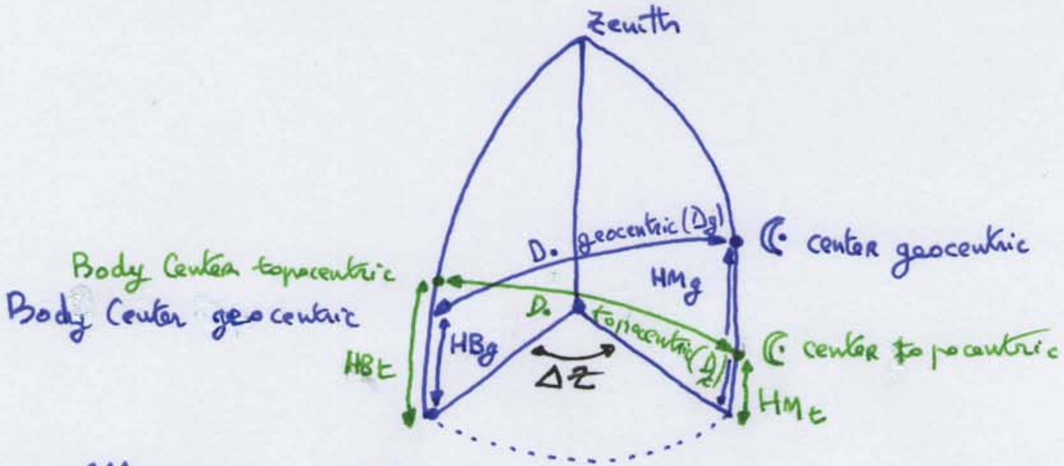
LUNARS "CLASSICAL" COMPUTATION



All geocentric values are for:
- BODY Centers
- NO PARALLAX, and
- NO REFRACTION

All topocentric values are for:
- BODY CENTERS
- with PARALLAX, and
- with REFRACTION

We have the following equations:

$$(1)\ \cos D_t = \sin HM_t \sin HB_t + \cos HM_t \cos HB_t \cos \Delta Z$$
$$(2)\ \cos D_g = \sin HM_g \sin HB_g + \cos HM_g \cos HB_g \cos \Delta Z$$

We know HM_t, HM_g, HB_t, HB_g and D_t
therefore we solve (1) for $\cos \Delta Z$, then solve (2) for D_g

- HM_t (01) HM_g (04)
- HB_t (02) HB_g (05)
- D_t (03) D_g (06)

Example: Douglas Denny's Betelgeuse LUNAR (Betelgeuse LUNAR)

26 Dec 2010 From (N 50°49'8, W 000°51'2) at UT = $00^H31^m 13,0^S$ observe the following Sextant Distance: 67°06'3 (Far Limb)

Through using Douglas's values as follows: (Ref his email Dec 31, 2010 8:24PM)

Topocentric values (Body Center with Refr.)
- HM_t = 25°01'0 = 25°.01667
- HB_t = 45°23'2 = 45°.38667
- D_t = 66°49'9 = 66°.83167

Geocentric values
- HM_g = 25°52'3 = 25°87167
- HB_g = 45°22'2 = 45°37000

... we get D_g = 66°27731 = 66°16'639 (with T = −2°C I find 66°16'633)

which happens at UT (very close from) $00^H33^m26,6^S$

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Jan 01, 2011

Jan 04, 2011

USE OF THE CLASSICAL LUNARS CLEARING 2 COSINE FORMULAE.

Note 1 - For simplicity here, we will assume that all measured/computed angles discussed here-after are observed at the very same UT time.

The 2 Lunars Clearing cosine formulae are exactly the same. In total we need to know 5 data measured in 2 different plans in order to determine the 6 th (unknown) one.

Such plans are parallel to one another as follows :
- The first plan is the Observer's Local (topographic) Horizontal plan, and
- The second plan passes through the Earth Center and is parallel to the Observer's topographic horizontal plan.

Note 2 : Because the Earth is not exactly spherical, the Earth Center is NOT lying exactly on the vertical line "right under" the feet of the Observer. In other words the Observer's Vertical local vertical "zenith" line is most generally not the same as the geocentric zenith "vertical" line passing through the Earth Center, although both are parallel. Both lines are the very same ones only when observing from the Poles and from the Equator. As a consequence, a finite distance body (and at first our Lady Moon to name her) is not shining in the exact same azimuth when seen from a topocentric horizontal plan, or when seen from the geocentric plan parallel to such local horizontal plan.

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One cosine formula is used in the topocentric environment. Let's call it the "Topocentric Cosine Formula" :

$$\cos Dt = \sin MHt * \sin BHt + \cos MHt * \cos BHt * \cos Zt$$

It requires topocentric data affected by Refraction. (Topocentric also necessarily implies "affected by parallax"). Such data are :
- MHt : Topocentric Moon Center Altitude (i.e. topocentric, with height of eye=0ft, including the effect of both refraction and parallax), and
- BHt : Topocentric Body Center Altitude (same remarks as line above), and
- Dt : Topocentric Moon Center to Body Center, and

from MHt, BHt and Dt, the Topocentric Cosine Formula enables to determine "Cos Zt" which is the Cosine of the Difference in the topographic Azimuth between Moon and Body.

The very same Cosine formula is also used in the geocentric environment. Let's call it the "Geocentric Cosine Formula" :

$$\cos Dg = \sin MHg * \sin BHg + \cos MHg * \cos BHg * \cos Zg$$

It also requires 3 geocentric data as follows :
- MHg : Geocentric Moon Center Altitude, and
- BHg : Geocentric Body Center Altitude, and
- Cos Zg, which we are assuming to be identical to the cos Zt value which we just determined through the use of the Topocentric Formula, and

from MHg, BHg and cos Zg (remember : Zg = Zt, with the "limitation" mentioned in Note 2 hereabove), we can determine Cos Dg and accordingly Dg which is our (long sought) Lunar Cleared Distance.

Where do we we get all data from ?
- MHt is either sextant observed, or reconstructed from MHg through Observer's Position and UT, and
- BHt is either sextant observed, or reconstructed from BHg through both Observer's Position and UT, and
- Dt is derived from Sextant (far)Limb(s) observation, corrected for topocentric Augmented Semi-Diameter(s), and
- MHg is either derived from MHT, or directly computed from Observer's (known) Position and (known) UT,
- BHg is either derived from BHt, or directly computed from Observer's Position and UT, and
- Cos Zg is assumed to be equal to Cos Zt, which is "almost" the case (see Note 2 here-above).

Note 3 : Since the main aim of Lunars is to determine UT, we should not forget that when using ***Sextant Observed*** MHt and BHt values, MHg and BHg values should then be preferably derived from MHt and BHt only through "general use tables or computations" which are to NOT include any specific entry for either the Observer's position and/or (approximate) UT.

***Note 4* : IMPORTANT**

Exactly in the same manner as their Sextant Observed "real world" counterpart/similar values, the MHg and BHg values, as well as their MHt, BHt derived values - if and when all 4 of them derived from both previously known position and UT and not from Sextant Observations - are to be used in the Topocentric Formula and then in the Geocentric Formula in order to actually determine ... a value for UT !!! just earlier used as "first UT value" in order to compute these very same MHg, BHg values, and then to derive MHT, BHt values ! Therefore, we should then - at least once and with this "Lunar Derived UT" this time - compute again all our MHt, BHt, and MHg, BHt values, and afterwards run again the Topocentric then Geocentric Formulae to check for the stability of "UT" so determined. To te best of my knowledge, this specific need for a "repeat" procedure seems to have been ignored on Navlist.

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A QUITE FAMILIAR DEC. 26, 2010 BETELGEUSE LUNAR EXAMPLE

You are observing from your known position N50°49'8 W000°51'2, on Dec 26 th, 2010.

Your Height of eye is 10 meters (this specific data not necessary here), Outside temperature is 28.4 °F (-2°C) and atmospheric pressure is standard : 1013.25 mb/hPa (29.92" Hg)

At UT=00h31m13.0s, you observe a Far Limb Betelgeuse-Moon Lunar at a Sextant Distance of 67°06'3

FIRST COMPUTATION with UT(0) = 00h33m13.0s

With TT-UT = 67.1 s the required 5 preliminary data computed for UT(0) = 00h31m13.0s are as follows :

MHt = (25°01'0) 25°00'698 / Azimuth = 116°03338 (Parallax in Azimuth = -11".709)
BHt = (45°23'2) 45°23'303 / Azimuth = 197°65881 (Parallax in Azimuth = 0".000)
Dt = 66°49'9
MHg = (25°52'3) 25°52'329 / Azimuth = 116°03663 (not the same as Topocentric Az)
BHg = (45°22'2) 45°22'306 / Azimuth = 197°658881 (no Parallax in Azimut for Betelgeuse)

With these values, get : Dg = 66°16'420 , and from Dg, get UT(1) = 00h33m05 s as follows :

At UT = 00h31m13.0s , geocentric distance between Moon and Betelgeuse is : 66°15'3646,
At UT = 00h32m53.0s (100 seconds later), such distance is : 66°16'3092, therefore through Linear Interpolation we find such is distance is equal to 66°16'420 when UT = 00h33m05 s
(*check* : for UT= 00h33m05 s, such distance is 66°16'4226 ... good enough)

Therefore our new value(1) is : UT = 00h33m05 s

"REPEAT 1" COMPUTATION with UT(1) = 00h33m05 s

We again compute all data for UT(0)=00h33m05.0s this second time :

MHt = 25°15'744
BHt = 45°17'832
Dt = 66°49'9 ALWAYS Keep this value *unchanged*
MHg = 26°07'288
BHg = 45°16'831

With these values, get : Dg = 66°16'557 , and from Dg, get UT(2) = 00h33m19.2s as follows :

At UT = 00h31m13.0s , geocentric distance between Moon and Betelgeuse is : 66°15'3646,
At UT = 00h32m53.0s (100 seconds later), such distance is : 66°16'3092, therefore through Linear Interpolation we find such is distance is equal to 66°16'557 when UT = 00h33m19.2 s
(*check* : for UT= 00h33m19.2s, such distance is 66°16'557 ... excellent !)

Therefore our new value is : UT(2) = 00h33m19.2s

"REPEAT 2" COMPUTATION with UT(2) = 00h33m19.2s

We again compute all data for UT(2)=00h33m19.2s this third time :

MHt = 25°17'648

BHt = 45°17'124

Dt = 66°49'9 ALWAYS Keep this value ***unchanged***

MHg = 26°09'181

BHg = 45°16'124

With these values, get : Dg = 66°16'602 , and from Dg, get UT(3)= 00h33m24.0s as follows :

At UT = 00h31m13.0s , geocentric distance between Moon and Betelgeuse is : 66°15'3646,
At UT = 00h32m53.0s (100 seconds later), such distance is : 66°16'3092, therefore through Linear Interpolation we find such is distance is equal to 66°16'602 when UT = 00h33m24.0 s

(*check* : for UT= 00h33m24.0s, such distance is 66°16'602 … excellent !)

"REPEAT 3" COMPUTATION with UT(3) = 00h33m24.0s

We again compute all data for UT(3)=00h33m24.0s this third time :

MHt = 25°18'291

BHt = 45°16'885

Dt = 66°49'9 ALWAYS Keep this value ***unchanged***

MHg = 26°09'821

BHg = 45°15'884

With these values, get : Dg = 66°16'608 , and from Dg, get UT(4) = 00h33m24.6s as follows :

At UT = 00h31m13.0s , geocentric distance between Moon and Betelgeuse is : 66°15'3646,
At UT = 00h32m53.0s (100 seconds later), such distance is : 66°16'3092, therefore through Linear Interpolation we find such is distance is equal to 66°16'608 when UT = 00h33m24.6 s

(*check* : for UT= 00h33m24.6s, such distance is 66°16'6077 … excellent !)

FINAL RESULTS : Let us stop and analyze our results :

We have observed that, after one computation and 3 iterations, at UT = 00h33m24.6 s we observe Dg = 66°16'602 which is the Geocentric Lunar Distance "image" of our Topocentric Observed Lunar Distance Dg = 66°49'9

We also have observed a good stability and convergence in the UT determination method which we have used :
UT(0) = 00h31m13.0s , UT(1) = 00h33m05 s , UT(2) = 00h33m19.2s , UT(3) = 00h33m24.0s and UT(4) = 00h33m24.6s
(Δ = 112.0s) (Δ = 17.2 s) (Δ = 4.8 s) (Δ = 0.6 s)

Therefore, since we now estimate that any next computation would hardly bring us any benefit, then we should consider that - through the use of our computed data and always leaving "Dt" unchanged (here Dt = 66°49'9) - the use of the Topocentric Cosine and Geocentric Cosine Formulae gives us the following result :

UT time of Betelgeuse Lunar is 00h33m24.6s

NOTE : On this specific example, with a quite different method but with the very same numerical data, I am getting the following result : ***UT time of Betelgeuse Lunar is 00h33m26.6s***.
While this "different method" is more accurate since it integrates the actual value of the "refracted" Semi-Diameters measured in the exact direction towards the other body in order to accurately take in account refractional flattening , and since it also takes in account parallax in Azimuth, the difference of our results between both methods is insignificant here in this specific Betelgeuse Lunar.