**Velocidad de Seguimiento Lunar**

Visto desde la Tierra y debido a la rotación de ésta, aparentemente los astros se mueven por la bóveda celeste de Este a Oeste. El eje de AR de nuestra montura ecuatorial se encuentra alineado con el eje de esta bóveda, lo cual permite hacer un seguimiento de todos ellos. Pero no todos van a la misma velocidad.

La velocidad Sideral (velocidad a la que se mueven las estrellas) podemos considerar que es constante; 15,041067 arcseg/segundo.

La velocidad Solar (velocidad a la que se mueve el Sol) también podemos considerar que es constante; 15 arcseg/segundo.

Pero la velocidad Lunar (velocidad a la que se mueve la Luna) no es constante debido entre otras cosas a la excentricidad de la órbita lunar y al movimiento Tierra-Luna alrededor del Sol. No es fácil de calcular el movimiento, pero por suerte tenemos el siguiente enlace:

<https://ssd.jpl.nasa.gov/horizons.cgi>

**Horizons** es un programa de la JPL de la NASA que realiza cálculos de los objetos del Sistema Solar. A continuación, se muestra un ejemplo para un período determinado, de cómo varía la velocidad de la luna respecto a las estrellas día a día tanto en AR como en DEC:

|  |  |
| --- | --- |
| Ephemeris Type [[change](https://ssd.jpl.nasa.gov/horizons.cgi?s_type=1" \l "top)] : | **OBSERVER** |
| Target Body [[change](https://ssd.jpl.nasa.gov/horizons.cgi?s_target=1" \l "top)] : | **Moon [Luna]** [301] |
| Observer Location [[change](https://ssd.jpl.nasa.gov/horizons.cgi?s_loc=1" \l "top)] : | **Terrassa** [C35] ( 2°02'05.6''E, 41°34'17.7''N, 320.8 m ) |
| Time Span [[change](https://ssd.jpl.nasa.gov/horizons.cgi?s_time=1" \l "top)] : | Start=**2021-04-24**, Stop=**2021-05-24**, Step=**1** **d** |
| Table Settings [[change](https://ssd.jpl.nasa.gov/horizons.cgi?s_tset=1" \l "top)] : | QUANTITIES=**1,3** |
| Display/Output [[change](https://ssd.jpl.nasa.gov/horizons.cgi?s_disp=1" \l "top)] : | *default* (formatted HTML) |

------------------------------------ Object Data Page -----------------------------------------

Revised: July 31, 2013 Moon / (Earth) 301

GEOPHYSICAL DATA (updated 2018-Aug-15):

Vol. mean radius, km = 1737.53+-0.03 Mass, x10^22 kg = 7.349

Radius (gravity), km = 1738.0 Surface emissivity = 0.92

Radius (IAU), km = 1737.4 GM, km^3/s^2 = 4902.800066

Density, g/cm^3 = 3.3437 GM 1-sigma, km^3/s^2 = +-0.0001

V(1,0) = +0.21 Surface accel., m/s^2 = 1.62

Earth/Moon mass ratio = 81.3005690769 Farside crust. thick. = ~80 - 90 km

Mean crustal density = 2.97+-.07 g/cm^3 Nearside crust. thick.= 58+-8 km

Heat flow, Apollo 15 = 3.1+-.6 mW/m^2 Mean angular diameter = 31'05.2"

Heat flow, Apollo 17 = 2.2+-.5 mW/m^2 Sid. rot. rate, rad/s = 0.0000026617

Geometric Albedo = 0.12 Mean solar day = 29.5306 d

Obliquity to orbit = 6.67 deg Orbit period = 27.321582 d

Semi-major axis, a = 384400 km Eccentricity = 0.05490

Mean motion, rad/s = 2.6616995x10^-6 Inclination = 5.145 deg

Apsidal period = 3231.50 d Nodal period = 6798.38 d

Perihelion Aphelion Mean

Solar Constant (W/m^2) 1414+-7 1323+-7 1368+-7

Maximum Planetary IR (W/m^2) 1314 1226 1268

Minimum Planetary IR (W/m^2) 5.2 5.2 5.2

--------------------------------------- Results ------------------------------------------------------

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Ephemeris / WWW\_USER Sun Apr 25 08:05:24 2021 Pasadena, USA / Horizons

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Target body name: Moon (301) {source: DE441}

Center body name: Earth (399) {source: DE441}

Center-site name: Terrassa

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Start time : A.D. 2021-Apr-24 00:00:00.0000 UT

Stop time : A.D. 2021-May-24 00:00:00.0000 UT

Step-size : 1440 minutes

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Target pole/equ : IAU\_MOON {East-longitude positive}

Target radii : 1737.4 x 1737.4 x 1737.4 km {Equator, meridian, pole}

Center geodetic : 2.03490000,41.5716085,0.3267151 {E-lon(deg),Lat(deg),Alt(km)}

Center cylindric: 2.03490000,4778.94886,4210.3423 {E-lon(deg),Dxy(km),Dz(km)}

Center pole/equ : High-precision EOP model {East-longitude positive}

Center radii : 6378.1 x 6378.1 x 6356.8 km {Equator, meridian, pole}

Target primary : Earth

Vis. interferer : MOON (R\_eq= 1737.400) km {source: DE441}

Rel. light bend : Sun, EARTH {source: DE441}

Rel. lght bnd GM: 1.3271E+11, 3.9860E+05 km^3/s^2

Atmos refraction: NO (AIRLESS)

RA format : HMS

Time format : CAL

EOP file : eop.210423.p210715

EOP coverage : DATA-BASED 1962-JAN-20 TO 2021-APR-23. PREDICTS-> 2021-JUL-14

Units conversion: 1 au= 149597870.700 km, c= 299792.458 km/s, 1 day= 86400.0 s

Table cut-offs 1: Elevation (-90.0deg=NO ),Airmass (>38.000=NO), Daylight (NO )

Table cut-offs 2: Solar elongation ( 0.0,180.0=NO ),Local Hour Angle( 0.0=NO )

Table cut-offs 3: RA/DEC angular rate ( 0.0=NO )

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

Date\_\_(UT)\_\_HR:MN R.A.\_\_\_\_\_(ICRF)\_\_\_\_\_DEC dRA\*cosD d(DEC)/dt

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

$$SOE

2021-Apr-24 00:00 m 11 29 22.73 +08 05 51.7 1443.917 -949.964

2021-Apr-25 00:00 m 12 22 42.89 +01 55 24.2 1386.068 -970.229

2021-Apr-26 00:00 m 13 17 01.80 -04 34 02.4 1365.721 -958.628

2021-Apr-27 00:00 m 14 13 12.84 -10 57 02.8 1386.206 -914.568

2021-Apr-28 00:00 m 15 11 59.65 -16 44 50.1 1446.184 -834.191

2021-Apr-29 00:00 m 16 13 36.05 -21 28 21.4 1537.689 -712.247

2021-Apr-30 00:00 m 17 17 25.66 -24 43 10.5 1645.680 -546.948

2021-May-01 00:00 m 18 21 56.87 -26 14 50.7 1751.673 -345.437

2021-May-02 00:00 19 25 07.79 -26 02 11.0 1841.021 -124.695

2021-May-03 00:00 20 25 11.79 -24 16 06.6 1908.487 94.27529

2021-May-04 00:00 21 21 11.59 -21 14 41.1 1957.632 294.0033

2021-May-05 00:00 22 13 03.52 -17 17 36.7 1996.024 463.8926

2021-May-06 00:00 23 01 21.13 -12 42 44.3 2030.949 598.9947

2021-May-07 00:00 23 46 56.22 -07 44 56.1 2067.477 697.2509

2021-May-08 00:00 00 30 45.91 -02 36 26.2 2108.198 757.3517

2021-May-09 00:00 01 13 46.03 +02 32 16.8 2153.514 777.7099

2021-May-10 00:00 01 56 48.38 +07 31 33.6 2201.904 756.3281

2021-May-11 00:00 02 40 39.15 +12 11 51.1 2249.985 691.2966

2021-May-12 00:00 03 25 56.93 +16 23 14.1 2292.457 581.7857

2021-May-13 00:00 04 13 09.28 +19 55 19.5 2322.215 429.4534

2021-May-14 00:00 05 02 28.09 +22 37 35.1 2331.035 240.0434

2021-May-15 00:00 05 53 45.15 +24 20 07.9 2311.219 24.56345

2021-May-16 00:00 06 46 31.25 +24 54 55.6 2258.110 -200.949

2021-May-17 00:00 07 40 02.00 +24 17 01.6 2172.437 -417.805

2021-May-18 00:00 m 08 33 30.21 +22 25 23.2 2060.988 -608.640

2021-May-19 00:00 m 09 26 20.43 +19 22 55.7 1934.950 -761.028

2021-May-20 00:00 m 10 18 19.25 +15 16 00.5 1806.923 -868.925

2021-May-21 00:00 m 11 09 38.50 +10 13 51.9 1688.370 -931.721

2021-May-22 00:00 m 12 00 52.74 +04 28 31.4 1588.450 -952.088

2021-May-23 00:00 m 12 52 53.78 -01 44 37.7 1513.971 -933.797

2021-May-24 00:00 m 13 46 43.47 -08 05 52.4 1469.616 -880.050

$$EOE

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Column meaning:

TIME

Times PRIOR to 1962 are UT1, a mean-solar time closely related to the

prior but now-deprecated GMT. Times AFTER 1962 are in UTC, the current

civil or "wall-clock" time-scale. UTC is kept within 0.9 seconds of UT1

using integer leap-seconds for 1972 and later years.

Conversion from the internal Barycentric Dynamical Time (TDB) of solar

system dynamics to the non-uniform civil UT time-scale requested for output

has not been determined for UTC times after the next July or January 1st.

Therefore, the last known leap-second is used as a constant over future

intervals.

Time tags refer to the UT time-scale conversion from TDB on Earth

regardless of observer location within the solar system, although clock

rates may differ due to the local gravity field and no analog to "UT"

may be defined for that location.

Any 'b' symbol in the 1st-column denotes a B.C. date. First-column blank

(" ") denotes an A.D. date. Calendar dates prior to 1582-Oct-15 are in the

Julian calendar system. Later calendar dates are in the Gregorian system.

NOTE: "n.a." in output means quantity "not available" at the print-time.

SOLAR PRESENCE (OBSERVING SITE)

Time tag is followed by a blank, then a solar-presence symbol:

'\*' Daylight (refracted solar upper-limb on or above apparent horizon)

'C' Civil twilight/dawn

'N' Nautical twilight/dawn

'A' Astronomical twilight/dawn

' ' Night OR geocentric ephemeris

LUNAR PRESENCE (OBSERVING SITE)

The solar-presence symbol is immediately followed by a lunar-presence symbol:

'm' Refracted upper-limb of Moon on or above apparent horizon

' ' Refracted upper-limb of Moon below apparent horizon OR geocentric

ephemeris

'R.A.\_\_\_\_\_(ICRF)\_\_\_\_\_DEC' =

Astrometric right ascension and declination of the target center with

respect to the observing site (coordinate origin) in the reference frame of

the planetary ephemeris (ICRF). Compensated for down-leg light-time delay

aberration.

Units: RA in hours-minutes-seconds of time, HH MM SS.ff{ffff}

DEC in degrees-minutes-seconds of arc, sDD MN SC.f{ffff}

'dRA\*cosD d(DEC)/dt' =

The angular rate of change in aparent RA and DEC of the target. This is

with respect to the non-inertial IAU76/80 Earth true equator and equinox

of-date reference frame. d(RA)/dt is multiplied by the cosine of declination

to provide a linear rate in the plane-of-sky. Units: ARCSECONDS PER HOUR

Computations by ...

Solar System Dynamics Group, Horizons On-Line Ephemeris System

4800 Oak Grove Drive, Jet Propulsion Laboratory

Pasadena, CA 91109 USA

Information : https://ssd.jpl.nasa.gov/

Documentation: https://ssd.jpl.nasa.gov/?horizons\_doc

Connect : https://ssd.jpl.nasa.gov/?horizons (browser)

telnet ssd.jpl.nasa.gov 6775 (command-line)

e-mail command interface available

Script and CGI interfaces available

Author : Jon.D.Giorgini@jpl.nasa.gov

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Si miramos la columna **dRA\*cosD** vemos la diferencia de velocidad de la Luna respecto a la de las estrellas en el eje de AR. El valor se encuentra expresado en ARCSECONDS PER HOUR.

Si por ejemplo tomamos los valores máximo y mínimo podemos calcular las velocidades de la siguiente manera:

**26 de abril** – 1365.721 arcsecs/hora

Convertimos a arcsecs/segundo 🡪 1365.721/3600 = 0,3793669

Se lo restamos a la velocidad Sideral 🡪 15,041067 - 0,3793669 = **14,6617 arcsecs/segundo**

**14 de mayo** 2331.035 arcsecs/hora

Convertimos a arcsecs/segundo 🡪 2331.035/3600 = 0,6475097

Se lo restamos a la velocidad Sideral 🡪 15,041067 - 0,6475097 = **14,3935 arcsecs/segundo**

Bibliografía:

<https://www.cloudynights.com/topic/624764-how-would-i-calculate-the-lunar-tracking-rate/>

<https://86400.es/2007/03/16/%C2%BFcuanto-dura-un-dia-lunar/>

<https://ascom-standards.org/Help/Platform/html/T_ASCOM_DeviceInterface_DriveRates.htm>