NEW MOON DATES AND COORDINATES

Mohammed J. F. Al Bermani, Hayder H. J. Al Baghdadi
Department of physics, College of Science, University of Kufa. Kufa-Iraq

Abstract

Computer simulation have been developed to calculate the dates, ecliptical, equatorial and horizontal coordinates every month at al Najaf holy city. The new moon starts at the moment when the ecliptic longitude of the sun matches that of the moon, i.e., the difference between them vanishes. The program can be used to predict the birth dates of the moon for the next ten year or more.

تاريخ ولادة القمر الجديد وإحداثياته

محمد جعفر فاضل البيرماني، حيدر حسن جواد البغدادي
قسم الفيزياء، كلية العلوم ، جامعة الكوفة. الكوفة-العراق

الخلاصة

تم في هذا البحث تطوير برنامج حاسوبي لحساب تواريخ ولادة القمر الجديد في كل شهر وموقعه نسبة للإحداثيات البروجية فضلا عن الإحداثيات الاستوائية والافقيه لمدينة النجف الاشرف. حيث يحدد تاريخ ولادة القمر في أي لحظه عند حصول توافق بين خط الطول البروجي لكل من القمر والشمس اى عند تلاشي الفرق بينهما. وقد تمكنا من توقع ولادة القمر لعشر سنين قادمة بدقة عالية.

1:Introduction

The moon turns its unilluminated face toward the Earth forming the New Moon in approximately every 30 days. An observer looking down on the north pole of the ecliptic would see the Sun, Moon and Earth in a straight line. At the time of New Moon, the moon is usually above or below the Earth's orbital plane , so that it's shadow misses the Earth.. The Moon crosses the ecliptic plane on two times each month, but one of these dates coincides with New Moon, then the Sun, Moon and Earth are in line. The time of New Moon is the moment when the difference between ecliptic longitudes of the Sun and Moon disappears. The mean interval between successive New Moons, the synodic period, is found to vary between 29.26 to 29.80 days or on the average of 29.53 days due to perturbation effects, at that interval the moon passing through a four states that called moon phases the first phase is first quarter a week later from new moon the second is full moon two weeks later and the third quarter ,these phases differ from each other by the area of the segment where waxes(The circumstance when the phase of the Moon is increasing from new to full)[1] until reach the full moon then begin decreasing to wane. The orbit of the Moon is inclined with respect to the ecliptic plane over the course of the year between the mean angles.. $-5^{\circ}9' to +5^{\circ}9'$.

The lunar theory was developed by E.W. Brown at the beginning of the 20th century [2] which described the lunar motion analytically. Lunar ephemeris were improved by the Nautical Almanac in 1954. for long time the relevant tables [3] were the basis for calculation of lunar coordinates, recent progress in computer technology and new requirement for accuracy of lunar ephemeris stimulated further studies to improve (Hill_Brown) method and series [4,5] as well as on the development of new analytical theories of lunar motion [6,7,8,9,10,11,12,13,14,15,16] at the same time numerical ephemerides of moon have been successfully developed ,among them the most recent and accurate are the ephemerides of DE/LE-series don at the jet propulsion laboratory JPL ,USA [17,18,19,20,21] the ephemerides of EPM-series don at Russian institute of applied astronomy [22,23,24,25,26] and ephemerides of INPOP-series done at IMCCE observatiore de Paris ,France [27]. Empirical formulas for predicting the New Moon by crescent sighting were put forward by [28,29,30,31,32 ,33].

In this paper, the dates of New Moon, and their corresponding ecliptic coordinates at the Al Najaf Al Alshraf holy city are calculated by computer simulation .The predicted dates and coordinates are estimated for the next ten years with high precession.

2.Theoretical model

We can determine the dates of the new moon for every month and then investig the position of the moon relative to the ecliptic. The time of new moon is the moment when the ecliptic longitude of the sun and moon (λ_s and λ_m respectively) agree, i.e. when the difference ($\lambda_m - \lambda_s$) disappear. The latter for its part consists of the difference D between the mean longitude plus the difference between the periodic perturbations [2]

$$\lambda_m - \lambda_s = D + (\Delta\lambda_m - \Delta\lambda_s) \quad \text{-------------(1)}$$

$$D = D_\circ + D_1 T \quad \text{---------------(2)}$$

$$D = 297.85027 + 445267.11135 T + 0.00143 T^2 \quad \text{----------(3)}$$

$$T = (JD - 2451545)/36525 \quad \text{----------(4)}$$

Where T is the Julian century, JD is the Julian date and D is the elongation also D_1 indicates the amount of change in D over a Julian century the mean interval between two successive new moon i.e. the time in which D alters by 360º is found to be 29.53 days approximately. This enables the approximates times of new moon through the year to be simply The periodic perturbations of the lunar and solar orbits very little over short period of time Δt, which means that over that interval $\lambda_m - \lambda_s$ essentially varies only D_1. $\Delta t/36525^d$ an approximation $t_\circ$ for the time of new moon can therefore be improved by using

$$t_1 = t_\circ - \frac{D(t_\circ) + (\Delta\lambda_m(t_\circ) - \Delta\lambda_s(t_\circ))}{D_1} \quad \text{------(5)}$$

If this step is repeated then the time of new moon is determined to a sufficient degree of accuracy, λ_s and λ_m may be determined by short series expressions involving the longitudes and anomalies of the sun and the moon[1].

$$l = 134^\circ.96292 + 477198^\circ.86753.T + 33^\circ.25.T^2 \quad \text{-----------(6)}$$

$$l' = 357^\circ.52543 + 35999^\circ.04944.T - 0.58.T^2 \quad \text{------------(7)}$$

$$F = 93^\circ.27283 + 483202^\circ.01873.T - 11^\circ.56.T^2 \quad \text{------------(8)}$$

$$L_0 = 218^\circ.31617 + 481267^\circ.88088.T - 0.001127.T^2 \quad \text{--------(9)}$$

Where l, l', F, L_0 are the moon's mean anomaly ,the sun's mean anomaly.mean distance of the moon from the ascending node and the mean longitudeofthemoon

$$\Delta\lambda_m = 6.288^\circ \sin(l) - 1.2738^\circ \sin(l - 2D) + 0.6583^\circ \sin(2D) + 0.2136^\circ \sin(2l) - 0.1855^\circ \sin(l') \quad \text{---------------------------------(10)}$$

$$\Delta\lambda_s = 1.9147^\circ \sin(l') + 0.02^\circ \sin(2l) \quad \text{------(11)}$$

The ecliptic latitude and the longitude of the moon can also be expressed by a similar equation

$$\beta = 5.128^\circ \sin(F) + 0.2805^\circ \sin(l + F) + 0.2777^\circ \sin(l - F) - 0.1733^\circ \sin(F - 2D) - 0.05527^\circ \sin(l - F - 2D) - 0.04638^\circ \sin(l + F - 2D) + \ldots \quad \text{-----------------(12)}$$

$$\lambda_m = L_0 + \Delta\lambda_m \quad \text{----------------(13)}$$

Also the ecliptic longitude of the sun is given as follows[34]

$$\lambda_s = 279^\circ.69688 + 36000^\circ.76892.T + 0^\circ.0003025.T^2 + 1.91946\sin(l') - 0.004789.T\sin(l') - 0.000014.T^2\sin(l') -- + 0.020094\sin(2l') - 0.0001.T\sin(2l') + 0.000293\sin(3l')$$

(14)

There is another way we use it to compute the ecliptic coordinates of the moon firstly by solving Kepler equation using iteration formula [35,34].

$l = E - e.\sin E$ ------------------------------(15)

Then the true anomaly can be calculated by the formula.

$$\tan(\nu/2) = \sqrt{\frac{1+e}{1-e}}\tan(E/2) \text{ ----------------(16)}$$

Where E, e, ν the eccentric anomaly ,eccentricity and true anomaly of the moon, then we compute the rectangular (x,y) coordinates in the plane of lunar orbit where computed[36].

$$x = r.\cos\nu$$
$$y = r.\sin\nu$$
$$r = \sqrt{x^2 + y^2}$$
$$\nu = \tan^{-1}(y/x) \text{ ------------------------(17)}$$
$$e = 0.05554552$$
$$r = a'(1 - e.\cos(E))$$

Where r, a' is the radial distance and semi major axis, In order to convert the coordinates from the plane of lunar orbit to the moon ecliptic coordinates (x,y,z)system[35, 36].

$$x_{ecl} = r.(\cos\Omega.\cos(\nu+\omega) - \sin\Omega.\sin(\nu+\omega).\cos i)$$
$$y_{ecl} = r(\sin\Omega.\cos(\nu+\omega) + \cos\Omega.\sin(\nu+\omega).\cos i)$$
$$z_{ecl} = r.\sin(\nu+\omega).\sin i$$

---(18)

Where Ω, ω, i longitude of ascending node of moon, argument of perihelion and moon inclination[37,2].

$$\Omega = 125^\circ.0.44555 - 1935^\circ.53315\ .T + 0^\circ.0017672\ .T^2$$
$$\omega = 318^\circ.308688 + 6003^\circ.149886\ .T + 0^\circ.00886546\ T^2$$
$$i = 5^\circ.15668983$$

Then the ecliptic longitude and latitude are given by[2].

$$\lambda_m = \tan^{-1}(y_{ecl}/x_{ecl}) + \Delta\lambda_m$$
$$\beta = \tan^{-1}(z_{ecl}/r) + \Delta\beta_m$$

-------------(19)

Where $\Delta\beta$ is the perturbation in moon latitude[33]

$$\Delta\beta_m = -0.173\sin(F-2D) - 0.055\sin(l-F-2D) - 0.046\sin(l+f-2D) + 0.033\sin(F+2D) + 0.017\sin(2l+F)$$

------------------(20)

The calculation of the moon equatorial coordinates needs conversion of ecliptic coordinates into rectangular coordinates (x,y,z)[2].

$$x = r.\cos(\lambda).\cos(\beta)$$
$$y = r.\sin(\lambda).\cos(\beta) \text{ -----------------------(21)}$$
$$z = r.\sin(\beta)$$

Then rotate the rectangular system around the x-axis by angle of obliquity of the ecliptic (ε) to get a new coordinates (x', y', z').

$$x' = x$$
$$y' = y.\cos\varepsilon - z.\sin\varepsilon \text{ ----------------------(22)}$$
$$z' = y.\sin\varepsilon + z.\cos\varepsilon$$

Then the right ascension and the declination can be written as follows:

$$\alpha = \tan^{-1}(y'/x')$$
$$\delta = \sin^{-1}(z'/r)$$

---------------------------(23)

Transformation of equatorial coordinates into horizon system can be performed by implementing the following spherical trigonometric relations.

The altitude and azimuth are given by[38].

$$a = \sin^{-1}(\sin\delta.\sin\phi + \cos\delta.\cos\phi.\cos H)$$
$$A = \cos^{-1}\left(\frac{\sin\delta - \sin\phi.\sin a}{\cos\phi.\cos a}\right)$$

-----------------------(24)

The hour angle is related to the right ascension as follows

$H = LST - \alpha$ -------------------------------(25)

Where $\alpha, \delta, a, A, H, LST, \phi$ are right ascension, declination, moon altitude, azimuth , hour angle, local sidereal time and observer geographical latitude.

3. Results and discussion

Computer simulation have been developed to predict and calculate the New Moon dates and coordinates for the next ten years. The birth of the New Moon starts from the conjunction between the ecliptic longitude of the sun and moon. The new moon ecliptic and equatorial coordinates are calculated also horizontal coordinates at Al Najaf Al Ashraf holly city ($31^\circ 59' N, 44^\circ 20' E$) are calculated with accepted accuracy. The results shown in table (١)the dates (year and day) are tabulated in the first two columns. The time (hour and minute) in columns 3 and 4(in UT) .the ecliptic latitude β and longitude λ in columns 5 and 6.the conjunction difference $\Delta\lambda$ in column 7 .the horizontal coordinates (azimuth A and altitude a) in columns 8 and 9 .

The equatorial coordinates (right ascension α (hours) and declination δ) in columns 10 and 11.in order to confirm the results of present work, a comparison of the equatorial coordinates against time as calculated in the present work with those of Almanac [39] is shown in (figures 1,2,3 and 4).

Relative error in new moon time calculated for our results with respect to United State Naval Observatory Circular No 169[39] for the years 2009,2010,2011,2012 are shown in (figure 5).

It can be concluded from these results that the model implemented in the present work can give good results of the new moon dates with range of accuracy (95.76%-99.99%) for ten years or more.

Table 1 :The time of new moon and ecliptic, equatorial and horizon coordinates for Al Najaf Al Ashraf city at new moon moment

year ٢٠٠٩		day	Time(UT) hour	minute	β^o	λ°	$\Delta\lambda^\circ$	A^o	å	$\alpha(hour)$	δ°
month	١	٢٦	7	58	-٠,٢٤	٣٠٦,٩٤	-0.0٢	١٥٦,١٤	٣٥,١٤	٢٠,٥٥٩٤	-١٩,١١
	٢	٢٥	1	40	٢,٤٢	٣٣٧,٣	-0.9٤	84.27	-23.45	٢٢,4395	-7.2029
	٣	٢٦	16	9	٤,٣٢	٦,91	-0.8	٢٨4.89	-١٢,٧٥	٠,1899	٦,0212
	٤	٢٥	3	24	٤,٩٩	٣٥,٧٢	0.1٥	٧٩,٢٣	١٥,69	١,٩٩12	17.6653
	٥	٢٤	12	13	٤,٣٤	٦٣,9	0.92	٢٧4.44	٤٤,٨٢	3.٩٧٠١	25.0٨٠١
	٦	٢٢	19	38	٢,٥4	٩١,68	0.86	338.26	-٢٩,٤	6.0804	26.0674
	٧	٢٢	2	36	٠,٠8	١١٩,32	0.05	68.48	2.96	8.1166	20.2996
	٨	٢٠	10	2	-٢,٤٢	١٤٧,12	-0.8	٢١4.02	63.63	9.9641	9.7221
	٩	١٨	18	45	-4.27	١٧5.38	-0.94	٣٠7.57	-48.9	11.7004	-2.9071
	١٠	١٨	5	35	-٤,٩٨	٢٠4.27	-0.17	١٢٨,56	23.99	13.49	-14.8956
	١١	١٦	19	15	-٤,٣١	٢٣3.89	0.81	٢٨٧,12	-٦٨,٣٥	15.4٧٨٨	-23.٤٢٦٢
	١٢	١٦	12	2	-٢,٣٦	٢٦٤,18	0.91	٢٢٢,32	17.06	17.6617	-25.7004
year ٢٠١٠		day	Time(UT) hour	minute	β^o	λ°	$\Delta\lambda^\circ$	A^o	å	$\alpha(hour)$	δ°
month	١	١٥	7	14	٠,٣5	٢٩4.9	-٠,1	١٤7.٥٤	٢٩,37	19.8177	-20.6618
	٢	١٤	2	56	٢,٩٧	٣٢٥,5٨	-0.99	٩٦,74	-9.55	21.7642	-10.2634
	٣	١٥	21	4	٤,٦٣	٣٥٥,72	-٠,٦4	1.32	-٥٦,٣1	23.5462	2.2139
	٤	١٤	12	31	٤,٩٢	٢5.١٤	٠,٤3	٢٦٣,34	٣٦,20	1.3224	13.8725
	٥	١٤	1	7	٣,٨٨	٥٣,85	١,٠0	57.56	-٨,82	3.2301	22.2166
	٦	١٢	11	19	١,٨٤	٨١,98	٠,٥7	٢٦٦,72	٥٧,53	5.2806	25.0709
	٧	١١	19	44	-٠,٦٨	١٠٩,75	-٠,38	٣٣7.90	-٣4.05	7.3247	21.5505
	٨	١٠	3	10	-٣,٠٤	١٣٧,47	-0.98	80.17	7.57	9.2236	12.8266
	٩	٨	10	32	-٤,٦٣	١٦٥,44	-٠,٧٣	٢٢2.13	50.8	11.0004	1.2535
	١٠	٧	18	47	-٤,٩٨	١٩3.91	٠,17	٣٠1.64	-56.04	12.7893	-10.6131
	١١	٦	4	53	-٣,٩3	٢٢٣,02	0.95	١٢4.89	١3.02	14.7359	-20.0558
	١٢	٥	17	36	-١,٧4	٢٥2.79	٠,79	٢٦6.73	-٤5.95	16.8811	-24.2287
year٢٠١١		day	Time(UT) hour	minute	β^o	λ°	$\Delta\lambda^\circ$	A^o	å	$\alpha(hour)$	δ°
month	١	٤	9	4	0.98	٢٨٣,١١	-٠,٢٥	١٧٧,٨٠	35.7٥	19.0627	-21.4891
	٢	٣	2	35	3.43	٣١٣,66	-1.02	96.03	-16.02	21.0773	-12.9624
	٣	٤	20	50	4.84	344.01	-0.55	351.45	-59.76	22.9110	-1.5632
	٤	٣	14	33	4.81	١٣,84	0.59	275.26	9.39	0.6920	9.8431
	٥	٣	6	52	3.40	43.06	1.02	108.70	59.52	2.5576	18.8182
	٦	١	21	8	1.10	٧١,٦٩	0.٣١	3.43	-35.49	4.552	23.2115
	٧	١	8	59	-1.٤٣	٩٩,٨٢	-0.70	178.59	-79. 68	6.5750	21.8367
	٧	٣٠	18	43	-3.59	١٢٧,68	-1.00	320.05	-33.36	8.4924	15.2655
	٨	٢٩	3	6	-4.85	١٥٥,60	-0.39	87.39	4.89	10.2899	5.3108
	٩	٢٧	11	11	-4.85	١٨٣,٨٩	0.٥٦	٢٢٩,٨٥	37.41	12.0703	-5.8694
	١٠	٢٦	19	59	-3.49	212.72	1.00	326.60	-71.53	13.9727	-15.8576
	١١	٢٥	6	11	-1.08	٢٤٢,15	0.50	139.23	23.04	16.0744	-21.8399
	١٢	٢٤	18	8	1.66	٢٧٢,08	-0.51	273.23	-49.55	18.2759	-21.5768

year٢٠١٢		day	Time(UT)		β^o	λ°	$\Delta\lambda^\circ$	A^o	å	$\alpha(hour)$	δ°
			hour	minute							
month	١	٢٣	7	43	3.88	302.28	-1.00	151.13	37.00	20.3665	-15.2472
	٢	٢١	22	40	4.94	332.42	-0.40	41.57	-57.04	22.2695	-5.2654
	٣	٢٢	14	40	4.58	2.26	0.68	271.44	7.38	0.0750	5.5896
	٤	٢١	7	19	2.91	31.68	0.99	121.20	61.24	1.9151	14.9344
	٥	٢٠	23	50	0.42	60.65	0.15	44.06	-23.93	3.8627	20.6600
	٦	١٩	15	8	-2.13	89.17	-0.85	289.17	8.75	5.8657	21.3119
	٧	١٩	4	29	-4.07	117.37	-0.91	86.30	26.38	7.8015	16.9083
	٨	١٧	15	56	-4.95	145.50	-0.05	285.89	-9.29	9.6215	8.7928
	٩	١٦	2	13	-4.57	173.85	0.84	86.89	-8.24	11.3917	-1.2262
	١٠	١٥	12	6	-2.94	202.61	0.90	237.80	23.46	13.2348	-11.1431
	١١	١٣	22	11	-0.41	231.88	0.10	60.74	-66.62	15.2544	-18.5148
	١٢	١٣	8	43	2.30	261.60	-0.80	175.57	36.27	17.4311	-20.8253

year٢٠١٣		day	Time(UT)		β^o	λ°	$\Delta\lambda^\circ$	A^o	å	$\alpha(hour)$	δ°
			hour	minute							
month	١	١١	١٩	٤٥	4.31	291.55	-0.92	302.17	-65.88	19.5907	-17.1180
	٢	١٠	٧	٢٣	4.99	321.45	-0.11	141.97	40.39	21.5904	-8.9114
	٣	١١	١٩	٥٤	4.23	351.09	0.84	327.43	-52.74	23.4537	1.1609
	٤	١٠	٩	٣٦	2.31	20.38	0.92	200.27	67.15	1.2919	10.6612
	٥	١٠	٠	٢٩	-0.23	49.35	0.00	52.87	-20.77	3.1972	17.5147
	٦	٨	١٦	1	-2.72	78.01	-0.3	294.51	-1.76	5.1707	20.1173
	٧	٨	٧	19	-4.46	106.٤٣	-0.8١	11٤.٤٢	6٢.٠9	7.1240	17.9375
	٨	٦	٢١	53	-4.99	134.80	0.20	18.60	-45.06	8.9843	11.7501
	٩	٥	١١	38	-4.20	163.36	0.99	242.53	40.39	10.7719	3.0518
	١٠	٥	٠	38	-2.29	192.28	0.72	78.38	-30.26	12.5758	-6.3981
	١١	٣	١٢	54	0.29	221.57	-0.29	242.91	12.63	14.4982	-14.5428
	١٢	٣	٠	25	2.86	251.21	-0.99	88.71	-40.89	16.5826	-19.0762

year ٢٠١٤		day	Time(UT)		β^o	λ°	$\Delta\lambda^\circ$	A^o	å	$\alpha(hour)$	δ°
			hour	minute							
month	١	١	11	16	4.62	281.07	-0.71	217.22	29.56	18.7445	-18.3095
	١	٣٠	21	41	4.97	310.93	0.27	20.33	-69.	20.8314	-12.4524
	3	١	8	2	3.84	340.53	0.99	151.17	73	22.7845	-3.5073
	٣	٣٠	18	45	1.63	9.71	0.76	311.32	50.04	0.6615	6.0124
	٤	٢٩	6	14	-0.96	38.50	-0.22	104.57	-39.55	2.5498	13.8653
	٥	٢٨	18	42	-3.26	67.01	-0.98	320.20	46.10	4.4897	18.3106
	٦	٢٧	8	12	-4.71	95.34	-0.72	133.93	-29.74	6.4434	18.4116
	٧	٢٦	22	43	-4.93	123.67	0.34	30.79	71.23	8.3426	14.3258
	٨	٢٥	14	12	-3.81	152.26	1.03	270.15	-38.75	10.1690	7.1024
	٩	٢٤	6	16	-1.63	181.29	0.56	125.62	12.38	11.9717	-1.7266
	١٠	٢٣	22	1	1.02	210.76	-0.54	43.95	39.93	13.8316	-10.2965
	١١	٢٢	12	35	3.39	240.53	-1.03	237.50	-62.28	15.8139	-16.5175
	١٢	٢٢	1	37	4.81	270.49	-0.40	96.54	15.9	17.9111	-18.5028
									-26.66		

year ٢٠١٥		day	Time(UT)		β^{o}	λ°	$\Delta\lambda^{\circ}$	A^{o}	$\mathring{a}$	$\alpha(hour)$	δ°
			hour	minute							
month	١	٢٠	13	16	4.82	300.47	0.62	241.71	12. 62	20.0233	-15.4449
	٢	١٨	23	50	3.38	330.23	1.02	66.01	-46. 89	22.0500	-8.2510
	٣	٢٠	9	38	0.94	-0.45	0.44	192.84	57.78	23.9828	0.9276
	٤	١٨	18	57	-1.71	28.٣٣	-0.5٤	317.٣9	-38.٦٣	1.8822	9.6665
	٥	١٨	4	15	-3.81	56.65	-1.00	84.60	21.31	3.8050	15.9112
	٦	١٦	14	8	-4.89	84.71	-0.51	278.27	21.48	5.7551	18.3192
	٧	١٦	1	26	-4.73	112.73	0.51	61.81	-12.71	7.6855	16.4876
	٨	١٤	14	52	-3.35	141.02	1.03	277.73	7.48	9.5553	10.9539
	٩	١٣	6	41	-1.01	169.84	0.43	125.39	46.30	11.3771	2.9405
	١٠	١٣	0	10	1.67	199.28	-0.67	71.68	-37.36	13.2091	-5.8610
	١١	١١	17	50	3.88	229.21	-0.97	284.22	-46.22	15.1205	-13.4458
	١٢	١١	10	29	4.93	259.44	-0.12	208.73	34.21	17.1471	-17.8127

year ٢٠١٦		day	Time(UT)		β^{o}	λ°	$\Delta\lambda^{\circ}$	A^{o}	$\mathring{a}$	$\alpha(hour)$	δ°
			hour	minute							
month	١	١٠	١	٣١	4.55	289.74	0.85	94.09	-28.75	19.2439	-17.5413
	٢	٨	١٤	٤٢	2.82	319.84	0.89	255.89	-2.13	21.3065	-12.5561
	٣	٩	١	٥٧	0.25	349.45	-0.03	83.94	-18.60	23.2747	-4.3169
	٤	٧	١١	٢٥	-2.38	18.42	-0.83	237.05	47.37	1.1768	4.8988
	٥	٦	١٩	٣١	-4.28	46.79	-0.92	329.05	-40.45	3.0805	12.8088
	٦	٥	٣	٢	-5.01	74.71	-0.18	74.21	7.01	5.0266	17.5883
	٧	٤	١١	٣	-4.44	102.٤٣	0.7٤	248.٢٨	60.٦٣	6.9929	18.1779
	٨	٢	٢٠	٤٤	-2.75	130.30	1.01	351.47	-43.78	8.9196	14.5255
	٩	١	٩	٢	-0.34	158.64	0.28	178.19	65.15	10.7778	7.5278
	١٠	١	٠	١٤	2.24	187.69	-0.77	66.51	-35.34	12.6006	-1.2783
	١٠	٣٠	١٧	٤٣	4.25	217.45	-0.94	285.94	-41.83	14.4604	-9.9699
	١١	٢٩	١٢	١٩	5.01	247.7٤	0.0٤	233.٦٢	١٩,٨٧	16.4257	-16.4515
	١٢	٢٩	٦	٥٣	4.24	278.34	0.97	144.58	30.00	18.5018	-18.8266

year ٢٠١٧		day	Time(UT)		β^{o}	λ°	$\Delta\lambda^{\circ}$	A^{o}	$\mathring{a}$	$\alpha(hour)$	δ°
			hour	minute							
month	١	٢٨	0	10	2.21	308.90	0.72	80.00	-46.62	20.5944	-16.1680
	٢	٢٦	15	3	-0.46	338.99	-0.34	261.12	-4.18	22.5932	-9.2413
	٣	٢٨	3	1	-2.96	8.34	-1.00	89.06	-2.62	0.4852	-0.0733
	٤	٢٦	12	18	-4.61	36.95	-0.67	253.98	38.83	2.3435	9.0495
	٥	٢٥	19	47	-5.00	64.98	0.24	336.37	-39.41	4.2511	16.0521
	٦	٢٤	2	33	-4.07	92.67	0.94	69.38	2.40	6.2323	19.2459
	٧	٢٣	9	47	-2.10	120.31	0.85	212.04	73.32	8.2268	17.7613
	٨	٢١	18	30	0.42	148.22	0.00	312.23	-32.45	10.1519	11.9862
	٩	٢٠	5	30	2.84	176.70	-0.87	108.22	31.48	11.9935	3.3628
	١٠	١٩	19	15	4.53	205.92	-0.85	311.83	-55.39	13.8178	-6.1759
	١١	١١	11	45	4.96	235.87	0.15	227.98	27.38	15.7215	-14.4979
	١٢	١٢	6	30	3.91	266.38	1.00	139.86	26.59	17.7627	-19.3930

year ٢٠١٨		day	Time(UT) hour	minute	β^o	λ°	$\Delta\lambda^\circ$	A^o	$\mathring{a}$	$\alpha(hour)$	δ°
	١	١٧	٢	١٩	1.62	297.17	0.60	100.36	-21.31	19.8838	-19.1489
	٢	١٥	٢١	١٠	-1.14	327.75	-0.55	356.42	-71.98	21.9357	-13.7106
	٣	١٧	١٣	١٦	-3.49	357.68	-1.02	249.40	20.51	23.8418	-4.8578
	٤	١٦	٢	٠	-4.81	26.78	-0.38	76.94	-11.86	1.6584	5.0412
	٥	١٥	١١	٥١	-4.83	55.17	0.61	255.18	46.26	3.4971	13.8168
month	٦	١٣	١٩	٤٧	-3.59	83.06	1.01	338.60	-36.46	5.4378	19.4864
	٧	١٣	٢	٥١	-1.40	110.72	0.53	70.60	6.62	7.4619	20.4532
	٨	١١	١٠	٠	1.17	138.43	-0.41	218.26	70.42	9.4590	16.2883
	٩	٩	١٨	٣	3.44	166.50	-0.99	303.95	-31.21	11.3505	8.1076
	١٠	٩	٣	٥٠	4.79	195.15	-0.65	98.21	8.11	13.1699	-2.0740
	١١	٧	١٦	٥	4.82	224.50	0.36	268.57	-21.68	15.0251	-11.9930
	١٢	٧	٧	٢١	3.47	254.54	1.03	151.98	32.91	17.0195	-19.2308

year ٢٠١٩		day	Time(UT) hour	minute	β^o	λ°	$\Delta\lambda^\circ$	A^o	$\mathring{a}$	$\alpha(hour)$	δ°
	١	٦	1	29	1.05	285.11	0.50	96.82	-32.77	19.1502	-21.4734
	٢	٤	21	8	-1.73	315.85	-0.65	349.13	-75.77	21.2636	-17.7580
	٣	٦	16	9	-3.95	346.23	-0.97	268.46	-16.38	23.2162	-9.4169
	٤	٥	8	53	-4.95	15.92	-0.12	171.53	58.31	1.0254	1.0402
	٥	٤	22	48	-4.56	44.89	0.84	35.09	-40.48	2.8099	11.2293
month	٦	٣	10	6	-2.98	72.22	0.91	234.28	69.41	4.6861	18.9936
	٧	٢	19	21	-0.64	101.10	0.12	332.94	-31.47	6.6857	22.3458
	٨	١	3	15	1.88	128.83	-0.76	73.71	11.21	8.7146	20.1416
	٨	٣٠	10	40	3.95	156.70	-0.97	233.12	61.06	10.6500	12.8893
	٩	٢٨	18	30	4.98	184.99	-0.33	306.28	-40.88	12.4807	2.4384
	١٠	٢٨	3	42	4.63	213.87	0.64	103.65	3.98	14.3071	-8.8393
	١١	٢٦	15	8	2.95	243.40	1.01	255.68	-12.74	16.2603	-18.2806
	١٢	٢٦	5	14	0.39	273.51	0.33	126.82	10.67	18.3905	-23.0428

year ٢٠٢٠		day	Time(UT) hour	minute	β^o	λ°	$\Delta\lambda^\circ$	A^o	$\mathring{a}$	$\alpha(hour)$	δ°
	١	٢٤	21	45	-2.29	30٣.٩٨	-0.7٥	٢٨.١٠	-78.23	20.5630	-21.2897
	٢	٢٣	15	37	-4.٢٩	334.٤٢	-0.9٤	2٥٩.٨٦	-1٠.٧٣	22.5٧٨٨	-13.7469
	٣	٢٤	9	31	-5.01	4.42	0.02	186.01	54.37	0.4056	-2.9725
	٤	٢٣	2	27	-4.27	33.85	0.95	77.76	-4.54	2.1606	8.3862
month	٥	٢٢	17	43	-2.35	62.69	0.79	309.67	-22.46	3.9850	17.9566
	٦	٢١	6	48	0.14	91.01	-0.22	98.12	59.39	5.9489	23.4507
	٧	٢٠	17	38	2.56	118.97	-0.97	311.38	-16.81	7.9827	23.2232
	٨	١٩	2	45	4.34	146.88	-0.79	72.45	3.53	9.9401	17.2594
	٩	١٧	11	3	5.02	175.03	0.09	235.35	51.64	11.7699	7.1026
	١٠	١٦	19	35	4.34	203.68	0.88	321.81	-57.96	13.5598	-5.0066
	١١	١٥	5	10	2.38	232.92	0.86	123.89	17.43	15.4608	-16.3695
	١٢	١٤	16	18	-0.31	262.69	0.00	258.11	-28.74	17.5772	-23.7061

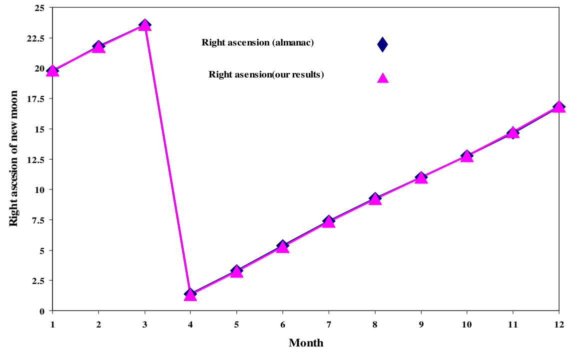

Figure 1: comparison between our results and lmanac [39] one of right ascension versus month for the year 2009.

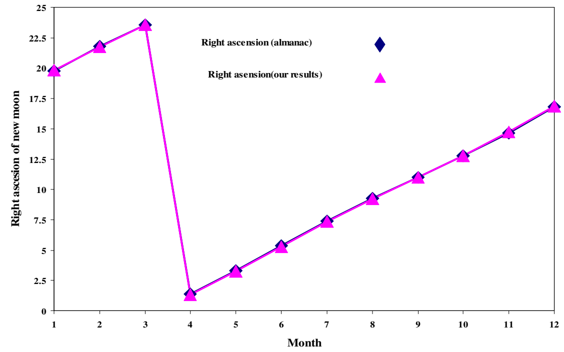

Figure 3: comparison between our results and almanac [39] one of right ascension versus month for the year 2010.

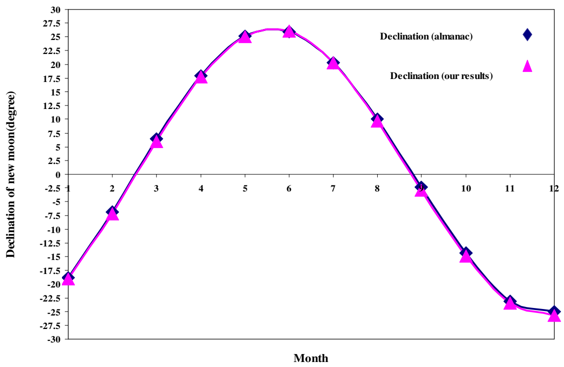

Figure 2:omparison between our results and almanac [39] one of declination versus month for the year 2009

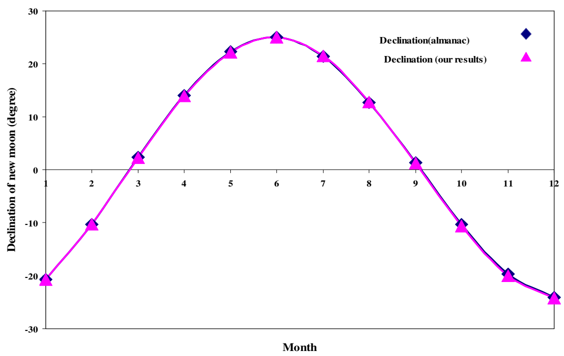

Figure 4:comparison between our results and almanac [39] one of declination versus month for the year 2010

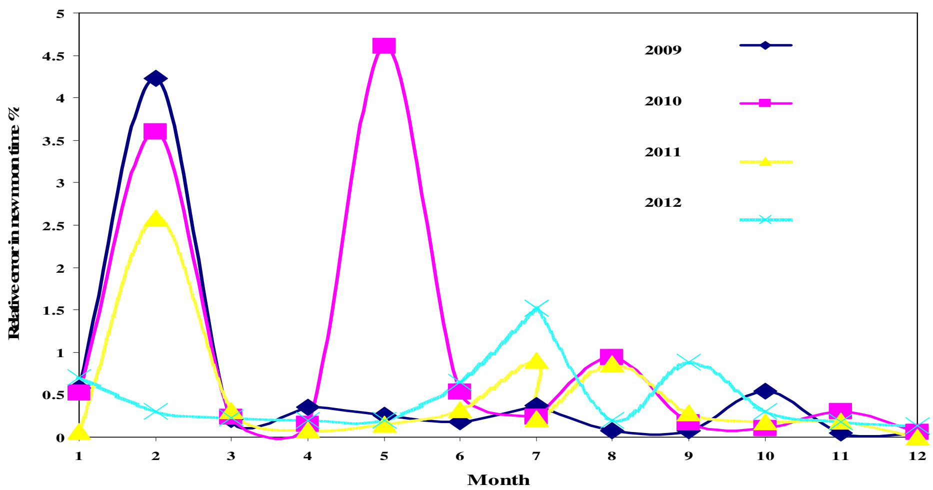

Figure 5:relationship between the relative error of new moon times for our results and United stats naval observatory circular No 169 and months for the years 2009,2010,2011and 2012.

4.References:

1. IanRidpath,**1997,***A Dictionary of Astronomy***,** Oxford University Press, pp.508**.**
2. Oliver Montenbruck ,Thomas Pfleger, **1994,***Astronomy on personal computer* , Springer Verlag, pp.153-176 .
3. Brown, E. W, **1919,** *Tables of the motion of the Moon* ,New Haven: Yale University Press, pp.12-14.
4. Eckert, W. J, Jones, R., & Clark, H. K. ,**1954,** *Improved lunar ephemeris1952–1959***,** Washington D.C. US Government Printing Office**.**
5. Schmidt, D. S, **1980**,The main problem of the lunar theory solved by the method of Brown, *The Moon and the Planets*, 23, pp.135-164.
6. Deprit, A, Henrard, J, & Rom, **1971a,** Analytical lunar ephemeris: Delaunay's theory *A& A* , 76, p.269**.**
7. Deprit, A, Henrard, J., & Rom, **1971b** , Analytical lunar ephemeris: The Variational Orbit *A& A* ,76, p.723**.**
8. Henrard, J, **1979,** A new solution to the main problem of lunar theory *Celest. Mech*., 19, p.337**.**
9. Henrard, J, **1980,**perturpations due to the shape of the moon in lunar theory, *Celest. Mech*., 22, p.335**.**
10. Henrard, J,**1981,**the earth-figure perturbations in the lunar theory, *Celest. Mech*., 25, p.417,**.**
11. Chapront –Touze. M, Chapront. J,**1983,** The lunar ephemeris ELP200, *A&A*.124, pp.50-62.
12. Chapront. J, Chapront –Touze. M,**1988,** ELP2000-85:a semi-analytical lunar ephemeris adequate for historical times, *A&A*.190, pp.342-352.
13. Chapront, J, & Chapront-Touzé, M, **1997,** lunar motion :theory and observation,*Celest. Mech. Dyn. Astr*., 66, p.31**.**
14. Bidart. P,MPP01,**2001,** A new solution for planetary perturbations in the orbital motion of the Moon, *A&A* p.366, p.351, p.358.
15. Chapront, J., Chapront-Touzé, M., & Francou, G, **2002,** A new determination of lunar orbital parameters,precession constant and tidal acceleration from LLR measurements *A&A*, 387, 700.
16. Chapront. J , Francou G, **2003,** The lunar theory ELP revisited. Introduction of new planetary perturbations, *A&A* 404, pp.735–742,.
17. Standish, E. M., Newhall, X. X., Williams, J. G., & Folkner, W. F, **1995,** JPL Planetary and Lunar Ephemerides, *JPL IOM* 314.pp.10-127.
18. Standish, E. M, **1998,** JPL Planetary and Lunar Ephemerides DE405/LE405 ,*JPL IOM* 312.F-98-048 .
19. Standish, E.M,**2003a,** JPL Planetary and Lunar Ephemerides DE409/LE409*JPL IOM* 312N-03-007.
20. Standish,E.M,**2003b**, JPL Planetary and Lunar Ephemerides DE410/LE410,*JPL IOM* 312N-03-009.
21. Standish, E. M. **2006,** JPL Planetary, DE414, Interoffice Memorandum., *JPL IOM* 343R-06-002, pp.1-8.
22. Krasinsky, G. A. **2002,** Selenodynamical parameters from of LLR observations of 1970-2001, *Commun. IAA RAS*, 148, 1,**.**
23. Pitjeva, E. V,**2001,** Modern numerical ephemerides of planets and importance of ranging observations for their creation., *Celest. Mech. Dyn. Astron*, 80, pp.249-271.
24. Pitjeva, E. V. **2003,** The Planetary Ephemerides Epm and Their Orientation to Icrf, *Commun. IAA RAS*, 156, 1.
25. Pitjeva, E. V,**2005,**High-Precision Ephemerides of Planets—EPM and Determination of Some Astronomical Constants., *Sol. Sys. Res*., 39, pp.176-186.
26. S. M. Kudryavtsev ,**2007**,Long-term harmonic development of lunar ephemeris, *A&A* 471, pp.1069–1075.
27. Fienga, A., Manche, H., Laskar. J, & Gastineau, M. **2008** ,INPOP06: anew numerical planetary ephemeris, *A&A*,477,315-327.
28. Maunder, M., **1911,** On the Smallest Visible Phase of Moon, J. *British Astron. Assoc*,21: pp.355-362.
29. A.Danjon ,Ĺ Astronomie, **1932,**46,57**.**
30. Bruin, F, **1977,** The first visibility of the lunar crescent, *Vistas in Astronomy*,21, 331-358.
31. Yallop, B.D., **1998** ,A Method of Predicting the First Sighting of New

Moon, *NAO Technical Note No.69, HM Nautical Almanac Office,* Royal Greenwich Observatory, Cambridge*, UK.*

32. Fatoohi, L.J., Stephenson, F.R. and Al-Dargazelli, S.S., **1998,** "The Danjon Limit of First Visibility of the Lunar Crescent", *Observatory*, 118, pp.65-72.
33. J. Caldwell & C. Laney, **2000,** *African Skies* 5, 15.
34. Jean Meeus, **1988***,* *Astronomical formulae for calculations*, *Willmann-Bell,Inc,* pp*79-159*.
35. Smart.w.m, **1986,***textbook on spherical astronomy* ,3rd edition ,*Cambridge university press,* pp*.98-139.*
36. Oliver Montenbruck,**1989,***Practical ephemeris calculations*, Springer Verlag, pp.1-45.
37. J.L. Simon ,P .Brentagnon ,J. Chapront ,M. Chapront –Touze ,G .Francou ,and J.Laskar, **1994,** numerical expressions for precession formulae and mean elements for the moon and the planets ,*A&A.*282,663-683,.
38. Peter Duffett Smith, **1995**, *Practical astronomy with your calculator*, Cambridge university press, pp*.36-37.*
39. "The Astronomical Almanac", His Majesty's Stationary Office, London,**2009**-**2010**.
40. Richard E. Schmidt*,* **1986** Phases of the moon2000-2049, November *4* , *U.S* .Naval observatory , Washington*,D.C.*20390, circularNo.169.