Calculate the Longitude and Orbital Motion for Amaletha, Europa, Ganymede and Callisto Satellites

Rasha H. Ibrahim*
Department of Astronomy and Space, College of Science, University of Baghdad. Baghdad,Iraq

Abstract
The orbital motion and longitude for some Jupiter's satellites (Amaletha, Europa, Ganymede and Callisto) were calculated from two different locations Iraq and Syria. A program was designed, the input parameters were the desired year, month, day and the longitude of the location, the output parameters results were applied in form of a file, and this file includes the longitude, orbital motion, and local time of these satellites. A specific date 1-10-2013 was taken, the results of longitude was (20-336) º and orbital motion was (92-331) º for both Iraq and Syria location with observing time (05:24:14-15:18:10) for Iraq and (04:56:33-14:50:30) for Syria. The difference in time between the two locations was constant (00:45:00), these results were compared with the results of Gilbert in 1974, but he worked only on the longitude with respect to the universal time, which his values was (34-296)º.

Keywords: Galilean Satellites, Longitude and Orbital Motion of Amaletha, Longitude and Orbital Motion of Europa.

حساب خط الطول وحركه الاقمار اماليثا و يوربا وجاينيميد و كاليستو

رشا هاشم ابراهيم
قسم الفلك والفضاء، كلية العلوم، جامعة بغداد

الخلاصة:
في هذا البحث, تم حساب خط الطول والحركة لبعض اقمار كوكب المشتري (اماليثا و يوربا وجاينيميد و كاليستو) من موقعيين مختلفين, بواسطة تصميم برنامج. كانت معاملات الادخال السنه والشهر واليوم المطلوبين من قبل الراصد وخط الطول للموقع تعرض النتائج في فايل يتضمن هذا الفايل خط الطول وحركة الاقمار والتوقيت المحلي. اخذ تاريخ 1-10-2013 لعرض النتائج. كانت نتائج خط الطول (20-336) درجة وحركة الاقمار (92-331) درجة للموقعيين العراق وسوريا وبزمن رصد للعراق (05:24:14-10:18:10) و (04:56:33-14:50:30) لسوريا ,كان فرق الوقت بين الموقعين (00:45:00) وهو ثابت. قورنت هذة النتائج مع نتائج غيلبرت في العام 1974 لكنه عمل فقط على خط الطول معتمد على التوقيت العالمي وكانت قيم خط الطول (34-296) درجة.

Introduction:

On January 7, 1610 Galileo pointed his new telescope at Jupiter's planet. He saw not only Jupiter, but also what he described as three small stars. After that he found another small star. By the end of January, Galileo proved there were four new plants orbited around Jupiter; he named them according

*E-mail: rasha_hashimi@yahoo.com.

to their distance from Jupiter Io, Europa, Ganymede and Callisto. They became known as the Galilean satellites. They are among the largest satellites in the solar system [1, 2].

Pioneer 10 spacecraft reached its closest approach of $2.84R_J$ from the center of Jupiter; it was traveled through Jupiter's magnetosphere, measured its magnetic field and trapped radiation belt particles. The magnetic coordinates of Jupiter innermost satellites had been calculated, when the spacecraft passed through the L shell of each of these satellites [3]. Io was the only satellite in the solar system that was responsible for the radio emission to occur through its rotation around Jupiter's planet [4], that is firstly discovered by Bigg in 1964 [5]. Later were found that Io and Europa generated an auroral emission, originating at the foot of either Io's or Europa's magnetic flux tube, are mainly limited to longitude where Jupiter's inospheric conductivity is better [6,7]. The arrangement of the orbits of the Galilean satellites of Jupiter induces phenomena between the satellites themselves twice each Jovian year of 11.6 year [8]. The polar metric measurements of the Galilean satellites with U, B, V and R filters at phase angles ranging from nearly 0º to 12º , the polarization phase curves of Io,
Europa and Ganymede in the B, V and R filters obviously show the existence of the polarization opposition effect in the form of the sharp peak of negative polarization centered at very small phase angle between (0.6-0.7)º and superimposed on the negative polarization [9]. In 2002, Robin and William applied some properties of Galilean satellites like the mass, temperature and orbital period [10], while Woolfson studied the formation of regular satellites [11]. In this paper, the coordinates of Amaletha, Europa, Ganymede and Callisto had been calculated at a specific local time, day and month for two different locations with respect to the observer on the Earth.

Longitude, Orbital Motion and Time:

The majority of larger planetary satellites have the characteristic that they are in closely circular direct orbit, or close to the equatorial plane of the planet. It is commonly assumed that the formation of the regular satellites is linked to the formation of the planet [11], with respect to Amalthea satellite; it lies inside the orbit of Io, not consider as a part of the Galilean satellite [1]. The longitude (λ) of Jupiter satellite is measured clockwise starting from the meridian this point in the direction of Jupiter's planet, while the orbital motion (Φ) is measured counterclockwise, as shown in figure-1 [12].

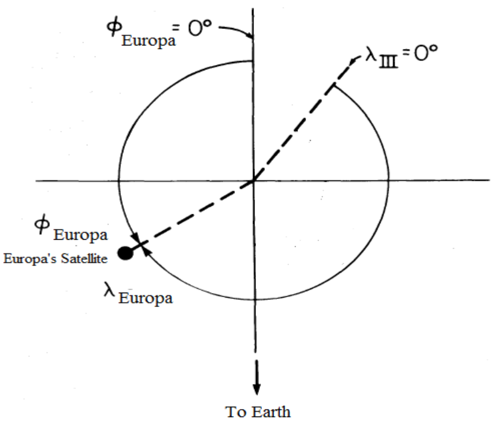


Figure 1- Explains the longitude and the orbital motion of Europa [6].

Each satellite completes one full crescent during one co-rotation period, which means the longitude of the satellites increases by 360º. After co-rotating for the Earth Jupiter light-time and using the mean synodic period of each satellite, their east solar orbital motion are given by [3]:

Φ (Amalthea) =49º +722º.55T ...... (1)

Φ (Europa) =52º +101º.29T ……... (2)

Φ (Ganymede) =351º +50º.23T .... (3)

Φ (Callisto) =47º +21º.49T ……... (4)

The longitude of the satellites that is measured from the meridian of Jupiter is given by [3]:

λ (Amalthea) =223º +14 º.91T ...… (5)

λ (Europa) =284º +667º.05T ..…... (6)

λ (Ganymede) =281º +820º.22T ..… (7)

λ (Callisto)=225º +848º.96T …... (8)

Where T: is the Julian date that is given by[13]:

$$JD = INT(365.25 \times y) + INT((m+1) \times 30.6001) + d + b + 1720994.5 \quad .. (9)$$

Where:

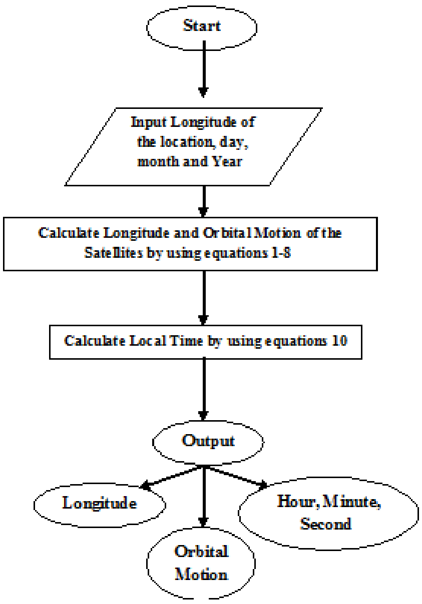
b: is Gregorian calendar,Y: is the year,M: is the month,d: is the day. It is often convenient in making astronomical calculations to use UT to deduce the LT in hours by [14]:

$$L.T. = U.T. + \left(\frac{L_{Location}}{15°}\right) \quad .... (10)$$

Where:

U.T.: is the universal time measured in hours, $L_{Location}$: is the longitude of the location measured in degrees (Iraq=44°E and Syria=37°E, www.Google Earth.com.).

Methodology:



Results and Discussion:

In this paper, the longitude and orbital motion of Amaletha, Europa, Ganymede and Callisto satellites at specific local time, and date. A program was designed to calculate them; the input parameters of the program were the desired day, month and year that were chosen by the user and longitude of the location with respect to the observer on the Earth. The output parameters results were applied in a form of file; this file includes the longitude and orbital motion of these satellites and local time. Each satellite completes one cycle around itself in range (0-360)º, the same for the orbital motion, which the satellite completes also one cycle but around Jupiter. figure-2 and figure-3 show the results at specific date that is 1-10-2013 from two different locations (Syria and Iraq), the values of longitude were (20-336)º and orbital motion were (92-331)º, this varying is taken hourly with respect to the observer during the rotation of these satellites, they are increasing and decreasing randomly between (0-360)º, while the local time was (04:56:33-14:50:30) for Syria location, and (05:24:14-15:18:10) for Iraq location. The local time of observing them depends on the longitude of the observer.

These results were compared with results of Gilbert in 1974, but he worked only on the longitude, which was between (43-296) º, he depended in his work on the universal time. This program can applied for any desired date and any location. Some results are shown in table-1 and table-2 for multi dates. The difference between times of the two locations was constant (00:45:00) for both longitude, as equation (11) and the orbital motion, as equation (12).

$\Delta t_{\lambda} = t_1 - t_2$ .... (11)

$\Delta t_{\Phi} = t_3 - t_4$ .... (12)

Where: t_1 and t_2 are the time of longitude for Iraq and Syria locations respectively 04:56:33, 05:24:14, which are the first column in figure-2 and figure-3. Therefore the difference (Δt) is (00:45:00). The same for the orbital motion, t_3 and t_4 are the time of orbital motion for Iraq and Syria location respectively 05:50:30, 06:18:10, which are the second column. Therefore the difference (Δt) is also (00:45:00).

Figure -4 shows the difference in local time for twelve hours, which is constant; this difference is constant along the current year and any other year. For another location with respect to Iraq or Syria location this value is not constant, it is changing according to the location.

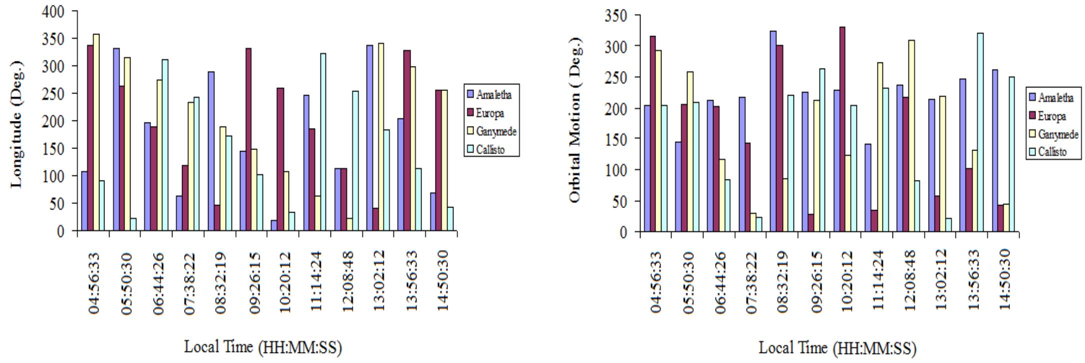


Figure 2- Time of observing the longitude and orbital motion Amaletha, Europa, Ganymede and Callisto satellites for Syria location.

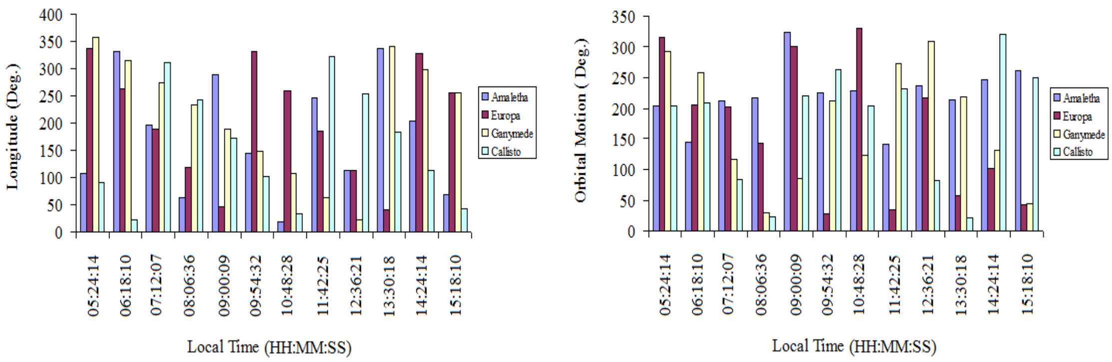


Figure 3- Time of observing the longitude and orbital motion Amaletha, Europa, Ganymede and Callisto satellites for Iraq location.

Table 1- The longitude and orbital motion of Amaletha, Europa, Ganymede and Callisto satellites for Syria location for multi dates.

Name of Satellites	Date	LT (HH:MM:SS)	λ (Deg.)	Φ (Deg.)	Name of Satellites	Date	LT (HH:MM:SS)	λ (Deg.)	Φ (Deg.)
Amaletha	1-12-2000	20:05:12	32	149	Amaletha	8-8-2010	21:14:21	50	134
Europe			88	250	Europe			190	80
Ganymede			45	11	Ganymede			34	66
Callisto			200	109	Callisto			330	129
Amaletha	22-10-2006	03:00:00	206	22	Amaletha	13-8-2012	12:27:25	30	60
Europe			33	111	Europe			333	311
Ganymede			144	255	Ganymede			121	70
Callisto			122	239	Callisto			78	23

Table 2- The longitude and orbital motion for Amaletha, Europa, Ganymede and Callisto satellites for Iraq location for multi dates.

Name of Satellites	Date	LT (HH:MM:SS)	λ (Deg.)	Φ (Deg.)	Name of Satellites	Date	LT (HH:MM:SS)	λ (Deg.)	Φ (Deg.)
Amaletha	1-12-2000	20:50:12	32	149	Amaletha	8-8-2010	22:59:21	50	134
Europe			88	250	Europe			190	80
Ganymede			45	11	Ganymede			34	66
Callisto			200	109	Callisto			330	129
Amaletha	22-10-2006	03:45:00	206	22	Amaletha	13-8-2012	13:12:25	30	60
Europe			33	111	Europe			333	311
Ganymede			144	255	Ganymede			121	70
Callisto			122	239	Callisto			78	23

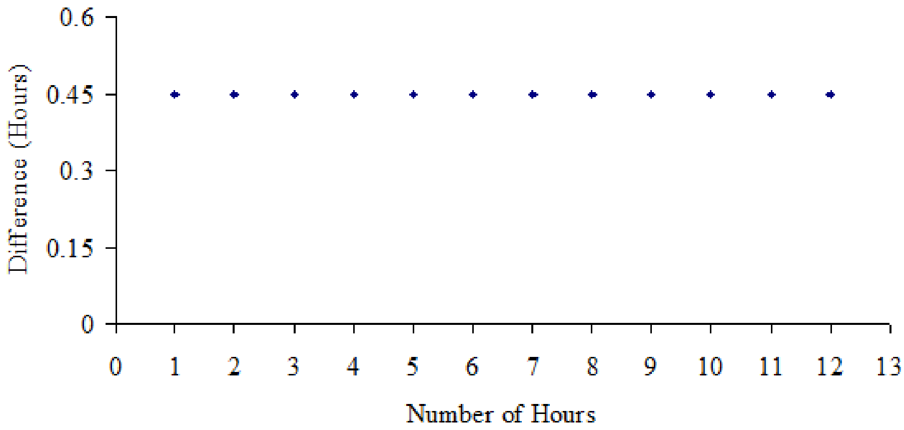


Figure 4- Explains the difference in time between the two locations.

Conclusion:

The varying in values of longitude and orbital motion of each satellite depends on two significant parameters: the motion of each satellite around itself and Jupiter's planet, they are affected by the gravitational force of the massive planet in the solar system, like Jupiter because the closer satellite affects by the gravitational force of the planet more than the far satellites, this will effect on the values of longitude and orbital motion during their rotation. The local time depends on the longitude of the location, when the longitude of the observer decrease, the observer can observe them in an early time, so the observer on Syria location ($L_{Location}$=37°E) can observe them in an early time more than observer observes from Iraq location ($L_{Location}$=44°E). The difference in time is constant all over the other years not only the current year; moreover the year is not effect on the longitude and orbital motion of these satellites.

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