



The Qur'an and Laws of Planetary Motion

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Abstract

This paper is an attempt to establish the laws governing the motion of the planets and other heavenly bodies as described in the verses of the *Qur'an*. The Qur'anic descriptions of the motion of the sun, the moon and the earth are discussed in detail, and in relation to modern developments in astronomy.

Keywords: Laws of motion, shining of sun and moon, path and shape of sun

Abstrak

Melalui ayat-ayat Qur'an, usaha telah dilakukan untuk merungkaikan hukum yang mengawal pergerakan planet. Usaha ini dilakukan tanpa mengabaikan perkembangan astronomi moden. Pergerakan matahari, bulan dan bumi dibincangkan secara terperinci.

Kata kunci: Hukum gerakan, sinaran matahari dan bulan, laluan dan rupa bentuk matahari.

Introduction

Throughout the last fourteen centuries, no book has been read so widely nor has shaped the human mind as The Qur'an. The Qur'an is the book of Allah, the Wise and Worthy of all Praise. There is only one version of The Qur'an. It is the only religious book that was never altered since its revelation to Prophet Mohammed (s.a.w) about fourteen hundred years ago. This is a fact which even the critics of Islam admit. Before studying The Qur'an it must be realized that, unlike all other writings, this is a unique book with a supreme author. Its contents are not confined to a particular theme or style, but contain the foundations of the entire system of life. The word "Qur'an" means "to recite" or "to collect". Thus The Qur'an is a complete code covering all aspects of life, whether spiritual, intellectual, social, economic or scientific. These messages are spread throughout The Qur'an in a variety of ways. The Qur'an also encourages the quest for knowledge. In this context, consider the following first five verses which were revealed to Prophet Muhammad (s.a.w):

Read (Proclaim) In the name of thy Lord and Cherisher-Who created, Created man out of a leech-like clot: Proclaim! And thy Lord is Most Bountiful, He Who taught (the use of) the Pen, Taught man that Which he knew not.

(The Qur'an 96: 1-5)¹.

Allah is the Creator of everything that is present in the universe, so what are the philosophical reasons behind this creation. We have to think about these reasons. Verse 2 above states the process of creation of human being; and the truth and exact knowledge involved in any process of creation is just the definition of science. Thus verse 2 above clearly indicates that if we want to know the factuality, genuineness and reality of a creation, we then have to study science. Moreover, in these verses the Arabic word *Iqra* appears twice, while the Arabic word *Qalam* is mentioned only once. This means that one has to read more than once. That is in order to establish facts and to arrive at the right conclusion, a systematic investigation and study has to be made; which in turn has to be recorded. And this is what we mean by research. Summing up the message given by the above verses, we can say that The Qur'an invites us to make a habit of reading, writing, study and research and get knowledge of all kinds including science, self-knowledge, spiritual understanding etc. However, it may be noted that the Qur'an does not explain

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scientific theories but it provides some hints/insight on the natural phenomenon for motivation of knowledge inquiry and to guide people to faith in God (Iman).

It is for these reasons that an attempt has been made here, in the light of the verses of The Qur'an, to find out the laws that govern the motion of planets. The motion of the sun, the moon and the earth has been discussed in detail. What are the scientific reasons behind the shining of the sun and the moon? Why the sun is of spherical shape? The answers to such and similar other related questions have been discussed here with the help of the verses of The Qur'an.

Laws of motion

The Qur'an was revealed in the seventh century. There are many verses in The Qur'an which describe the scientific facts, most of which were discovered only in the last one hundred years. There is a consistency in its description of various phenomena. The verses accurately describe ideas that are in agreement with the modern observations about the universe (the verses of The Qur'an that we shall be using in this paper have been designated as V-1, V-2 etc.). Now we have

V-1: He to whom belongs the dominion of the heavens and the earth: no son has He begotten, nor has He a partner in his dominion: It is He Who created All things, and ordered them In due proportions.

(The Qur'an 25:2).

V-2: Allah is the Creator Of all things, and He Is the Guardian and Disposer Of all affairs. To Him belong the keys of the heavens and the earth:

(The Qur'an 39: 62-63).

Allah has not only created all the Worlds, but also He maintains them (according to some law) and cares for them. In verse V-1, the Arabic words *Faqaddarah Taqdeera* are used, meaning thereby "in due proportions or fixed laws"; while in verse V-2, the Arabic word *Maqaleed* is used, which means "keys or laws". Thus these two verses clearly indicate that the universe by definition, the totality of all space and matter, is governed by certain laws assigned by Allah. We can discover these laws because Allah has given us the ability to do so, and in this context, The Qur'an says:

V-3: Taught man that which he knew not.

(The Qur'an 96: 5).

The Qur'an also encourages that one should develop the scientific temperament in his approach and this is clearly indicated in the following verse.

V-4: Behold! In the creation Of heavens and the earth, And the alternation of night and day, there are indeed signs for men of understanding, -Men who remember Allah Standing, sitting and lying down on their sides, and contemplate the (wonders of) creation in the heavens and the earth, (saying): Our Lord not for naught Hast Thou created (all) this! Glory to Thee! Give us salvation from Chastisement of the fire.

(The Qur'an 3: 190-191).

A true scientist always think again and again over the problem with which he is working. It does not matter whether he is standing, sitting, lying or busy in something else. His main objective is to think over the problem in a serious manner. In verse V-4 there is an invitation for us to think, in the spirit of a true scientist, over the creation of heavens and the earth and the alternation of day and night. Allah has not created these things just for fun. There are some specific reasons, and of course some laws, for the creation of heavens and the earth. The day and night are also changing, so we have to search for these specific reasons and laws. In this context, the Qur'an says:

V-5: The sun and the moon follow courses (exactly) computed.

(The Qur'an 55: 5).

V-6: It is He who created The Night and the Day, and the sun and the moon: All (the celestial bodies) swim along, each in its Rounded course.

(The Qur'an 21: 33).

Verses V-5 tells us that the sun, the moon and all the celestial bodies are moving along their paths according to some fixed laws, or well defined scheme, assigned by Allah. The earth and the other planets too, are bound to move around the sun in a closed orbit referred in V-6 as "rounded course". If the earth is not bound to move around the sun, then there will be no question of having different seasons on the earth; so why this earth is bound to move around the sun. Is there any law for this movement? We will now try to find this law as follows:

If a particle is moving under the influence of a force which is always directed towards or away from a fixed point, then the particle is said to move under the action of a central force and such a system is known as a central force system (Ahsan 2004), (Synge and Griffith 1970). Let the sun, of mass M , be considered as a fixed point and the earth, of mass m , considered to be a particle moving along a curve under the action of a force F . Since the earth is bound to move around the sun (cf., V-6), this means that the

force acting on the earth is directed towards the sun. If the force acting on the earth is away from the sun, then the earth will not move around the sun. This force, known as the force of gravitation, obeys inverse square law and was discovered by Isaac Newton. The magnitude of this force F is given by the equation

$$F = \frac{GMm}{r^2}$$

where G is the gravitational constant and r is the distance between the sun and the earth. This is now commonly known as law of gravitation, discovered by Newton. In almost all the text books of physics, this law is mentioned as Newton's law of gravitation. In fact this is a law assigned by Allah and not by Newton- Newton has discovered it (see V-3).

The system of differential equations which gives the path of a particle in a central force system is

$$\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2 = -Fm^{-1} \quad (2)$$

$$\frac{1}{r} \frac{d}{dt} \left(r^2 \frac{d\theta}{dt} \right) = 0 \quad (3)$$

(Ahsan 2004, pp.311-317)

where r is the radius vector and θ is the angle which the radius vector makes with the axis. The solution of equations (2) and (3), using equation (1) is

$$r = \frac{ep}{1 + e \cos \theta} \quad (4)$$

(Ahsan 2004)

which is the equation of a conic section in polar coordinates (r, θ), e and p are positive constants. The conic section is an ellipse if $0 < e < 1$, a parabola if $e = 1$ and a hyperbola if $e > 1$, where e is the eccentricity of the conic section.

From verse V-6, the path of a celestial body is closed (rounded course) and the only figure which is closed (bounded) is that of an ellipse (the circle is also a closed figure, but it is a special case of an ellipse). Thus *“the earth (and the other planets too) are moving around the sun in an elliptic orbit and since the ellipse has two focus, so the sun is at one of the foci of the ellipse”*.

This is the first law of planetary motion discovered by Kepler. Moreover, equation (3) leads to

$$r^2 \frac{d\theta}{dt} = \text{constant} \quad (5)$$

which means that the areal velocity is constant (Ahsan 2004, Synge and Griffith 1970). This can alternatively be expressed as *“the radius vector, drawn from the planet (earth) to the sun, sweeps out equal areas in equal interval of time”*.

This is the second law of planetary motion discovered by Kepler (1571-1630). The third law of planetary motion can be obtained from equation (5) and the geometrical properties of the ellipse, and is given by

$$T^2 \propto a^3$$

where T is the time required for the planet to make one complete revolution about the sun and a is the semi-major axis of the elliptical orbit.

Motion of the sun and the earth

The motion of the sun and the moon has been mentioned in The Qur'an at a number of places. For example, The Qur'an makes the following statement about the sun and the moon:

V-7: *And the Sun Runs unto a resting place, for him: that is the decree of (Him), the exalted in Might, the All-Knowing. And the moon,-We have measured for her Stations (to traverse) Till she returns Like the old (and withered) Lower part of a date-stalk. It is not permitted to the Sun to catch up The Moon, nor can The Night outstrip the Day: Each (just) swims along in (its own) orbit (According to Law)*

(The Qur'an 36: 38-40).

V-8: *It is Allah Who alternates The Night and the Day: Verily in these things Is an instructive example For those who have vision!*

(The Qur'an 24: 44).

Wherever in The Qur'an, the motion of the sun and the moon (and all the celestial bodies) are mentioned (cf., V-6 to V-8), the word “swim” is used for the movements of the celestial bodies. This word may be referred to as not only describing the uniform translatory motion, but also rotational motion. One can visualize these motions by sliding a soccer ball on the surface of water, the ball will undergo translatory as well as rotational movements. This also suggests

that most of the celestial objects are spherical in shape. So the motions of the sun and the earth are translatory as well as rotational. Moreover, the sun is not only moving around the galaxy but also rotating about its axis; and it takes nearly twenty five days for one complete rotation about its axis. This can be checked very easily by looking at the changing positions of the sun spots. The alternation of day and night is due to earth's rotation on its axis.

From our present knowledge of Astronomy, it is known that the sun and other stars in the neighbourhood of our solar system revolve slowly around the centre of the galaxy. In the course of this motion, our solar system completes one full turn around the galaxy in about 250 million years covering a distance of nearly one million trillion miles in that time at an average speed of 150 miles / second. The entire galaxy, carrying earth with it, is moving through space relative to other nearby galaxies. As a consequence of this motion, our galaxy and the Andromeda galaxy (galaxy nearest to us at a distance of 10^6 light years; one light year is equal to 9.46×10^{12} km) are approaching one another at a speed of 180 miles / second. The earth is carried along with our galaxy in this motion. Thus, even the motion of the earth is very complicated. It rotates about its axis, revolves around the sun, moves with the sun around the centre of the galaxy and moves with the galaxy on its journey towards Andromeda.

Ibne Shatir, a twelfth century mathematician and astronomer, gave a hypothesis that the earth was not at the centre of the universe and it was the sun which was at the centre of the universe and the planets were moving around the sun. He proved it by trigonometry (cf., <http://www.islamiska.org/e/Astro.htm>). Later on this theory was restated by Nicolas Copernicus (1473-1543) to Europeans and even today the credit is given to Copernicus. It was only in the beginning of the twentieth century that the sun was found to be located in one of the arms of our spiral galaxy and thus lost the pride position of being at the centre of our universe. It (the sun) just becomes one of the billions of stars in our galaxy. The solar system (the sun, the planets, the large number of minor planets between Mars and Jupiter-called Asteroides, large number of comets and meteors) is a part of our galaxy. In comparison to the sun, the earth appears like a dot; and if we compare the sun with the universe then our sun is buried deep within the Orion arm about 26000

light years from the centre of our milky way galaxy. Our own milky way galaxy contains about ten thousand crore stars like our sun. Besides our own galaxy there are billions of galaxies in the universe, each containing similarly large number of stars. Although the milky way galaxy is but one of the billions of galaxies in the universe, the milky way galaxy has special significance to us as it is the home of our solar system.²

How the sun/moon shine?

Having known about the motion of the sun and the moon, now let us find out the reasons behind the shining of these objects. In this connection, we have the following verses of The Qur'an:

V-9: *It is He who made the sun to be a shining glory and the moon to be a light*

(The Qur'an 10: 5).

V-10: *Blessed is He Who made Constellations in the skies, And placed therein a Lamp And a Moon giving light*

(The Qur'an 25: 61).

V-11: *See ye not How Allah has created the seven heavens one above another, and made the moon A light in their midst, And made the sun as a (Glorious) Lamp?*

(The Qur'an 71: 15-16).

V-12: *And placed (therein) a blazing Lamp*

(The Qur'an 78: 13).

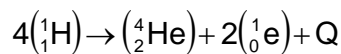
In verse V-9, the Arabic word *dhiya* is used for sun and *nur* for the moon. The word *dhiya* means 'own light', while the *nur* stands for 'borrowed light'. Thus verse V-9 clearly indicates that the sun has got its own light while the moon is shining due to borrowed light. In verse V-10, the Arabic word *siraj* (which means Lamp) is used for the sun while for moon the Arabic word *munir*, which means reflection of light, is used. The sun is mentioned here as a lamp, while the moon shines due to the reflection of light. While in verses V-11 and V-12, the sun is mentioned as a glorious and blazing lamp, respectively. Thus, from these verses it is clear that the sun is a lamp which is

shinning due to its own light, while the glow of the moon is due to the reflection of light. But for a blazing lamp a proper fuel is required. Since in space oxygen based combustion is not allowed, so what should be the nature of the fuel that keep the lamp (the sun) shinning continuously. The hint for such a fuel is mentioned in following verse of Al Qur'an.

V-13: *Allah is the Light Of the heavens and the earth. The parable of His light Is as if there were a Niche and within it a Lamp: The lamp enclosed in Glass: The glass as it were a brilliant star: Lit from a blessed Tree, an olive, neither of the East nor of the West, Whose Oil is well-neigh Luminous, though fire scarce touched it: Light upon Light! Allah doth guide whom He will to His Light: Allah dot set forth Parables for men: and Allah Doth know all things.* (The Qur'an24: 35).

In this verse, the lamp (enclosed in a glass) is shinning like a brilliant star whose fuel is that which can light (ignite) itself even though the fire has not touched it. From modern science, it is now known that such a fuel is the nuclear fuel produced by the nuclear fusion reaction which is explained as follows:

The process by means of which two or more nuclei of lighter atoms combine to form a heavy nucleus with a release of enormous amount of energy is called nuclear fusion. In this reaction, lighter nuclei fuse in the star to produce heavier nuclei with the release of a large quantity of heat; and the chemical equation for such reaction is



Here four protons (nuclei of hydrogen atom) fuse to give helium nuclei, two positrons (positive electrons) and a large amount of heat Q. For fusion reaction to begin in star, the star should have a minimum temperature requirement of 4×10^6 °C (cf., Narlikar 1978).

It is known that the sun is a ball of flaming gases containing 70 percent of hydrogen, 28 percent of helium and 2 percent of heavier gases like carbon, nitrogen, oxygen etc. The radius of the sun is almost hundred times that of the earth (radius of the earth is 6378.14 km) and the mass about a million times that of earth (mass of the earth is 6×10^{24} kg). The surface temperature of the sun is 6000 °C, while the temperature at the centre is 15×10^6 °C and the

density at the centre is 10^4 kg/m³. Very high temperature on the sun's centre and very high pressure on it provide ideal conditions for nuclear fusion. Since the sun is a star, almost all the stars produce their energy through the process of nuclear fusion and hence we can say, in the light of these discussions and verses V-9 to V-13 that: The sun is shinning due to its own light which is produced through the nuclear fusion reaction, while the moon is shinning due to the reflected light from the sun.

Rising/setting of sun

East and west are the two extreme points of the rising and setting of the stars (the sun is also one of the stars of the sky) and the celestial bodies. Since the rotation of the earth is from west to east, so every celestial object appears to rise from the east and appears to set in the west. Now let us find out what The Qur'ansays about the rising and setting of the sun (and the celestial objects). From Al Qur'an, we have

V-14: *To Allah belong the East and the West.* (The Qur'an 2: 115).

V-15: *(He is) Lord of Easts and Lord of Wests.* (The Qur'an55: 17).

V-16: *Now I do Call to witness the Lord of all points In the East and the West.* (The Qur'an70: 40).

A possible interpretation of these verses (V-14 to V-16) in the context of the sun (and the celestial objects) is as follows:

In verse V-14, the Arabic words *mashriq* and *maghrib* are used, which mean one east and one west; while in verse V-15, the Arabic words *mashriqain* and *maghribain* are used, which mean two east and two west. In verse V-16, the Arabic words *mashariq* and *magharib* are used, which mean number of east and west. The sun rises exactly from the east and sets exactly in the west on vernal and autumnal equinoxes (March 21st and September 23rd) and thus the sun has exactly one east (*Mashriq*) and one west (*Maghrib*) on these two occasions. The sun rises from the middle point of east and south and sets at the middle point of south and west on December 22nd (winter solstice); while on June 21st (summer solstice), the sun rises from the middle of east and north and sets in the middle of west and north. Thus on December 22nd

and June 21st, the sun has got two east (*Mashriqain*) and two west (*Maghribain*). But the sun is rising and setting every day, so it has number of east (*Mashariq*) and number of west (*Magharib*). These discussions not only indicate that everyday the rising and setting points of the sun are different, but also that every celestial body (and sun is one of them) has its own well defined path [see also (Jaffereys and Robins 1981) and (Pananides 1974)].

Path of the sun

Once we have seen that the sun rises from different points in different parts of the year, now let us find out the path which the sun follows during its course of movement in the sky. The following verse of the Qur'an provides a clue for the path of the sun:

V-17: *By the Sky, with its constellations* (The Qur'an85: 1).

The glorious sky with its constellations is mentioned here. The bright stars linked to a certain geometrical pattern are known as constellations. More than 88 constellations have so far been identified by the astronomers. These constellations are spread throughout the sky and are connected with the seasons and months of the year [cf., (Ahsan 2004 a) and (Jaffereys and Robins 1981)]. A sound knowledge about their appearance in the sky proves helpful in the study of navigation sciences and related areas. These constellations may be twelve signs of zodiac or may be some other constellations such as Big Dipper, Orion, Cygnus, Hercules, Perseus, Canis Major, Lyra, Aquila etc.

V-18: *Blessed is He Who made Constellations in the skies, And placed therein a Lamp And a Moon giving light* (The Qur'an25: 61).

The glorious lamp of the sky is the sun and next to it, is the moon. The path of the sun (which is known as ecliptic) is defined in this verse. The sun apparently moves around the sky once every year, and in the process passes through the constellations which are known as signs of zodiac. The twelve signs of zodiac (along with the dates in which the sun appears in a particular sign) are: Aquarius (Jan. 20 - Feb. 17), Pisces (Feb. 18 - Mar. 19), Aries (Mar. 20- Apr 19),

Taurus (Apr. 20 - May 20), Gemini (May 21 - June 20), Cancer (June 21 - July 22), Leo (July 23 - Aug. 22), Virgo (Aug. 23 - Sept. 22), Libra (Sept. 23 - Oct. 22), Scorpius (Oct. 23 - Nov. 21), Sagittarius (Nov.22- Dec. 21), Capricorn (Dec. 22 - Jan. 19).

Thus, for example between September 23 and October 22, the sun is in the zodiac sign Libra etc³. It may be noted that the moon moves in an orbit, the plane of which is inclined to the plane of ecliptic (path of the sun) at an angle of about 5°. Since this angle is small we can neglect it, and assume that the path of the moon always lies on the ecliptic. That is the path of the moon, on a particular day, is same as the path of the sun. This helps us to locate the position of the crescent moon for any particular Islamic month. The path of the moon crosses the ecliptic twice every month, and it is at these crossing points the eclipses occur.

Shape of the sun

From the above discussions, we have seen that everyday the sun is rising as well as setting from a different point in the sky. If we look at the sun, either at the time of rising or setting, the sun appears to be a red/orange colour spherical object. So, why the shape of the sun is spherical? We will now find an answer for this. The Qur'ansays

V-19: *And He hath made subject to you the sun and the moon, both diligently perusing their courses;* (The Qur'an14: 33).

The sun and the moon are working for the mankind according to some fixed law. Sun dominates the solar system and is the cause of heat, energy and physical life for the whole solar system. Earth receives almost all the energy from the sun. Fortunately, we are receiving the right proportion of energy. A little less or more would have made our life impossible on the surface of the earth. Allah is the Absolute Creator, so He can create the sun in any shape (for example, rectangular, triangular, elliptical or any other irregular figure etc.). Why Allah Has Created the sun in spherical shape? The reason for this, in two dimensional case, can be given by the following problem of calculus of variations (a branch of mathematics): *"Of all the closed non-intersecting curves of given length (perimeter), find the one which encloses maximum area."*

The solution of this problem turns out to be a circle

[cf., (Ahsan 2004, pp. 474)]. While for a three dimensional case, the above problem can be stated as “Of all the surface of revolutions with a given surface area, find the one which encloses maximum volume.”

The solution of this problem comes out to be a sphere. If the sun has not got the shape of a sphere, we would never be able to receive the right amount of energy and heat etc. from the sun at each and every point on the earth; and thus there would be no question of life on this earth.

Conclusion

The laws describing the motion of the planets were first discovered by Kepler and then by Newton. In this paper, we have formulated these laws from the perspective of The Qur'anic verses. Considering a number of verses of Al Qur'an, the motions of the sun, the moon and the earth are discussed and it is found that the motions of the sun and the earth are translatory as well as rotational. An attempt has also been made to find the reasons responsible for the shining of the sun and the moon; and it is observed, through the verses of The Qur'an, that the sun is shining due to its own light which is produced through the nuclear fusion reaction while the moon is shining due to the reflected light from the sun. Further, it is found that everyday the rising and setting points of the sun are different, and that every celestial body (and sun is one of them) has its own well defined path. It is seen that the paths of the sun and the moon are through the constellations which are known to be sign of zodiac. Allah has created every thing with a genuine reason and law. From the verses of The Qur'an and the results of calculus of variations (a branch of mathematics), we have found the reason about the spherical shape of the sun.

Thus we have seen that whatever scientifically established facts (about the sun, the moon and the earth etc.) that are available today, we can find their indications/hints in the Qur'an which have been revealed some fourteen hundred years ago. This is nothing other than a miracle for the believers. A learned reader will always find in Al Qur'an, the scientific truths and realities; and we confidently hope and expect that as the knowledge in various fields advance, other Qur'anic statements will likewise prove true. It may, however, be noted that not every discovery of modern science has been revealed in Al Qur'an. Of course, the holy Qur'an has provided every thing that is necessary for human success in this life and the Next.

These discussions convince us to think about the Knowledge and Power of The Creator. Ever ponder over the signs of the Creator? All Praise must be to the Lord of the Universe, The Almighty, The All-Knowing, The Omnipotent. Now imagine the Knowledge and Power of the Creator of this universe and then imagine our own place in this universe whose boundaries are yet to be discovered.

REFERENCES

- Ahsan, Zafar, *Differential Equations and Their Applications*, New Delhi: Prentice Hall of India, 2nd Edition 2004.
- Ahsan, Zafar, The Qur'an and Modern Theories of the Universe, Islamic Culture, Vol. LXXVIII, No. 4, 25-50, 2004.
- Jaffereys, W.H. and Robins, R.P., *Discovering Astronomy*, Toronto: John Wiley, 1981.
- Narlikar, J.V., *The Structure of the Universe*, Oxford: Oxford University Press, 1978.
- Pananides, N.A., *Introductory Astronomy*, California: Addison Wesley Publishing Company, 1974.
- Synge, J.L. and Griffith, B.A., *Principles of Mechanics*, Singapore: 3rd Ed. McGraw-Hill Book Company, 1970.

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NOTES

¹ The English version of these verse and the verses that appeared in this paper are taken from “The Holy Qur'an - English translation of the meanings and commentary. Revised and Edited by the Presidency of Islamic Researches, Ifta, call and Guidance. The Custodian of the Two Holy Mosques, King Fahad Complex For the Printing of The Holy Qur'an. P.O.Box 3561, Al-Madinah al-Munawwarah, Kingdom of Saudi Arabia (1413 Hijri)

² For a detailed account of the shapes, sizes and physical properties of other galaxies of the universe, see (Jaffereys and Robins 1981) and (Narlikar 1978).

³ For more details about the motion of the sun, see (Jaffereys and Robins 1981) and (Pananides 1974).