 1429 Mar 21 | C | 16 | 23.2 | 00.9 | 02.7 | 1.08 |
| 1433 Jan 06 | C | 16,20 | 01.7 | 03.5 | 05.3 | 1.16 |
| 1433 Jul 03 | A | 16 | - | 19.9 | 21.4 | 0.52 |
| 1433 Jul 03 | C | 14 | - | 19.3 | 20.5 | 0.52 |
| 1460 Jul 03 | C | 20 | 21.0 | 22.1 | 23.1 | 0.28 |
| 1461 Jun 23 | C | 20 | 20.7 | 22.7 | 00.8 | 1.69 |

| Julian Date | Plc. | Ref. | Beg. | Max. | End | Mag. |
|---|---|---|---|---|---|---|
| 1462 Jun 12 | C | 20 | 02.6 | 04.0 | 05.4 | 0.59 |
| 1465 Oct 04 | C | 20 | - | 18.6 | 20.5 | 1.40 |
| 1468 Aug 04 | C | 20 | 02.1 | 04.0 | - | 1.45 |
| 1471 Nov 28 | C | 20 | 21.0 | 22.8 | 00.7 | 1.14 |
| 1476 Mar 11 | C | 20 | 18.4 | 20.7 | 22.2 | 1.12 |
| 1482 Oct 26 | C | 20 | 17.1 | 18.8 | 20.4 | 0.89 |
| 1483 Oct 16 | C | 20 | 01.0 | 02.9 | 04.8 | 1.45 |
| 1486 Feb 18 | C | 20 | 17.1 | 18.9 | 20.6 | 1.15 |
| 1487 Feb 08 | C | 20 | 03.4 | 05.1 | - | 1.23 |
| 1490 Jan 03 | C | 20 | 22.0 | 23.9 | 01.7 | 1.85 |
| 1493 Apr 02 | C | 20 | 01.6 | 03.5 | 05.4 | 1.10 |
| 1494 Mar 22 | C | 20 | 01.6 | 03.6 | 05.5 | 1.21 |
| 1500 Nov 06 | C | 20 | 01.2 | 02.8 | 04.4 | 0.86 |
| 1502 Oct 16 | C | 20 | 00.4 | 01.5 | 02.5 | 0.28 |
| 1504 Mar 01 | C | 20 | 00.8 | 02.6 | 04.4 | 1.10 |
| 1505 Aug 15 | C | 20 | 20.2 | 22.1 | 00.0 | 1.08 |
| 1509 Jun 02 | C | 20 | 23.2 | 0.55 | 01.9 | 0.63 |
| 1511 Oct 06 | C | 20 | 23.1 | 00.7 | 02.3 | 1.05 |
| 1516 Jul 14 | C | 20 | 23.1 | 00.9 | 02.7 | 1.04 |
| 1516 Jul 14 | D | 21 | 23.5 | 01.2 | 03.0 | 1.04 |
| 1518 May 25 | C | 20 | 23.2 | 00.8 | 02.3 | 0.76 |
| 1519 Nov 07 | C | 20 | 17.8 | 19.7 | 21.5 | 1.52 |
| 1520 May 03 | C | 20 | 20.4 | 21.3 | 22.3 | 0.12 |

Table (6.1): Summary of the recorded lunar eclipses in the consulted medieval Arabic chronicles. The computed local times are given for each eclipse. A sign (-) means that the Moon set or rose eclipsed. In AD.1400, the total phase was not visible from the Damascus. All the names of the places and the references are abbreviated according to the tables (1.5) and (2.1).

```
----------------------------------------------------------------
Julian Date    Plc.        Observed Magnitude              Comp. Mag
----------------------------------------------------------------

 867 Nov 15     D    Most of it disappeared with obscurity   1.22
 936 Mar 11     Mo   Total                                   1.06
 936 Sep 04     Mo   Total                                   1.13
 939 Dec 29     Mo   Total                                   1.20
 940 Dec 17     B    Total                                   1.23

 951 May 24     Mo   Total                                   1.85
 962 Apr 23     Mo   Total                                   1.47
 965 Feb 19     B    Total                                   1.12
 966 Aug 04     B    Total                                   1.20
 969 Jun 03     Mo   Total                                   1.80

1117 Jun 16     B    Total                                   1.22
1256 Jul 09     C    Reddish                                 0.20
1309 Aug 22     C    Total                                   1.67
1324 May 10     C    Covered by blackness                    1.17
1396 Jun 21     C    With darkness                           1.72

1399 Apr 21     C    Total                                   1.12
1399 Apr 21     D    Total                                   1.12
1403 Aug 03     C    Total, its light completely disappeared 1.57
1407 May 22     C    Total                                   1.50
1422 Aug 02     C    Almost fully eclipsed                   0.99

1425 Nov 26     C    Total                                   1.21
1429 Mar 21     C    Almost unnoticed                        1.08
1433 Jan 06     C    Total                                   1.16
1433 Jul 03     C    Most of it was eclipsed                 0.52
1460 Jul 03     C    Total                                   0.28

1461 Jun 23     C    with very darkness                      1.69
1468 Aug 04     C    Total, with darkness                    1.45
1471 Nov 28     C    Total                                   1.14
1476 Mar 11     C    Total, with darkness                    1.12
1483 Oct 16     C    Total, with darkness                    1.45

1486 Feb 18     C    With darkness                           1.15
1487 Feb 08     C    With darkness                           1.23
1493 Apr 02     C    Total                                   1.10
1494 Mar 22     C    Total, with darkness                    1.21
1500 Nov 06     C    Total                                   0.86

1505 Aug 15     C    Greatly eclipsed                        1.08
1511 Oct 06     C    Greatly eclipsed, with darkness         1.05
1516 Jul 14     C    Greatly eclipsed, with darkness         1.04
1519 Nov 07     C    Greatly eclipsed, with dakrness         0.52
1520 May 03     C    With darkness                           0.12
----------------------------------------------------------------
```

Table (6.2): Comparison between the observed and computed magnitude of some lunar eclipses which were recorded in consulted medieval Arabic chronicles.

```
--------------------------------------------------------------------
  Julian Date      Plc.    Observed Local Time
--------------------------------------------------------------------

   882 Aug 03       B      Set eclipsed
   893 Dec 26       Du     Cleared at end of night
   951 May 24       Mo     Rose eclipsed
   966 Aug 04       B      Set eclipsed
   969 Jun 03       Mo     Set eclipsed

  1178 Aug 30       B      From last 1/3 of night to MR
  1256 Jul 10       Mo     From beginning of night
  1324 May 10       C      Rose eclipsed
  1371 Oct 25       C      Ended at Fajr
  1377 Dec 16       C      Rose eclipsed to before SS

  1386 Jan 16       C      From end of night
  1396 Jun 22       C      From after Isha
  1399 Apr 21       C      After Isha prayer to MN
  1400 Oct 04       D      Rose eclipsed to end of twilight
  1406 Jun 02       C      End after Fajr prayer

  1414 Dec 27       C      For 4 hour
  1422 Aug 02       C      Before MN to Fajr
  1425 Nov 26       C      For 12 deg.
  1433 Jan 06       C      For 3 hour
  1433 Jul 03       C      Rose eclipsed to Isha

  1462 Jun 12       C      Ended near Fajr
  1465 Oct 04       C      For 40 deg.
  1468 Aug 04       C      Until near end of night
  1476 Mar 11       C      For 40 deg.
  1482 Oct 26       C      For 50 deg.

  1483 Oct 16       C      For 50 deg.
  1486 Feb 18       C      For 50 deg.
  1487 Feb 08       C      For 50 deg.
  1490 Jan 03       C      For 40 deg.
  1494 Mar 22       C      For 30 deg.

  1500 Nov 05       C      Until near Fajr
  1504 Mar 01       C      For 20 deg.
  1505 Aug 15       C      Until end of night
  1509 Jun 02       C      For 41 deg.
  1511 Oct 06       C      For 50 deg.

  1516 Jul 14       C      For more than 50 deg.
  1516 Jul 14       D      From when Moon in mid-sky
  1518 May 25       C      For 48 deg.
  1519 Nov 07       C      For more than 40 deg.
  1520 May 03       C      For 1 hour
--------------------------------------------------------------------
```

Table (6.3): Observed local time of lunar eclipses in medieval Arabic chronicles. SS, MN and MR indicate to sunset, midnight and moonrise respectively.

160

| Julian Date | Plc. | Observed Local Time (Reduced) | Computed Local Time Beg. | End | Duration |
|---|---|---|---|---|---|
| 882 Aug 03 | B | End (5.33) | 03.3 | (5.2) | 1.9 |
| 893 Dec 26 | Du | End 5.75 | 21.3 | 23.0 | 1.7 |
| 951 May 24 | Mo | Beg (20.22) | (19.1) | 22.6 | - |
| 966 Aug 04 | B | End (5.38) | 03.3 | (5.3) | - |
| 969 Jun 03 | Mo | End (4.87) | 02.3 | (4.8) | - |
| 1178 Aug 30 | B | >1.43 to (5.65) | 03.7 | (5.7) | - |
| 1256 Jul 10 | Mo | Beg 19.35 | 08.1 | 09.8 | 1.7 |
| 1324 May 10 | C | Beg 19.62 | (18.8) | 21.3 | - |
| 1371 Oct 25 | C | End 4.57 | 20.1 | 23.6 | 3.5 |
| 1377 Dec 16 | C | 17.9 to <16.88 | (17.0) | 19.6 | - |
| 1386 Jan 16 | C | Beg ~5.25 | 04.3 | (6.8) | - |
| 1396 Jun 22 | C | >20.68 | 22.1 | 01.8 | 3.7 |
| 1399 Apr 21 | C | >19.90 to 24.0 | 20.5 | 23.7 | 3.2 |
| 1400 Oct 04 | D | 17.63 to 18.63 | .... | 19.1 | - |
| 1406 Jun 02 | C | End >3.15 | 01.2 | 04.4 | 3.2 |
| 1414 Dec 27 | C | For 4 hr. | 17.1 | 20.1 | 3.0 |
| 1422 Aug 02 | C | <24.0 to 3.50 | 23.8 | 02.9 | 3.1 |
| 1425 Nov 26 | C | For 0.8 hr. | 21.9 | 01.4 | 3.5 |
| 1433 Jan 06 | C | For 3 hr. | 01.7 | 05.3 | 3.6 |
| 1433 Jul 03 | C | (19.5) to 20.68 | (18.9) | 21.0 | - |
| 1462 Jun 12 | C | End ~3.0 | 02.6 | 05.4 | 2.8 |
| 1465 Oct 04 | C | For 2.70 hr. | (17.7) | 20.5 | - |
| 1468 Aug 04 | C | End ~3.55 | 02.1 | (5.5) | - |
| 1476 Mar 11 | C | For 2.70 hr. | 18.4 | 22.2 | 3.8 |
| 1482 Oct 26 | C | For 3.33 hr. | 17.1 | 20.4 | 3.3 |
| 1483 Oct 16 | C | For 3.33 hr. | 1.0 | 04.8 | 3.8 |
| 1486 Feb 18 | C | For 3.33 hr. | 17.1 | 20.6 | 3.5 |
| 1487 Feb 08 | C | For 3.33 hr. | 03.4 | (6.5) | - |
| 1490 Jan 03 | C | For 2.70 hr. | 22.0 | 01.7 | 3.7 |
| 1494 Mar 22 | C | For 2.0 hr. | 01.6 | 05.5 | 3.9 |
| 1500 Nov 05 | C | End ~4.60 | 01.2 | 04.4 | 3.2 |
| 1504 Mar 01 | C | For 1.33 hr. | 00.8 | 04.4 | 3.6 |
| 1505 Aug 15 | C | End 3.70 | 20.2 | 00.0 | 3.8 |
| 1509 Jun 06 | C | For 2.7 hr. | 23.2 | 01.9 | 2.7 |
| 1511 Oct 06 | C | For 3.33 hr. | 23.1 | 02.3 | 3.2 |
| 1516 Jul 14 | C | For >3.33 hr. | 23.1 | 02.7 | 3.6 |
| 1516 Jul 14 | D | Beg 23.45 | 23.5 | 03.0 | 3.5 |
| 1518 May 25 | C | For 3.20 hr. | 23.2 | 02.3 | 3.1 |
| 1519 Nov 07 | C | For >2.70 hr. | 17.8 | 21.5 | 3.7 |
| 1520 May 03 | C | For 1 hr. | 20.4 | 22.3 | 1.9 |

Table (6.4): Comparison between computed and reduced observed local time of lunar eclipses in medieval Arabic chronicles. Brackets indicate that the Moon set or rose eclipsed. The signs > and < here mean after and before respectively.
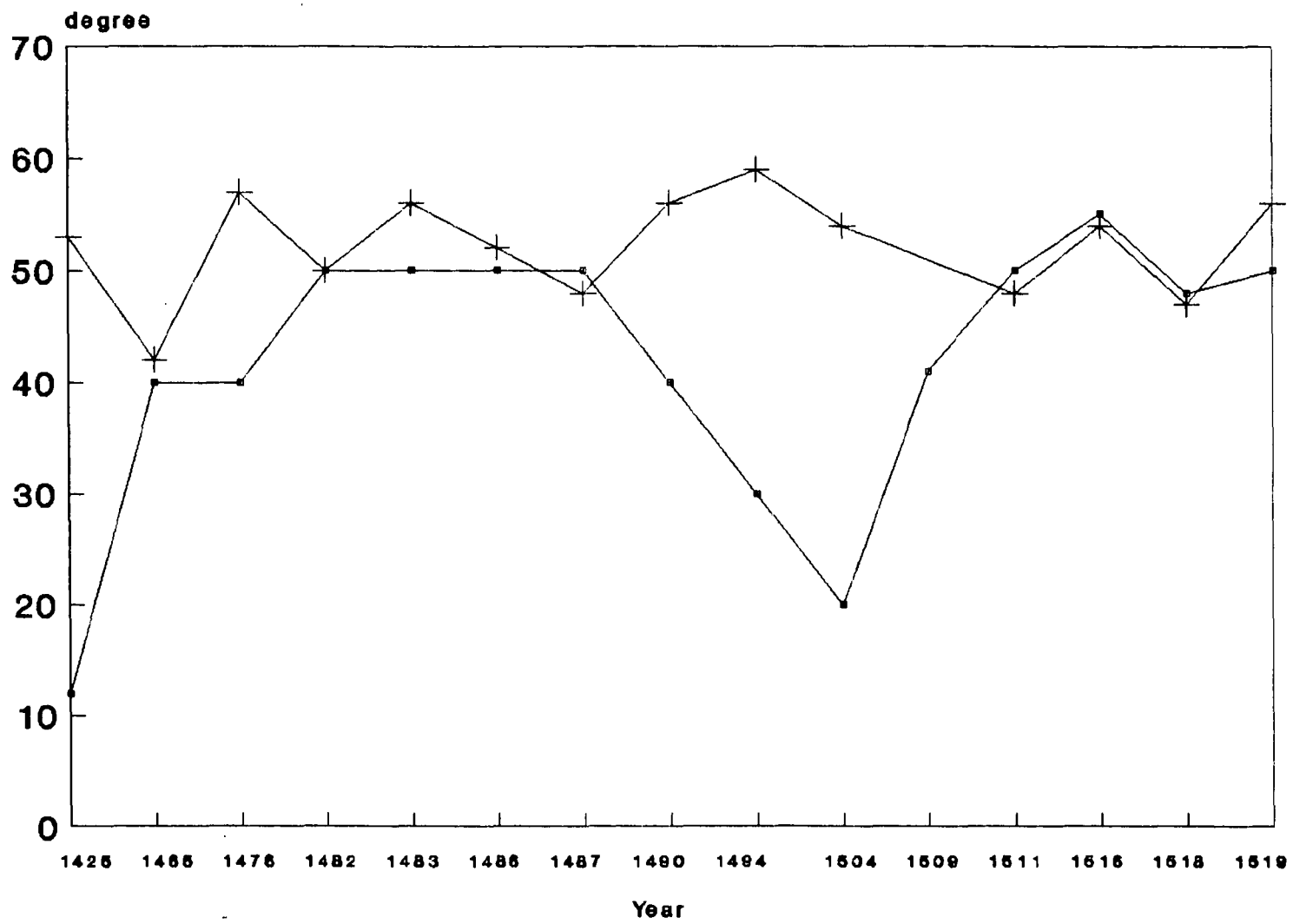
**Fig. (6.1):** Durations of Lunar eclipses as recorded by
*Ibn Iyas* are compared with the computed durations.

(2) AD.1433 July 3 " most of the Moon was eclipsed ",
while according to calculations the magnitude was 0.52.
Therefore the observed magnitude of this eclipse is very
approximate.

The eclipse of AD.1520 in Cairo was recorded by *Ibn Iyas*
who stated incorrectly that darkness covered the ground.
However, this is completely in discord with computation
which yields a magnitude of 0.12; only a very small
portion of the Moon disk was eclipsed.

## 6.3 Record of individual lunar eclipses

(1) AD.867 Nov 14 = 14 Dhu al-Qa'da AH.253

Damascus
" On the night of the 14th of the month Dhu al-Qa'da of
this year, the Moon was eclipsed until most of it
disappeared and its light was obscured ". (*Ibn Kathir,
Vol.11*).

This is the earliest recorded eclipse in the Arabic
chronicles which I have consulted. *Ibn Kathir* (1301-1372)
wrote several centuries after the event. He must have
quoted his account from that of a contemporary writer.

(2) AD.882 Aug 3 = 15 Muharram AH.269

Baghdad
" On the night of 14th of the month Muharram, the Moon
was eclipsed and set eclipsed ". (*al-Tabari, Vol.9*).

In this month, both lunar and solar eclipses were seen in
Iraq. This was during the life of *al-Tabari* who recorded
the double event in his notable book *Tarikh al-Tabari*.
This is the only reference to eclipses in his book. The
solar eclipse has been discussed in the previous chapter
(eclipse no.2). Three similar accounts to that given by
*al-Tabari*, mentioning only the month of occurrence, are
given by later writers: *Ibn al-Jawzi* of Baghdad, *Ibn
al-Athir* of Mosel and *al-Suyuti* of Cairo. The lunar
obscuration took place before dawn *(Fajr)* on Friday. The
computed time of the beginning of the eclipse is 3.3 am
and it would set totally obscured at 5.2 am.

(3) AD.893 Dec 26 = 14 Shawwal AH.280

Baghdad

" The Moon was eclipsed when 14 nights had passed in the
month Shawwal at Dubeel (City in Armenia). It reappeared
at the end of the night ". *(al-Tabari, Vol.10)*.

Two similar accounts were recorded by *Ibn al-Jawzi, Vol.5*
and *Ibn al-Athir, Vol.6*. This lunar eclipse was not seen
in Iraq, but it was recorded by the chronicler of Baghdad
according to a letter received from Dubeel stating that
the Moon was eclipsed on the above date and that a very
strong earthquake happened next night.

(4) AD.936 Mar 11 = 15 Rabi II AH.324
(5) AD.936 Sep  4 = 15 Shawwal AH.324

Mosel

" In this year, the Moon was totally eclipsed on the

night of Friday when 14 nights had passed in the month Rabi I. It was totally eclipsed too when 14 nights had passed in the month Shawwal ". *(Ibn al-Athir, Vol.6).*

(6) AD.939 Dec 29 = 15 Rabi I AH.328

Mosel

" (In AH.327), the Moon was totally eclipsed in the month Safar ". *(Ibn al-Athir, Vol.6).*

According to computation this eclipse began at 4.7 am and the Moon set eclipsed on 15 Rabi I AH.328. So, *Ibn al-Athir* made serious error in recording the year and the month. There was no (total) eclipse of the Moon in the previous year.

(7) AD.940 Dec 16 = 15 Rabi I AH.329

" On the night of the middle of month Rabi I, the Moon was totally eclipsed ". *(al-Hamathani).*

(8) AD.951 May 24 = 15  Dhu al-Hijjh AH.339

Mosel

" On the night of Saturday, the 14th of the month Dhu al-Hijjh, the Moon rose eclipsed, it was eclipsed totally ". *(Ibn al-Athir, Vol.6).*

(9) AD.962 Apr 23 = 16 Rabi I AH.351

Mosel

" On the middle of the month Rabi I, the Moon was totally eclipsed ". *(Ibn al-Athir, Vol.7).*

(10) AD.965 Feb 19 = 15 Safar AH.354

Mosel

" On the night of Saturday, the 14th of month Safar, the
Moon was totally eclipsed ". (*Ibn al-Athir, Vol.7*).

*Ibn al-Jawzi* also chronicled this eclipse, but he
mentioned the day of 13th Safar.

**(11) AD.966 Aug 4 = 15 Shaban AH.355**

Mosel

" The Moon was totally eclipsed on Saturday the 13th of
the month Shaban, and set eclipsed ". (*Ibn al-Athir,
Vol.7*).

The same account was recorded by *Ibn al-Jawzi, Vol.7,* but
without mentioning the week-day and the date of
occurrence was the next day (i.e. the 14th of Shaban).

**(12) AD.969 Jun 3 = 15 Rajab AH.358**

Mosel

" On the night of Thursday, the 14th of the month Rajab,
the Moon was totally eclipsed, and set eclipsed ". (*Ibn
al-Athir, Vol.7*)

**(13) AD.1117 Jun 16 = 14 Safar AH.511**

Mosel

" On the 14th of the month Safar, the Moon was totally
eclipsed ". (*Ibn al-Athir, Vol.8*).

**(14) AD.1178 Aug 30 = 15 Rabi I AH.574**
Baghdad

" The Moon was eclipsed after the last third of the night
on the middle of the month Rabi I. It remained like that
until it set after sunrise ". (*Ibn al-Jawzi, Vol.10*).

A similar account is recorded by *Ibn al-Athir, Vol.9* but he mentioned the following month, Rabi II.

(15) AD.1226 Feb 14 = 15 Safar AH.623

Mosel

" In this year, The Moon was eclipsed twice; the first one was on the 14th of the month Safar ". (*Ibn al-Athir, Vol.9*).

There is no indication at all about the second eclipse.

(16) AD.1256 Jul 10 = 15 Jumada II AH.654

Cairo

" On the night of 16th of the month Jumada II, the Moon was eclipsed at the beginning of the night. It was very reddish, then it recovered ". (*Ibn Taghribardi, Vol.7*).

The recorded time of occurrence is incorrect. The eclipse should have begun at about 8 am not at the beginning of the night. In Cairo, the Sun rose at the above date at about 5 am. So, this eclipse would be invisible from Cairo. Presumably *Ibn Taghribardi* has confused the date.

(17) AD.1309 Aug 22 = 15 Rabi I AH.709

Cairo

" In the month Rabi I, the Moon was totally eclipsed ". (*al-Maqrizi, al-Suluk, Vol.2, pt.2*).

(18) AD.1324 May 10 = 15 Jumada I AH.724

Cairo

" On the night of Sunday, the 15th of the month Jumada I, the Moon rose eclipsed (covered) with blackness ". (al-Maqrizi, al-Suluk, Vol.2, Pt.2).

**(19) AD.1371 Oct 25 = 15 Rabi II AH.773**

Cairo

" On the night of 14th of the month Rabi I, the Moon was eclipsed and continued (eclipsed) until the dawn (Fajr) prayer ". (al-Asqalani, Vol.1).

The time of ending is incorrect. According to calculation, this eclipse would end at 23.6 pm not at dawn.

**(20) AD.1376 Jul 31 = 14 Rabi I AH.778**

Cairo

" In the 2nd of the month Rabi I, the Moon was eclipsed too. It was four days between the solar and the lunar eclipse. This was considered as a strange rarity ". (Ibn Iyas, Vol.1)

The chronicler recorded incorrectly the date of the month. A lunar eclipse can not have taken place on the 2nd day of a lunar month. According to calculation, there were two lunar eclipses around this time. The first one was on 2 July (before a solar eclipse) and the second was on 31 July (after a solar eclipse). Possibly, Ibn Iyas's report points to the second eclipse, but he had mistaken the date. Or possibly the obscuration of the Moon in that date (2nd Rabi I = 19 July) was due to the atmospheric dimming.

(21) AD.1377 Dec 16 = 14 Shaban AH.779

Cairo

" In the month Shaban this year (AH.778), both the Sun and Moon were eclipsed. The Moon rose eclipsed on the night of Saturday the 14th then cleared quickly before the conclusion of the sunset *(Maghrib)* prayer. (For solar eclipse see previous chapter, event no.14) ". *(al-Asqalani, Vol.1)*.

Two abbreviated similar accounts were recorded by two later writers, *al-Suyuti, Vol.2* and *Ibn Iyas, Vol.2.* Both records were based on the above report by *al-Asqalani* who mistook both the year and the week-day. The year should be the following one (AH.779) and the week-day was Wednesday. The Moon would rise almost completely covered at about 17.0 pm, and end at 19.6 pm, it reached its maximum magnitude -1.27- at 17.6 pm.

(22) AD.1386 Jan 16 = 15 Dhu al-Hijjh AH.787

Baghdad

" On the night of Tuesday the 14th of the month Dhu al-Hijjh, the Moon was eclipsed àt the end of the night. It was 26 days between the solar (see previous chapter event no.15) and lunar eclipse ". *(al-Jawhri, Vol.1)*.

The solar eclipse occurred on the 28th of the month Dhu al-Qa'da, so the duration between the solar and lunar eclipses was 16 days, not 26 days as mentioned in the text. *Ibn Iyas, Vol.1,* added that the eclipse continued until sunrise

(23) AD.1396 Jun 22 = 15 Ramadan AH.798

Cairo

" In the month Ramadan, the Moon was eclipsed after nightfall until the Earth was darkened ". *(al-Asqalani, Vol.3)*.

There is another similar abbreviated account by *Ibn Iyas, Vol.1*

(24) AD.1399 Apr 21 = 15 Shaban AH.801

(a)Cairo and (b)Damascus

(a) " On the 13th of the month Shaban, the night of Monday according to visibility (the method of observing the crescent Moon to organize the lunar month, see section 5.3 in chapter 1) the Moon was totally eclipsed. The people regarded it as an omen that the Sultan would transient (vanish) and it was so ". *(Ibn Iyas, Vol.1)*.

(b) "On the night of Monday the 14th of the month Shaban, the Moon was totally eclipsed, and it continued eclipsed from after the nightfall *(Isha)* prayer until midnight. People performed the eclipse prayer in Damascus". *(al-Asqalani, Vol.4)*.

(25) AD.1400 Oct 4 = 15 Safar AH.803
Damascus

" On the night of Monday, the middle of the month Safar, the Moon rose eclipsed, then *Ibn Abi al-Baqa'a* in Damascus led the people for the eclipse prayer and

delivered an address (Khutbh). He finished (the address) at the nightfall (Isha) prayer. The Moon cleared at the end of twilight ". (al-Asqalani, Vol.4).

(26) AD.1403 Aug 3 = 15 Muharram AH.806

Cairo

" On the night of 14th of the month Muharram, the Nile river had stopped for several days when the Moon was totally eclipsed in Aquarius. Its light completely disappeared ". (al-Asqalani, Vol.5).

Although this is a contemporary account, the later chronicler Ibn Iyas, Vol.1 recorded this same eclipse more accurately in which he gave correctly the week-day, Friday, and approximate full duration as about five hours, 1h 24m longer than the computed one

(27) AD.1406 Jun 2 = 15 Dhu al-Hijjh AH.808

Cairo

" On the night of the middle of the month Dhu al-Hijjh, the Moon was eclipsed at the end of the night and continued (eclipsed) until after the beginning of the dawn (Fajr) prayer ". (al-Asqalani, Vol.5).
There is another abbreviated record by Ibn Iyas, Vol.1

(28) AD.1407 May 22 = 15 Dhu al-Hijjh AH.809
Cairo

" On the night of Sunday the 14th of the month Dhu al-Hijjh, the Moon was totally eclipsed ". (Ibn Iyas, Vol.1).

(29) AD.1414 Dec 27 = 15 Shawwal AH.817

Cairo

" On the night of Thursday the 14th of the month Shawwal, the Moon was eclipsed. It remained eclipsed for about four hours ". (al-Asqalani, Vol.7).

(30) AD.1421 Feb 17 = 15 Safar AH.824

Cairo

" In the month Safar, the Moon was eclipsed. People hoped that al-Muzaffar the King will vanish quickly ". (Ibn Iyas, Vol.).

(31) AD.1422 Aug 3 = 15 Shaban AH.825

" On the night of 14th of the month Shaban, the Moon was (almost fully) eclipsed, only very small portion of it was uneclipsed. It continued eclipsed from before midnight until it cleared with dawn ". (al-Asqalani, Vol.7).

(32) AD.1425 Nov 26 = 15 Muharram AH.829

Cairo

" on the night of 15th of the month Muharram, the Moon was totally eclipsed. It remained eclipsed for about twelve degrees ". (Ibn Iyas, Vol.2).

(33) AD.1429 Mar 21 = 15 Jumada II AH.832
Cairo

" In the night of the middle (of the month Jumada II), the Moon was eclipsed. Most people did not notice it ". (al-Asqalani, Vol.8)

**(34) AD.1433 Jan 6 = 15 Jumada I AH.836**

Cairo

" In the night of 13th of the month Jumada I, the Moon was totally eclipsed and remained eclipsed for about three hours ". *(al-Asqalani, Vol.8)*

*Ibn Iyas, Vol.2* also chronicled this eclipse and gave the duration as forty degrees (2h 40m). However, this figure is loss accurate than the above duration which is quite near to computed one, 3h 36m.

**(35) AD.1433 Jul 3 = 15 Dhu al-Qa'da AH.836**

(a) Cairo   (b) Aleppo

(a) " On the night of Friday, the 14th of the month Dhu al-Qa'da, most of the Moon was eclipsed. It appeared eclipsed from the eastern horizon. It cleared at the nightfall *(Isha) prayer*. It is a rarity that a lunar eclipse occurred after 15 days from a solar eclipse (see previous chapter, eclipse no.20) ". *(al-Maqrizi, al-Suluk, Vol.4, Pt.2)*.

(b) " On the 14th of the month Dhu al-Qa'da, the Moon was eclipsed ". *(al-Asqalani, Vol.8)*.(

**(36) AD.1460 July 3 = 15 Ramadan AH.864**

Cairo

"In the month Ramadan, the Moon was completely eclipsed". *(Ibn Iyas, Vol.2)*.

**(37) AD.1461 Jun 23 = 15 Ramadan AH.865**

Cairo

" In the month Ramadan, the Moon was eclipsed and the Earth became very dark. It was one of the greatest eclipses ". *(Ibn Iyas, Vol.2)*.

(38) AD.1462 Jun 12 = 14 Ramadan AH.866

Cairo

" In the month Ramadan, the Moon was eclipsed and continued like that until near dawn ". *(Ibn Iyas, Vol.2)*.

(39) AD.1465 Oct 5 = 15 Safar AH.870

Cairo

" On the 13th of the month Safar, the Moon was eclipsed and continued for about forty degrees until it cleared ". *(Ibn Iyas, Vol.2)*.

(40) AD.1468 Aug 4 = 15 Muharram AH.873

Cairo

" On the night of the 15th of the month Muharram, the Moon was totally eclipsed. The Earth became dark. This remained near to the end of the night until it cleared ". *(Ibn Iyas, Vol.)*.

(41) AD.1471 Nov 28 = 15 Jumada II AH.876
Cairo

" In the month Jumada II, the Moon was totally eclipsed. It was a large eclipse ". *(Ibn Iyas, Vol.3)*.

(42) AD.1476 Mar 11 = 15 Dhu al-Qa'da AH.880
Cairo

" In the month Dhu al-Qa'da, the Moon was totally eclipsed until the Earth became dark. It remained eclipsed for about forty degrees ". *(Ibn Iyas, Vol.3)*.

(43) AD.1482 Oct 27 = 15 Ramadan AH.887

Cairo

" In the month Ramadan, the Moon was eclipsed and remained eclipsed for about fifty degrees ". *(Ibn Iyas, Vol.3)*.

(44) AD.1483 Oct 16 = 15 Ramadan AH.888

Cairo

" In the month Ramadan, the Moon was totally eclipsed until the Earth became dark. It remained eclipsed for about fifty degrees ". *(Ibn Iyas, Vol.3)*.

(45) AD.1486 Feb 19 = 15 Safar AH.891

Cairo

" In the month Safar, the Moon was eclipsed and the Earth became dark. It continued like that for about fifty degrees ". *(Ibn Iyas, Vol.3)*.

(46) AD.1487 Feb 8 = 15 Safar AH.892

Cairo

" In the month Safar, the Moon was eclipsed. The Earth became dark. It remained eclipsed for about fifty degrees ".
    *(Ibn Iyas, Vol.3)*.

(47) AD.1490 Jun 3 = 15 Rajab AH.895

Cairo

" In the month Rajab, the Moon was eclipsed and remained eclipsed for about forty degrees until it cleared ". *(Ibn Iyas, Vol.)*

(48) AD.1493 Apr 2 = 15 Jumada II AH.898

Cairo

"In the month Jumada II, the Moon was totally eclipsed". *(Ibn Iyas, Vol.).*

(49) AD.1494 Mar 22 = 15 Jumada II AH.899

Cairo

" In the month Jumada II, the Moon was completely eclipsed until the Earth became dark. It remained eclipsed for about thirty degrees ". *(Ibn Iyas, Vol.).*

(50) AD.1500 Nov 5 = 14 Rabi II AH.906

" On the night of Friday, the 13th of the month Rabi II, the Moon was completely eclipsed and remained eclipsed until near dawn. It set eclipsed ". *(Ibn Iyas, Vol.).*

(51) AD.1502 Oct 16 = 15 Rabi II AH.908

Cairo

" On the night of Sunday, the 14th of the month Rabi II, the Moon was eclipsed too. In it (this month), the Sun was eclipsed when it rose and remained like that for about an hour until it cleared. It was a few days between solar and lunar eclipses. This was considered a rarity ". *(Ibn Iyas, Vol.).*

(52) AD.1504 Mar 1 = 14 Ramadan AH.909

Cairo

" In the month Ramadan, the Moon was eclipsed at the end of the night. It continued eclipsed for about twenty degrees ". *(Ibn Iyas, Vol.).*

**(53) AD.1505 Aug 15 = 16 Rabi I AH.911**

Cairo

" In the month Rabi I, the Moon was greatly eclipsed and continued eclipsed until the end of the night ". *(Ibn Iyas, Vol.).*

**(54) AD.1509 Jun 2 = 15 Safar AH.915**

Cairo

" On the night of Sunday, the 15th of the month Muharram, the Moon was eclipsed and continued eclipsed for about forty one degrees ". *(Ibn Iyas, Vol.)*

*Ibn Iyas* had been mistaken in recording the date of the occurrence. According to calculation, this eclipse occurred on the 15th of the following month (Safar) rather than the previous month (Muharram). However, the observed duration is exactly as the computed one.

**(55) AD.1511 Oct 6 = 14 Rajab AH.917**

Cairo

" One the night of Tuesday, the 14th of the month, the Moon was greatly eclipsed and continued eclipsed for about fifty degrees until the Earth became dark. It did not uncleared until near dawn ". *(Ibn Iyas, Vol.).*

**(56) AD.1516 Jul 14 = 14 Jumada II AH.922**

Cairo

" On the night of Monday, the 14th of this month (Jumada II), the Moon was greatly eclipsed until the Earth became dark. It remained eclipsed for more than fifty degrees, and the whole of it was covered by blackness. It continued eclipsed until the last third of the night ". (Ibn Iyas, Vol.5).

There is another account by *Ibn Tulun, Mufakahat al-Khullan, Vol.2* in Damascus.

(57) AD.1518 May 25 = 15 Jumada I AH.924

Cairo

" On the night of Tuesday, the 15th of the month Jumada I, the Moon was eclipsed and remained eclipsed for forty eight degrees ". (Ibn Iyas, Vol.5).

(58) AD.1519 Nov 7 = 15 Dhu al-Qa'da AH.925

Cairo

" On Sunday, the night of Monday, the 14th of the month Dhu al-Qa'da, the Moon was greatly eclipsed until the Earth became dark. It remained eclipsed for more than forty degrees. It was (also) said that it remained eclipsed for about fifty degrees. It was eclipsed when it rose and continued eclipsed until a large portion of the night had passed ". (Ibn Iyas, Vol.5).

(59) AD.1520 May 3 = 15 Jumada I AH.926

Cairo

" On the night of Thursday, the 15th of the month Jumada

I, the Moon was eclipsed and the Earth was darkened. It remained in that eclipse for about an hour, then it cleared ". *(Ibn Iyas, Vol.5).*

## 6.4 Conclusion

Like solar eclipses, medieval Arabic chroniclers occasionally recorded lunar eclipses. In general, the observed time of occurrence and magnitude of lunar eclipses is in fair accord with computation. There are serious errors in recording the dates of certain eclipse: in AD.939 (the month and the year are in error), AD.1376 (possibly the day of the month is incorrect), AD.1377 (incorrect year) and AD.1509 (incorrect month).

# 7 CONCLUSION

The work in this thesis has consisted of the assembling, translation and investigation of comets with especial reference to Halley's Comet, meteors, meteor showers and solar and lunar eclipses throughout the Islamic era.

Chapter 1 is a general introduction which was divided into seven sections. Section 1.1 explained the major research fields which use the observations of the pre-telescopic period. Section 1.2 reviewed Arabian astronomy in the pre-Islamic age. Sections 1.3 and 1.4 reviewed briefly the development of astronomy from the beginning of the Islamic era until the last prominent Islamic school in astronomy which was at Samarkand in the beginning of the 16th century. Section 1.5 dealt with the three areas of astronomical time-keeping in the medieval Islamic period which are: calculation of the time of the obligatory five prayers, the *Qibla* direction (direction of Mecca) and the different methods to organize the lunar month. Section 1.6 explained some of the Islamic terms which are used in this thesis. The last section, 1.7 the format of entry of each event.

Chapter 2 deals with the chroniclers and chronicles which have been consulted in this present work. This chapter was divided into three sections. Section 2.1 dealt with the usual tradition among the Muslim chroniclers in writing their chronicles, and also the type of astronomical events which they were typically recorded.

Section 2.2 reviewed briefly the tradition of the names of Arabs. Section 2.3 discussed the biography of each Muslim chronicler whose chronicle consulted.

Chapter 3 was an extensive investigation of the cometary observations in the medieval Islamic era with special reference to Halley's Comet. This chapter was divided into seven sections in which section 3.1 was an introduction. Section 3.2 dealt with the records of the comets in different civilizations: Chinese, Babylonians, medieval Europeans and medieval Arabs. Section 3.3 dealt with the search for Halley's Comet by different investigators. Section 3.4 summarized the terms which were used to denote a comet in medieval Arabic chronicles. Section 3.5 dealt with the observations of Halley's Comet in medieval Arabic records. Halley's Comet made eleven returns during the medieval Islamic era (between AD.684 and 1456). The first and second returns in AD.684 and 760 are not mentioned in the sources which were consulted and neither is that of AD.1301. Each record of observation was translated directly from the original source, investigated in details and compared with the modern calculations using results from the numerical integration method of Yeomans and Kiang (1981). In addition, each case was compared with the records from East Asia as mentioned by Stephenson and Yau (1985) and Stephenson and Walker (1985). Section 3.6 dealt with other comets in medieval Arabic records. Each record was compared with the records from East Asia as cited by Ho

Peng Yoke (1962). Section 3.7 conclude that only the Arab observation of AD.1066 is of real value for improving the date of perihelion passage. This comet appeared later than expected at perihelion according to numerical integration. This delay is possibly the result of the effects of non-gravitional forces. For other comets, there is a fairly good agreement in the recorded date of apparition between the Arabs and East Asian observations. However, the Arab records of comets demonstrate the existence a significant gap in the East Asian records between AD.1095 and 1107, during while Arabs observed five comets; among these is the remarkable daylight comet which was seen in December AD.1105.

Chapter 4 was an investigation of meteors and meteor showers in the medieval Islamic era. It was divided into 5 sections. The first three sections explained the phenomena of meteors and meteor showers. Forty individual meteors and 24 meteor showers were recorded in the medieval Arabic chronicles consulted. These are translated and reviewed in section 4.4. Several meteor showers in the month of October and the AD.1832 meteor shower recorded in November are associated with the comet 1866 I which causes the Leonid shower of Nov 16. The variation in the date of the maximum is shown to be caused by the difference between the length of the sidereal and tropical years.

Chapters 5 and 6 were investigation of solar and lunar eclipses records. Individual eclipse records were translated and commented on, and observed times of occurrence, magnitudes, etc. are reduced. Comparison are made between recorded local circumstances of both solar and lunar eclipse and present-day calculations. In general, Arabic chroniclers seldom intended to give an astronomically accurate description of an eclipse. However, the week-day and the date of occurrence are usually in fair good accord with the calculations, as often is the hour.

This present work investigated the observations of the celestial phenomena mentioned above which were recorded only in the primary Arabic chronicles. I would like to mention some points are not covered in this work because a limit of time.

1) There are a number of chronicles either published or in form of manuscript and astronomical treatises are not consulted in this work.

2)There is a gap in the chronicle of Arabian peninsula and Yeman is not cover in this thesis.

3) There are some astronomical or geophysical phenomena recorded in medieval Arabic chronicles are not uncovered in this work such as aurorae, planetary conjunctions, galactic Supernovae, sunspots (possibly), earth-quakes, etc.

These points will be investigated for further research, and I hope this will stimulate interest in these three points in medieval Arabic chronicles, both for their astronomical and chronological value.

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## Program for calculating the five daily pravers

```
C
C      ******PROGRAM FOR CALCULATING THE PRAY TIME**********
C      *          WRITTEN BY : SALAH HAMID                    *
C      *                     : Hussain A. al-Trabulsy
C      *  11 / 12 / 1992                                      *
C      ***************************************************************
C
C                      INPUT AND OUTPUT
C                      -------------------
C                          INPUT
C                      -------------------
C  1) ZONAL LONGITUDE OF THE PLACES (IN DEGREES): ALONGO
C  2) LONGITUDE OF THE PLACES (IN DEGREES): APLON
C  3) LATITUDE OF THE PLACES (IN DEGREES): ALAT
C  3) PLACE'S NAME  '              '
C  4) DATE OF THE COMPUTATION : IYEAR   MONTH  IDAY
C
       IMPLICIT REAL* 8 (A - H ,O - Z)
       INTEGER IHF$(6),MFR$(6)
       CHARACTER*10  NAME
       WRITE(6,*)' WELCOME TO  PRYSLHO PACKAGE  , TO COMPUTE THE PRAYING
      1 TIME FOR SEVERAL DAYS AT GIVEN PLACES ....'
       WRITE(6,*)' THIS PACKAGE IS VALID FOR THE PERIOD -4000 TO 7000
      1 THE SUN''S POSITION AND DELTA T ARE BASED ON BRETAGNON THEORY
      2 AND STEPHENSON'S WORK'
       WRITE(6,*)
       WRITE(6,*)' FIRST ENTER FOR EACH PLACE THE ZONAL LONG. (IN DEGREES
      1 , LONG.(IN DEGREES) , LATITUDE (IN DEGREES) , PLACE NAME (A10).'
 9191  CONTINUE
       READ(5,*)ALONGO,ALONG,ALAT,NAME
       IF(ALONGO.EQ.-9999.D0)GOTO 9292
C      ALONGO=45.D0
C      ALONG =46.72D0
C      ALAT  =24.63D0
       ISKIP=0
       WRITE(10,989)ALONGO,ALONG,ALAT,NAME
  10   CONTINUE
       IH=0
       IM=0
       IS=0
       IF(ISKIP.EQ.0)THEN
         WRITE(6,*)' ENTER THE YEAR,MONTH,DAY  FOR WHICH YOU WANT TO GET
      1  THE PRAYING TIME FOR THE PLACE WHICH YOU JUST ENTER .'
         GOTO 11
       ENDIF
       WRITE(6,*)' MORE DATES '
       WRITE(6,*)' IF YES , ENTER AGAIN THE YEAR,MONTH,DAY OF THE DATE'
       WRITE(6,*)' IF NO  , ENTER FOR THE DATE THE VALUE   -9999  0  0'
 11    CONTINUE
       READ(5,*,END=99)IYD,IMN,IDAY
       IF(IYD.EQ.-9999)THEN
         WRITE(6,*)' MORE PLACES'
         WRITE(6,*)' IF YES , ENTER AGAIN THE ZONAL LONG. , LONG , LAT ,
      1  NAME OF THE PLACE'
         WRITE(6,*)' IF NO  , ENTER  -9999.D0  0.D0  0.D0 ''  ''      '
```

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          GOTO 99
      ENDIF
      CALL UTET(IYD,IMN,IDAY,IH,IM,IS,UT,ET)
      CALL PRYSH(UT,ET,NAME,ALAT,ALONG,ALONGO,IHFS,MFRS)
      WRITE(10,8989)IYD,IMN,IDAY,(IHFS(KS),MFRS(KS),KS=1,6)
  989 FORMAT(1X,3F9.3,A10)
 8989 FORMAT(1X,I5,2I3,6(1X,2I3,1X))
      ISKIP=1
      GOTO 10
   99 CONTINUE
      GOTO 9191
 9292 CONTINUE
      STOP
      END
C ******************** SUBROUTINE *********************************
      SUBROUTINE PRAYTIME(YD,ET,PCITY,PLAT,PLONG,LONGO,IHFS,MFRS)
C ****************************************************************
      IMPLICIT REAL* 8 (A - H ,O - Z)
      REAL *8   ZS(6),AS(6),BS(6), HS(6),LONGO
      INTEGER IHFS(6),MFRS(6),EVENT
      CHARACTER*10 PCITY
      DATA AS/24.D0,24.D0,0.D0,0.D0,0.D0,0.D0/
      DATA BS/-1.D0,-1.D0,1.D0,1.D0,1.D0,1.D0/
C       *****************************************************************
C       *   CL        = LATITUDE OF THE PLACE (IN DEGREES)        *
C       *   ALO       = LONGITUDE OF THE PLACE (IN DEGREES)       *
C       *   DE        = DECLINATION OF THE SUN (IN DEGREES)
C       *   ALF       = RIGHT ASCENSION OF THE SUN (IN DEGREES)
C       *   CONST     = FACTOR TO CHANGE FROM DEGREES TO RADIANS  *
C       *   ZS(EVENT) = ARRAY DEFINING ZENITH DISTANCE OF THE SUN AT EVENT
C       *       FAJR  SUNR  ZUHR  ASR   MAGHRIB  ISHA           *
C       *  EVENT   1     2     3     4     5        6            *
C       ****************************************************************
C
C
C                 HOW TO CALCULAT THE PRAY TIME.:
C*1ST:.WE HAVE TO KNOW THE ZENITH DISTANCE OF TIMEAS IN DEGREES WHECH IS
C                    FAJR       SUNR        MAGHRIB      ISHA
C ZENITH DISTANCE =Z:  108    90+50/60     90+50/60      108 ,
C          FOR ZUHR WE DO NOT NEED IT BECAUSE : HOUR ANGLE=0 ,
C          AND FOR ASR IS EQUAL TO THE ZENITH WHEN THE SHADOW
C          OF AN OBJECT EQUALS ITS SHADOW IN ZUHR PLUS ITS LENGTH
C          AND WE HAVE TO CORRECT IT BY REFRACTION AS FOLLOWING:
C          SHADOW AT ZUHR            =ZUT = CL - DE
C          CORRECT BY REFRACTION     =SHD =ZUT-(58.D0/3600.D0)*TAN(ZUT)
C          LENGTH OF SHADOW AT ASR =LNSH=1.D0+TAN(SHD)
C          ZENITH DISTANCE AT ASR  =ZASR= ARC TAN(LNSH)
C          CORRECT OF REFRACTION FOR THE TURE ZENITH DESTANCE AT ASR IS
C                        = Z  =ZASR+(58.D0/3600.0D0)*TAN(ZASR)
C
C*2ND:-WE HAVE TO CALCULAT THE HOUR ANGLE FOR ALL THE TIMES IN DEGREES :
C      HOUR ANGLE = H =ARC COS((COS(Z)-SIN(DE)*SIN(CL))/COS(DE)*COS(CL))
C          BUT HOUR ANGLE OF ZUHR = H = 0 ,
C      TO HAVE HOUR ANGLE IN HOURS : HOUR= H/15
C               FOR FAJR AND SUNR =HOUR= 24 - HOUR
C
```

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C*3ED:-CALCULAT THE TIME OF PRAY AS IN SUBROUTINE LSTCT
C
      CONST= DATAN(1.DO)/45.DO
      CL=PLAT
      ALO=PLONG
      ALO=LONGO
      Z$(1)=108.DO*CONST
      Z$(2)=(90.DO+50.DO/60.DO)*CONST
      Z$(5)=Z$(2)
      Z$(6)=108.DO*CONST
C
      CALL LNLTSN(YD,ET,ALON,ALF,DE)
C
C   ZUT   : TRUE ZENITH DISTANCE OF SUN AT ZUHR IN DEGREES
C         : NOTICE THAT WE TAKE THE ABSOLUTE VALUE OF THE ZENITH DISTANCE
C         : SINCE BY DEFINITION IT SHOULD BE POSITIVE
C   Z$(3) : LATITUDE OF PLACE - DECLINATION OF THE SUN IN DEGREES
C
      ZUT=DABS(CL-DE)
      Z$(3)=CL - DE
      ZUT=ZUT-(58.DO/3600.DO)*DTAN(ZUT*CONST)
C
C   TAA   : LENGTH OF SHADOW AT ASR TIME
C
      TAA=1.DO+DTAN(ZUT*CONST)
C    ***CORRECT OF REFRACTION***
C   Z$(4) : APPARENT ZENITH DISTANCE OF THE SUN AT ASR IN RADIANS
C
      Z$(4)=DATAN(TAA)
C   Z$(4) : TRUE ZENITH DISTANCE OF THE SUN AT ASR IN RADIANS
      Z$(4)=Z$(4)+(58.DO/3600.0DO)*DTAN(Z$(4))*CONST
C
C
C      ***********************************************************
C      *       TO GET TO = GREENWICH MEAN SIDEREAL TIME (GMST)       *
C      *       TO GET TO = GREENWICH MEAN SIDEREAL TIME (GMST)       *
C      *    TU = INTERVAL OF TIME FROM CENTURIES OF 36525 DAY    *
C      * .H. =TIME IN HOURS , M.. = IN MINUTES , S.. = IN SECONDS *
C      ***********************************************************
C
      TU=(YD -2451545.0DO)/36525.DO
      TO=(24110.54841DO+8640184.812866DO*TU+0.093104DO*(TU**2))/3600.DO
      TO=DMOD(TO,24.DO)
      IF(TO.LT.0.0DO)TO=TO+24.DO
C
C   COMMENT   LATER FOR K52
C
      K5=2
CCCC            < TO GO THROUGH DIFFERENT EVENTS >                    P
      DO 1000 EVENT =1,6
         YDO=YD
CTEMP
         ETO=ET
C
C TO ALLOW FOR THE VARIATION OF THE SUN'S COORDINATES DURING THE EVENT
C TO IMPROVE LATER
```

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```
C
            DO 100 KK=1,K5
                CALL LNLTSN(YDO,ETO,ALON,ALF,DE)
                IF(EVENT.EQ.4)THEN
CCCC                < TO CORRECT THE TIME OF ASR >
C
C   ZUT : IN DEGREES: TRUE ZENITH DISTANCE AT ZUHR
C
                ZUT=DABS(CL-DZUHR)
C
C   ZUT : IN DEGREES: APP. ZENITH DISTANCE AT ZUHR
C
                ZUT=ZUT+(58.D0/3600.0D0)*DTAN(ZUT*CONST)
                TAA=1.D0+DTAN(ZUT*CONST)

            ****CORRECTION OF REFRACTION*****
C
C   Z$(4) : IN RADIANS : APP. ZENITH DISTANCE AT ASR
C
                Z$(4)=DATAN(TAA)
C
C   Z$(4) : TRUE  ZENITH DISTANCE OF SUN AT ASR IN RADIANS
C
                Z$(4)=Z$(4)+(58.D0/3600.0D0)*DTAN(Z$(4))*CONST
                Z=Z$(4)
            ELSE
                Z =Z$(EVENT)
            ENDIF
            DE$=DE*CONST
            CL$=CL*CONST
            CHF=(DCOS(Z)-DSIN(DE$)*DSIN(CL$))/(DCOS(DE$)*DCOS(CL$))
C
C
            IF (DABS(CHF).GT.1.D0.AND.EVENT.NE.3)THEN
                IHF$(EVENT)=99
                MFR$(EVENT)=99
                GOTO1000
            ENDIF
            IF(EVENT.EQ.3)THEN
                CHF = 1.D0
C
C   DZUHR : IN DEGREES
C
                DZUHR = DE
            ENDIF
            H$(EVENT)=(DARCOS(CHF))/CONST/15.D0
C
C   TO EXPLAIN LATER
C       DATA A$/24.D0,24.D0,0.D0,0.D0,0.D0,0.D0/
C       DATA B$/-1.D0,-1.D0,1.D0,1.D0,1.D0,1.D0/
C
C
C TO COMPUTE :
C AST :LOCAL SIDEREAL TIME
C GST :GREENWICH SIDEREAL TIME.
```

```
C GMT :GREENWICH MEAN INTERVAL.
C ACT :CIVIL TIME
C
      HFR= AS(EVENT)+BS(EVENT)*HS(EVENT)
      AST=HFR+ALF
      GST=AST-ALO/15.D0
      GST=DMOD(GST,24.D0)
      IF(GST.LT.0.D0)GST=GST+24.D0
      GMT=(GST-TO)
      GMT=DMOD(GMT,24.D0)
      IF(GMT.LT.0.D0)GMT=GMT+24.D0
      GMT=GMT*0.99726956634D0
      ACT=GMT+(ALO/15.D0)
      DJD=DMOD(ACT,24.D0)/24.D0
      YDO=YDO+DJD
      ETO=ETO+DJD
C
C
 100      CONTINUE
      HFR= AS(EVENT)+BS(EVENT)*HS(EVENT)
C                 < TO COMPUTE THE TIME OF THE EVENT >
      CALL LSTCT(HFR,ALF,ALO,ALO,TO,IHF,MFR,SFR)
      IF(SFR.GE.30.D0)MFR=MFR+1
      IF(MFR.GE.60)THEN
         MFR=MFR-60
         IHF=IHF+1
      ENDIF
      IHFS(EVENT)=IHF
      MFRS(EVENT)=MFR
1000  CONTINUE
      RETURN
      END
C --------------------------------------------------------------------------
C ********************** THE END OF THE **************************
C ********************** PROGRAM **************************
C      **********************************************************************
C      * ***** SUBROUTINE LSTCT(HOR,ALF,ALO,ALO,TO,IHC,MCT,SCT) *******
C      **********************************************************************
C      * LSTCT : COMPUTES THE CIVIL TIME (HRS , MINS , SEC) FOR LOCAL
C      *       : HOUR ANGLE HOR OF A BODY WITH RIGHT ASCENSION ALF
C      * ALO : LOCAL LONGITUDE
C      * ALO : ZONAL LONGITUDE
C      * ALF : RIGHT ASCENSION
C      * HOR : LOCAL HOUR ANGLE
C      * TO  : GREENWICH SIDEREAL TIME AT 0 UT
C      * IHC,MCT,SCT : THE CIVIL TIME (HRS , MIN , SEC ) CORRESPONDING
C      * TO THE LOCAL HOUR ANGLE HOR
C      **********************************************************************
      SUBROUTINE LSTCT(HOR,ALF,ALO,ALO,TO,IHC,MCT,SCT)
      REAL*8 GTO,AST,GST,GMT,ACT,HOR,ALO,ALF,TO,SCT,ALO
C
C TO COMPUTE :
C AST :LOCAL SIDEREAL TIME
C GST :GREENWICH SIDEREAL TIME.
C GMT :GREENWICH MEAN INTERVAL.
```

```
C ACT :CIVIL TIME
C
      AST=HOR+ALF
      GST=AST-ALO/15.D0
      GST=DMOD(GST,24.D0)
      IF(GST.LT.0.D0)GST=GST+24.D0
      GMT=(GST-T0)
      GMT=DMOD(GMT,24.D0)
      IF(GMT.LT.0.D0)GMT=GMT+24.D0
      GMT=GMT*0.99726956634D0
      ACT=GMT+(ALO/15.D0)
      IF(ACT.LE.0.D0)ACT=ACT+12.D0
      IF(ACT.GE.13.D0)ACT=ACT-12.D0
      IHC=ACT
      MCT =(ACT-IHC)*60.D0
      SCT =(ACT-IHC-MCT/60.D0)*3600.D0
      RETURN
      END
      SUBROUTINE RFRCTN(A,R)
CCC**************************************************************************
      REAL *8 ARFRC(10),X,A,R,FX
      DATA ARFRC/
     1 28.891741D0,-20.516167D0, 7.291562D0,-0.813492D0,-0.690042D0,
     2  0.340097D0,- 0.024576D0,-0.050041D0, 0.023252D0,-0.009406D0/
C TO COMPUTE THE NORMALIZED VALUE OF X
      X=0.442837D0*DLOG(A+1.5D0) - 1.0D0
      N=10
      CALL CHEBYV(X,N,ARFRC,FX)
      R=FX
      RETURN
      END
      SUBROUTINE CHEBYV(X,N,A,FX)
CCC**************************************************************************
C
      REAL *8 A(N),B(100),X,FX
      B(N+1)=0.D0
      B(N+2)=0.D0
      I=N
C     WHILE(I.GE.1)DO
      DO 1 RPT=1,N
       B(I) = 2.D0*X*B(I+1)-B(I+2)+A(I)
       I=I-1
C     ENDWHILE
1     CONTINUE
      FX=(B(1)-B(3))/2.D0
      RETURN
      END
C**************************************************************************
      SUBROUTINE
     1    LNLTSN(UT,ET,ALON,ALPHA,DELTA)
C**************************************************************************
C     INPUT   UT : UNIVERSAL TIME IN JULIAN DAY FORMAT         *
C     INPUT   et : EPHEMERIS TIME IN JULIAN DAY FORMAT         *
C     OUTPUTS ALON (APPARENT LONGITUDE), IN DEGREES            *
C             ALPHA (APPARENT RIGHT ASC.) , IN HOURS
```

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```
C                  DELTA (APPARENT DECINATION) , IN DEGREES
C**********************************************************************
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      CALL SUN(ET,DLS,DRS)
      GL=DLS
      GB=0.D0
      CALL ABERNU(ET,GL,GB,ALON,ALAT,ALPHA,DELTA)
      RETURN
      END
      SUBROUTINE UTET(IYEAR,MONTH,JDAY,IH,IM,IS,UT,ET)
C**********************************************************************
C     THIS SUBROUTINE COMPUTES :                                    *
C     UT BY THE FORMULAE OF MEEUS                                   *
C     ET BY THE FORMULA OF STEPHENSON AND MORRISON       *PRA03490
C**********************************************************************
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
C**********************************************************************
C     COMPUTATION OF UT                                             *
C**********************************************************************
      DATA DJ1800/2378497.D0/
      Y=IYEAR
      M=MONTH
      B=0.D0
      C=0.D0
      IF(M.GT.2) GO TO 1
      Y=Y-1
      M=M+12
1     IF(Y.LT.0) GO TO 5
      IF(IYEAR-1582) 6,2,4
2     IF(MONTH-10)   6,3,4
3     IF(JDAY.LE.4) GO TO 6
      IF(JDAY.LE.14) STOP 1582
4     A=AINT(Y/100)
      B=2.D0-A+AINT(A/4.D0)
      GO TO 6
5     C=-0.75D0
6     UT=AINT(365.25D0*Y+C)+AINT(30.6001D0*(M+1))+JDAY+B
     1  +1720994.5D0+(IH+(IM+IS/60.D0)/60)/24
C**********************************************************************
C     COMPUTATION OF ET                                             *
C**********************************************************************
      DELTAT=(-15+32.5D0*((UT-DJ1800)/36525.D0-0.1D0)**2)/86400.D0
      ET=UT+DELTAT
      RETURN
      END
      SUBROUTINE SUN(DJ,DL,DR)
C**********************************************************************
C     THIS SUBROUTINE COMPUTES GEOCENTRIC LONGITUDE AND RADIUS VECTOR *
C     OF THE SUN                                                    *
C     INPUT IS DJ (JULIAN DAY OF THE DATE IN ET)                    *
C     OUTPUTS ARE DL (LONGITUDE) IN RADIAN                          *
C                 DR (RADIUS VECTOR)                                *
C**********************************************************************
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION IL(50),AL(50),BL(50),IR(50)
```

```
C*************************************************************************
C      COEFFICIENTS OF THE TABLES ARE IN THE DATA :                      *
C      IL (AMPLITUDES OF THE PERIODIC TERMS OF THE LONGITUDE)            *
C      IR (AMPLITUDES OF THE PERIODIC TERMS OF THE RADIUS VECTOR)        *
C      AL (PHASES OF THE PERIODIC TERMS)                                 *
C      BL (FREQUENCIES OF THE PERIODIC TERMS)                            *
C*************************************************************************
       DATA IL/ 403406, 195207, 119433, 112392,    3891,    2819,    1721,
      2      0,    660,    350,    334,    314,    268,    242,    234,
      3    158,    132,    129,    114,     99,     93,     86,     78,
      4     72,     68,     64,     46,     38,     37,     32,     29,
      5     28,     27,     27,     25,     24,     21,     21,     20,
      6     18,     17,     14,     13,     13,     13,     12,     10,
      7     10,     10,     10/
       DATA AL/ 4.721964D0,5.937458D0,1.115589D0,5.781616D0,5.5474D0,
      2  1.5120D0 ,4.1897D0 ,1.163D0  ,5.415D0  ,4.315D0  ,4.553D0  ,
      3  5.198D0  ,5.989D0  ,2.911D0  ,1.423D0  ,0.061D0  ,2.317D0  ,
      4  3.193D0  ,2.828D0  ,0.52D0   ,4.65D0   ,4.35D0   ,2.75D0   ,
      5  4.50D0   ,3.23D0   ,1.22D0   ,0.14D0   ,3.44D0   ,4.37D0   ,
      6  1.14D0   ,2.84D0   ,5.96D0   ,5.09D0   ,1.72D0   ,2.56D0   ,
      7  1.92D0   ,0.09D0   ,5.98D0   ,4.03D0   ,4.27D0   ,0.79D0   ,
      8  4.24D0   ,2.01D0   ,2.65D0   ,4.98D0   ,0.93D0   ,2.21D0   ,
      9  3.59D0   ,1.50D0   ,2.55D0    /
       DATA BL/ 1.621043D0,62830.348067D0,62830.821524D0,62829.634302D0,
      2  125660.5691D0  ,125660.9845D0  , 62832.4766D0  ,      0.813D0,
      3 125659.310D0,  57533.850D0,    -33.931D0,777137.715D0, 78604.191D0,
      4      5.412D0, 39302.093D0,    -34.861D0,115067.698D0, 15774.337D0,
      5   5296.670D0, 58849.27D0 ,   5296.11D0 , -3980.70D0 , 52237.69D0 ,
      6  55076.47D0 ,    261.03D0 ,  15773.85D0 ,188491.03D0 , -7756.55D0 ,
      7    264.89D0 ,117906.27D0 ,  55075.75D0 , -7961.39D0 ,188489.81D0 ,
      8   2132.19D0 ,109771.03D0 ,  54868.56D0 , 25443.93D0 ,-55731.43D0 ,
      9  60697.74D0 ,   2132.79D0 ,109771.63D0 , -7752.82D0 ,188491.91D0 ,
      .    207.81D0 , 29424.63D0 ,     -7.99D0 , 46941.14D0 ,   -68.29D0 ,
      1  21463.25D0 ,157208.40D0 /
       DATA IR/      0, -97597, -59715, -56188,  -1556,  -1126,   -861,
      2  941,-264,-163,   0, 309,-158,   0, -54,   0, -93, -20,   0, -47,
      3    0,   0, -33, -32,   0, -10, -16,   0,   0, -24, -13,   0,  -9,
      4    0, -17, -11,   0,  31, -10,   0, -12,   0,  -5,   0,   0,   0,
      5    0,   0,   0,  -9/
       DATA PI/3.1415926535897930D0/
C*************************************************************************
C      COMPUTATION OF PARAMETER U                                        *
C*************************************************************************
       U=(DJ-2451545)/3652500
C*************************************************************************
C      COMPUTATION OF THE LONGITUDE                                      *
C*************************************************************************
       DL=0.D0
       DO 1 I=1,50
       DL=DL+IL(I)*DSIN(AL(I)+BL(I)*U)
1      CONTINUE
       DL=DL*1.D-7+4.9353929D0+62833.1961680D0*U
       DL=DMOD(DL,2*PI)
       IF(DL.LT.0.D0) DL=DL+2*PI
C*************************************************************************
```

```
C      COMPUTATION OF THE RADIUS VECTOR                                      *
C*********************************************************************************
       DR=0.D0
       DO 3 I=1,50
       DR=DR+IR(I)*DCOS(AL(I)+BL(I)*U)
3      CONTINUE
       DR=DR*1.D-7+1.000102600
       RETURN
       END
       SUBROUTINE ABERNU(DJ,GL,GB,ALON,ALAT,ALPHA,DELTA)
C*********************************************************************************
C      THIS SUBROUTINE COMPUTES THE APPARENT GEOCENTRIC COORDINATES          *
C      FROM THE MEAN GEOCENTRIC COORDINATES                                  *
C      INPUTS ARE DJ (JULIAN DAY OF THE DATE), IBODY (CODE OF THE            *
C              CELESTIAL BODY), GL (MEAN GEOCENTRIC LONGITUDE) AND           *
C              GB (MEAN GEOCENTRIC LATITUDE)                                 *
C      OUTPUTS ARE ALON (APPARENT LONGITUDE), IN DEGREES                     *
C                  ALAT(APPARENT LATITUDE)  , IN DEGREES                     *
C              ALPHA(APPARENT RIGHT ASC.)  , IN HOURS                        *
C              DELTA(APPARENT DECINATION)  , IN DEGREES                      *
C*********************************************************************************
       IMPLICIT DOUBLE PRECISION (A-H,O-Z)
       DATA DEGREE/57.295779513D0/
C*********************************************************************************
C      COMPUTATION OF PARAMETER U                                            *
C*********************************************************************************
       U=(DJ-2451545)/3652500
C*********************************************************************************
C      COMPUTATION OF ABERRATION CORRECTIONS                                 *
C*********************************************************************************
       ALON=GL+(-993+17*COS(3.10D0+62830.14D0*U))*1.D-7
       ALAT=0.D0
C*********************************************************************************
C      COMPUTATION OF NUTATION CORRECTIONS                                   *
C*********************************************************************************
       A1=2.13D0-3375.70D0*U+0.36D0*U**2
       A2=3.51D0+125666.39D0*U+0.10D0*U**2
       DPSI=(-334*SIN(A1)-64*SIN(A2))*1.D-7
       EPSI=0.4090928D0-0.0226938D0*U-75.D-7*U**2+96926.D-7*U**3
     2      -2491.D-7*U**4-12104.D-7*U**5+(446*COS(A1)+28*COS(A2))*1.D-7
       ALON=ALON+DPSI
C*********************************************************************************
C      COMPUTATION OF THE RIGHT ASCENSION AND DECLINATION                    *
C*********************************************************************************
       CE=COS(EPSI)
       SE=SIN(EPSI)
       CL=COS(ALON)
       SL=SIN(ALON)
       CB=COS(ALAT)
       SB=SIN(ALAT)
       DELTA=ASIN(CE*SB+SE*CB*SL)*DEGREE
       ALPHA=ATAN2(-SE*SB+CE*CB*SL,CB*CL)*DEGREE/15
       IF(ALPHA.LT.0.D0) ALPHA=ALPHA+24
C*********************************************************************************
C      CONVERSION OF THE APPARENT LONGITUDE AND LATITUDE IN DEGREE           *
```

```
C****************************************************************************
      ALON=ALON*DEGREE
      IF(ALON.LT.0.D0) ALON=ALON+360
      ALAT=ALAT*DEGREE
      RETURN
      END
      SUBROUTINE CHANGE(X,IX,MX,SX)
C
C     SUBROUTINE
C              CHANGE(X,IX,MX,SX)
C     GIVES    HOURS , MINUTES & SECONDS OF TIME
C       OR     DEGREES, MINUTES & SECONDS OF ARC
C       CORRESPONDING TO THE ANGLE X
C     INPUT :: X : ANGLE
C     OUTPUT:: IX : HOURS(OR DEGREES) , MX : (MINUTES OF TIME(OR ARC),
C              SX : SECONDS OF TIME(OR ARC) CORRESPONDING TO X
C
      IMPLICIT REAL*8 (A-H),REAL*8(O-Z)
      IX=X
      MX=(X-IX)*60.D0
      SX=(X-IX-MX/60.D0)*3600.D0
      RETURN
      END
C     *********************
C     * SUBROUTINE YRMNDY *
C     *********************
C
      SUBROUTINE YRMNDY(JD,YEAR,MONTH,DAY)
      IMPLICIT REAL*8 (A-H,O-Z)
C
C THIS SUBROUTINE GIVE YEAR , MONTH , DAY CORRESPONDING TO GIVEN JULIAN
C DATE JD
C THE ALGORITHM IS COPIED FROM MEEUS'S REFERENCE
C
      REAL *8 JD ,JDT
      INTEGER *4 Z,A,ALPHA,ALPHA4,B,C,D,E,E30,YEAR
      JDT = JD+0.5D0
      Z = JDT
      F = JDT - Z
      IF(Z.LT.2299161) THEN
        A = Z
      ELSE
       ALPHA = (Z - 1867216.25)/36524.25
       ALPHA4= ALPHA/4
       A     = Z + 1 + ALPHA - ALPHA4
      ENDIF
      B     = A + 1524
      C     = (B-122.1)/365.25
      D     = 365.25*C
      E     = ( B - D )/30.6001
      E30   = 30.6001*E
      DAY   = B - D - E30 + F
      IF(E.LE.13)THEN
          MONTH = E - 1
      ELSE
```

```fortran
      IF(E.GT.13) THEN
          MONTH = E -13
      ENDIF
   ENDIF
   IF(MONTH.GT.2) THEN
       YEAR = C - 4716
   ELSE
       IF(MONTH.LE.2) THEN
       YEAR = C - 4715
       ENDIF
   ENDIF
   RETURN
   END
```

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