Assignment #1 - Astronomia de Sistemas Planetários

[Modified Earth Ω and inclination]

Arthur Araujo Galdino dos Santos

Disponível em: https://github.com/araujoarthur/psastronomyclass/blob/main/A1/V3/A1V4EarthModifiedANL-INCL.ipynb

In [ ]:
```
using DataFrames, PlotlyJS, Statistics
const au = 149597870700.0
;
```

Utility Functions

In [ ]:

```
"""
arcCorrection(::Float64) : Float64

Receives an arc and return it if smaller than or equal to 360°, else retu

[Suboptimal. Won't solve problems like ARC < 0. But works for this assign
"""
function arcCorrection(ARC::Float64)
    if ARC >= 360.0
        return mod(ARC,360.0)
    else
        return Float64(ARC)
    end
end
"""
tt(::Integer, ::Integer, ::Integer, ::Integer, ::Integer) : Float64

Receives a day value, a month value, an year value, an hour value and a m
"""
function tt(d::Integer, m::Integer, y::Integer, h::Integer, mm::Integer)
    return 367 * y - floor(7*(y + ((m+9)/12) )/4) + floor(275*m/9) + d -
end

"""
E(::Float64, ::Float64, [::Float64]) : Float64

Receives the mean anomaly, the eccentricity and optionally [for recursive
Outputs an eccentric anomaly value in degrees.
"""
function E(M::Float64, EC::Float64, Ẽ::Float64=M)
    M_rad = deg2rad(M)
    Ẽ_rad = deg2rad(Ẽ)

    ΔE_rad = ((M_rad - Ẽ_rad) + EC * sin(Ẽ_rad))/(1 - (EC * cos(Ẽ_rad)))
    E_deg = rad2deg(Ẽ_rad + ΔE_rad)

    if abs(ΔE_rad) > 5E-6
        return E(M, EC, E_deg)
    else
        return E_deg
    end
end

"""
ν(::Float64, ::Float64) : Float64

Receives the eccentricity and the eccentric anomaly in degrees and return
"""
function ν(EC::Float64, E::Float64)
    return 2 * atand(sqrt((1 + EC)/(1 - EC))*tand(E/2))
end

"""
polarReferentialFix(::Float64) : Float64

Receives an angle and return it's equivalent counter clock-wise.
[Not optimal, won't solve problems like congruent angles (<360), but work
"""
function polarReferentialFix(ang::Float64)
    if 0 > ang
        return 360 + ang
    else
        return ang
```

```
        return any
    end
end

"""
sunDistance(::Float64, ::Float64, ::Float64) : Float64

Receives Major SemiAxis, Eccentricity and True Anomaly (the former in met
"""
function sunDistance(MSA::Float64, EC::Float64, ν::Float64)
    return (MSA * (1 - EC^2))/(1 + EC * cosd(ν))
end


"""
cartesian_X(::Float64, ::Float64, ::Float64, ::Float64) : Float64

Receives the distance between the Sun and the given body (R), the longitu
the true anomaly (v) and the tilt relative to the ecliptic (i) and output
"""
function cartesian_X(R::Float64, Ω::Float64, ω::Float64, v::Float64, i::F
    return (R * ( ( cosd(Ω) * (cosd(ω + v)) ) - ( sind(Ω) * (sind(ω + v))
end

"""
cartesian_Y(::Float64, ::Float64, ::Float64, ::Float64) : Float64

Receives the distance between the Sun and the given body (R), the longitu
the true anomaly (ν) and the tilt relative to the ecliptic (i) and output
"""
function cartesian_Y(R::Float64, Ω::Float64, ω::Float64, ν::Float64, i::F
    return R * ((sind(Ω) * cosd(ω + ν)) + (cosd(Ω) * sind(ω + ν) * cosd(i
end

"""
cartesian_Z(::Float64, ::Float64, ::Float64, ::Float64)

Receives the distance between the Sun and the given body (R), the perihel
tilt relative to the ecliptic (i) and outputs the rectangular coordinate
"""
function cartesian_Z(R::Float64, ω::Float64, ν::Float64, i::Float64)
    return R * sind(ω + ν) * sind(i)
end

"""
ℓ(::Float64, ::Float64) : Float64

Receives the X and Y coordinates and outputs the ecliptic longitude ℓ in
"""
function ℓ(XX::Float64, YY::Float64)
   return atand(YY, XX)
end

"""
Receives the X, Y and X coordinates and outputs the ecliptic latitude b i
"""
function b(XX::Float64, YY::Float64, ZZ::Float64)
    return atand((ZZ)/(sqrt((XX^2) + (YY^2))))
end
```

Out[ ]:
```
b
```

In [ ]:

```
function Mercury(t)
    mercuryDict = Dict()
    mercuryDict["PLANET"] = "Mercury"
    mercuryDict["Ω"] = 48.3313 + 3.24587E-5 * t
    mercuryDict["i"] = 7.0047 + 5.00E-8 * t
    mercuryDict["ω"] = 29.1241 + 1.01444E-5 * t
    mercuryDict["a"] = 0.387098*au
    mercuryDict["e"] = 0.205635 + 5.59E-10 * t
    mercuryDict["M"] = arcCorrection(168.6562 + 4.0923344368 * t)
    mercuryDict["E"] = arcCorrection(E(mercuryDict["M"], mercuryDict["e"]
    mercuryDict["ν"] = polarReferentialFix(ν(mercuryDict["e"], mercuryDic
    mercuryDict["Dist_Sun"] = sunDistance(mercuryDict["a"], mercuryDict["
    mercuryDict["X_COORD"] = cartesian_X(mercuryDict["Dist_Sun"], mercury
    mercuryDict["Y_COORD"] = cartesian_Y(mercuryDict["Dist_Sun"], mercury
    mercuryDict["Z_COORD"] = cartesian_Z(mercuryDict["Dist_Sun"], mercury
    mercuryDict["ℓ"] = ℓ(mercuryDict["X_COORD"], mercuryDict["Y_COORD"])
    mercuryDict["ℓ_corr"] = polarReferentialFix(ℓ(mercuryDict["X_COORD"],
    mercuryDict["b"] = b(mercuryDict["X_COORD"], mercuryDict["Y_COORD"],

    return mercuryDict
end

function Venus(t)
    venusDict = Dict()
    venusDict["PLANET"] = "Venus"
    venusDict["Ω"] = 76.6799 + 2.46590E-5 * t
    venusDict["i"] = 3.3946 + 2.75E-8 * t
    venusDict["ω"] = 54.8910 + 1.38374E-5 * t
    venusDict["a"] = 0.723330 * au
    venusDict["e"] = 0.006773 - 1.302E-9 * t
    venusDict["M"] = arcCorrection(48.0052 + 1.6021302244 * t)
    venusDict["E"] = arcCorrection(E(venusDict["M"], venusDict["e"]))
    venusDict["ν"] = polarReferentialFix(ν(venusDict["e"], venusDict["E"]
    venusDict["Dist_Sun"] = sunDistance(venusDict["a"], venusDict["e"], v
    venusDict["X_COORD"] = cartesian_X(venusDict["Dist_Sun"], venusDict["
    venusDict["Y_COORD"] = cartesian_Y(venusDict["Dist_Sun"], venusDict["
    venusDict["Z_COORD"] = cartesian_Z(venusDict["Dist_Sun"], venusDict["
    venusDict["ℓ"] = ℓ(venusDict["X_COORD"], venusDict["Y_COORD"])
    venusDict["ℓ_corr"] = polarReferentialFix(ℓ(venusDict["X_COORD"], ven
    venusDict["b"] = b(venusDict["X_COORD"], venusDict["Y_COORD"], venusD

    return venusDict
end

function Earth(t)
    earthDict = Dict()
    earthDict["PLANET"] = "Earth"
    earthDict["Ω"] = 180.378 # 0.0
    earthDict["i"] = 0.00672579 # 0.0
    earthDict["ω"] = 282.9404 + 4.70935E-5 * t
    earthDict["a"] = au
    earthDict["e"] = 0.016709 - 1.151E-9 * t
    earthDict["M"] = arcCorrection(356.0470 + 0.9856002585 * t)
    earthDict["E"] = arcCorrection(E(earthDict["M"], earthDict["e"]))
    earthDict["ν"] = polarReferentialFix(ν(earthDict["e"], earthDict["E"]
    earthDict["Dist_Sun"] = sunDistance(earthDict["a"], earthDict["e"], e
    earthDict["X_COORD"] = cartesian_X(earthDict["Dist_Sun"], earthDict["
    earthDict["Y_COORD"] = cartesian_Y(earthDict["Dist_Sun"], earthDict["
    earthDict["Z_COORD"] = cartesian_Z(earthDict["Dist_Sun"], earthDict["
    earthDict["ℓ"] = ℓ(earthDict["X_COORD"], earthDict["Y_COORD"])
    earthDict["ℓ_corr"] = polarReferentialFix(ℓ(earthDict["X_COORD"], ear
    earthDict["b"] = b(earthDict["X_COORD"], earthDict["Y_COORD"], earthD
```

```
    return earthDict
end

function Mars(t)
    marsDict = Dict()
    marsDict["PLANET"] = "Mars"
    marsDict["Ω"] = 49.5574 + 2.11081E-5 * t
    marsDict["i"] = 1.8497 - 1.78E-8 * t
    marsDict["ω"] = 286.5016 + 2.92961E-5 * t
    marsDict["a"] = 1.523688 * au
    marsDict["e"] = 0.093405 + 2.516E-9 * t
    marsDict["M"] = arcCorrection(18.6021 + 0.5240207766 * t)
    marsDict["E"] = arcCorrection(E(marsDict["M"], marsDict["e"]))
    marsDict["ν"] = polarReferentialFix(ν(marsDict["e"], marsDict["E"]))
    marsDict["Dist_Sun"] = sunDistance(marsDict["a"], marsDict["e"], mars
    marsDict["X_COORD"] = cartesian_X(marsDict["Dist_Sun"], marsDict["Ω"]
    marsDict["Y_COORD"] = cartesian_Y(marsDict["Dist_Sun"], marsDict["Ω"]
    marsDict["Z_COORD"] = cartesian_Z(marsDict["Dist_Sun"], marsDict["ω"]
    marsDict["ℓ"] = ℓ(marsDict["X_COORD"], marsDict["Y_COORD"])
    marsDict["ℓ_corr"] = polarReferentialFix(ℓ(marsDict["X_COORD"], marsD
    marsDict["b"] = b(marsDict["X_COORD"], marsDict["Y_COORD"], marsDict[

    return marsDict
end

function Jupiter(t)
    jupyterDict = Dict()
    jupyterDict["PLANET"] = "Jupiter"
    jupyterDict["Ω"] = 100.4542 + 2.76854E-5 * t
    jupyterDict["i"] = 1.3030 - 1.557E-7 * t
    jupyterDict["ω"] = 273.8777 + 1.64505E-5 * t
    jupyterDict["a"] = 5.20256 * au
    jupyterDict["e"] = 0.048498 + 4.469E-9 * t
    jupyterDict["M"] = arcCorrection(19.8950 + 0.0830853001 * t)
    jupyterDict["E"] = arcCorrection(E(jupyterDict["M"], jupyterDict["e"]
    jupyterDict["ν"] = polarReferentialFix(ν(jupyterDict["e"], jupyterDic
    jupyterDict["Dist_Sun"] = sunDistance(jupyterDict["a"], jupyterDict["
    jupyterDict["X_COORD"] = cartesian_X(jupyterDict["Dist_Sun"], jupyter
    jupyterDict["Y_COORD"] = cartesian_Y(jupyterDict["Dist_Sun"], jupyter
    jupyterDict["Z_COORD"] = cartesian_Z(jupyterDict["Dist_Sun"], jupyter
    jupyterDict["ℓ"] = ℓ(jupyterDict["X_COORD"], jupyterDict["Y_COORD"])
    jupyterDict["ℓ_corr"] = polarReferentialFix(ℓ(jupyterDict["X_COORD"],
    jupyterDict["b"] = b(jupyterDict["X_COORD"], jupyterDict["Y_COORD"],


    return jupyterDict
end

function Saturn(t)
    saturnDict = Dict()
    saturnDict["PLANET"] = "Saturn"
    saturnDict["Ω"] = 113.6634 + 2.38980E-5 * t
    saturnDict["i"] = 2.4886 - 1.081E-7 * t
    saturnDict["ω"] = 339.3939 + 2.97661E-5 * t
    saturnDict["a"] = 9.55475 * au
    saturnDict["e"] = 0.055546 - 9.499E-9 * t
    saturnDict["M"] = arcCorrection(316.9670 + 0.0334442282 * t)
    saturnDict["E"] = arcCorrection(E(saturnDict["M"], saturnDict["e"]))
    saturnDict["ν"] = polarReferentialFix(ν(saturnDict["e"], saturnDict["
    saturnDict["Dist_Sun"] = sunDistance(saturnDict["a"], saturnDict["e"]
    saturnDict["X_COORD"] = cartesian_X(saturnDict["Dist_Sun"], saturnDic
    saturnDict["Y_COORD"] = cartesian_Y(saturnDict["Dist_Sun"], saturnDic
    saturnDict["Z_COORD"] = cartesian_Z(saturnDict["Dist_Sun"], saturnDic
```

```
    saturnDict["ℓ"] = ℓ(saturnDict["X_COORD"], saturnDict["Y_COORD"])
    saturnDict["ℓ_corr"] = polarReferentialFix(ℓ(saturnDict["X_COORD"], s
    saturnDict["b"] = b(saturnDict["X_COORD"], saturnDict["Y_COORD"], sat


    return saturnDict
end

function Uranus(t)
    uranusDict = Dict()
    uranusDict["PLANET"] = "Uranus"
    uranusDict["Ω"] = 74.0005 + 1.3978E-5 * t
    uranusDict["i"] = 0.7733 + 1.9E-8 * t
    uranusDict["ω"] = 96.6612 + 3.0565E-5 * t
    uranusDict["a"] = (19.18171 - 1.55E-8 * t) * (au)
    uranusDict["e"] = 0.047318 + 7.45E-9 * t
    uranusDict["M"] = arcCorrection(142.5905 + 0.011725806 * t)
    uranusDict["E"] = arcCorrection(E(uranusDict["M"], uranusDict["e"]))
    uranusDict["ν"] = polarReferentialFix(ν(uranusDict["e"], uranusDict["
    uranusDict["Dist_Sun"] = sunDistance(uranusDict["a"], uranusDict["e"]
    uranusDict["X_COORD"] = cartesian_X(uranusDict["Dist_Sun"], uranusDic
    uranusDict["Y_COORD"] = cartesian_Y(uranusDict["Dist_Sun"], uranusDic
    uranusDict["Z_COORD"] = cartesian_Z(uranusDict["Dist_Sun"], uranusDic
    uranusDict["ℓ"] = ℓ(uranusDict["X_COORD"], uranusDict["Y_COORD"])
    uranusDict["ℓ_corr"] = polarReferentialFix(ℓ(uranusDict["X_COORD"], u
    uranusDict["b"] = b(uranusDict["X_COORD"], uranusDict["Y_COORD"], ura

    return uranusDict
end

function Neptune(t)
    neptuneDict = Dict()
    neptuneDict["PLANET"] = "Neptune"
    neptuneDict["Ω"] = 131.7806 + 3.0173E-5 * t
    neptuneDict["i"] = 1.7700 - 2.55E-7 * t
    neptuneDict["ω"] = 272.8461 - 6.027E-6 * t
    neptuneDict["a"] = (30.05826 + 3.313E-8 * t) * (au)
    neptuneDict["e"] = 0.008606 + 2.15E-9 * t
    neptuneDict["M"] = arcCorrection(260.2471 + 0.005995147 * t)
    neptuneDict["E"] = arcCorrection(E(neptuneDict["M"], neptuneDict["e"]
    neptuneDict["ν"] = polarReferentialFix(ν(neptuneDict["e"], neptuneDic
    neptuneDict["Dist_Sun"] = sunDistance(neptuneDict["a"], neptuneDict["
    neptuneDict["X_COORD"] = cartesian_X(neptuneDict["Dist_Sun"], neptune
    neptuneDict["Y_COORD"] = cartesian_Y(neptuneDict["Dist_Sun"], neptune
    neptuneDict["Z_COORD"] = cartesian_Z(neptuneDict["Dist_Sun"], neptune
    neptuneDict["ℓ"] = ℓ(neptuneDict["X_COORD"], neptuneDict["Y_COORD"])
    neptuneDict["ℓ_corr"] = polarReferentialFix(ℓ(neptuneDict["X_COORD"],
    neptuneDict["b"] = b(neptuneDict["X_COORD"], neptuneDict["Y_COORD"],

    return neptuneDict
end
```

Out[ ]:
```
Neptune (generic function with 1 method)
```

In [ ]:
```
gt = tt(1, 7, 2053, 0, 35)
```

Out[ ]:
```
19540.024305555555
```

In [ ]:
```
iteratorBodies = [Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune]

dfBodies = DataFrame(Mercury(gt))

for iterableBody ∈ iteratorBodies
    push!(dfBodies, iterableBody(gt))
end

dfBodiesCopy = copy(dfBodies)
show(dfBodies, allcols=true)
```

```
8×16 DataFrame
 Row │ Dist_Sun    E         M         PLANET   X_COORD      Y_COORD
Z_COORD      a           b           e           i           Ω         ν
ω         ℓ           ℓ_corr
     │ Float64     Float64   Float64   String   Float64      Float64
Float64      Float64     Float64     Float64     Float64     Float64   Fl
oat64   Float64   Float64    Float64
─────┼──────────────────────────────────────────────────────────────────
──────────────────────────────────────────────────────────────────────
──────────────────────────────────────────
   1 │ 6.84698e10  207.525   212.971   Mercury   1.24997e10  -6.69984e10
-6.56379e9   5.7909e10   -5.50105    0.205646    7.00568      48.9655  20
2.489    29.3223   -79.432   280.568
   2 │ 1.07602e11   33.8843   33.6687  Venus    -1.04412e11   2.5217e10
6.37187e9   1.08209e11   3.39486    0.00674756  3.39514      77.1617   3
4.1004   55.1614   166.422   166.422
   3 │ 1.52084e11  174.787   174.7     Earth     2.40838e10  -1.50165e11
1.76457e7   1.49598e11   0.0066478  0.0166865   0.00672579  180.378   17
4.873   283.861    -80.8884  279.112
   4 │ 2.49231e11  178.153   177.981   Mars     -2.26446e11   1.03818e11
7.75461e9   2.2794e11    1.78299    0.0934542   1.84935      49.9699  17
8.319   287.074    155.37    155.37
   5 │ 8.13271e11  202.326   203.384   Jupiter  -6.53688e11  -4.83554e11
1.66543e10  7.78292e11   1.1734     0.0485853   1.29996     100.995   20
1.291   274.199   -143.508   216.492
   6 │ 1.45961e12  247.537   250.468   Saturn    1.3594e12   -5.29636e11
-4.44706e10  1.42937e12  -1.74593    0.0553604   2.48649     114.13    24
4.635   339.976    -21.2865  338.714
   7 │ 2.73642e12   12.292    11.713   Uranus   -2.72807e12  -2.10813e11
3.4689e10   2.8695e12    0.726346   0.0474636   0.773671     74.2736   1
2.885    97.2584  -175.581   184.419
   8 │ 4.45967e12   17.5418   17.3924  Neptune   2.03772e12   3.96482e12
-1.28728e11  4.49675e12  -1.65407    0.00864801  1.76502     132.37     1
7.6917  272.728     62.7991   62.7991
```

Plotting

In [ ]:
```
graphData = DataFrame()
graphData[!, "RADIUS"] = [i for i in 1:8]
graphData[!, "PLANET"] = dfBodies.PLANET
graphData[!, "COORD"] = dfBodies.ℓ

show(graphData)
```

```
8×3 DataFrame
 Row │ RADIUS  PLANET   COORD
     │ Int64   String   Float64
─────┼──────────────────────────
   1 │      1  Mercury   -79.432
   2 │      2  Venus     166.422
   3 │      3  Earth     -80.8884
   4 │      4  Mars      155.37
   5 │      5  Jupiter  -143.508
   6 │      6  Saturn    -21.2865
   7 │      7  Uranus   -175.581
   8 │      8  Neptune    62.7991
```

In [ ]:
```
plot(scatterpolar(graphData, r=:RADIUS, theta=:COORD, color=:PLANET, mode
```

Out[ ]:

WebIO not detected.

Please read the troubleshooting guide for more information on how to resolve this issue.

https://juliagizmos.github.io/WebIO.jl/latest/troubleshooting/not-detected/

Data from NASA's SPICE Software

http://spice.esac.esa.int/webgeocalc/#OrbitalElements For Orbital Elements.

Kernel: (all GENERIC)
Orbiting Object: [Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune]
Center of Motion: Sun
Reference Frame:ECLIPJ2000
Time System: UTC
Time Format: Calendar date and time
Input Times: Single Time
Time: 2053-07-01T00:00:00.00 // Easier Calc
(True Anomaly and Sun Distance from NASA Horizons)

http://spice.esac.esa.int/webgeocalc/#StateVector For Position

Kernel: (all GENERIC)
Target: [Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune]
OBSERVER: Sun
Frame Name:ECLIPJ2000
Time System: UTC
Time Format: Calendar date and time
Input Times: Single Time
Time: 2053-07-01T00:35:00.00

In [ ]:
```
# Subsetting my DataFrame

subsetBodies = dfBodies[:, [:M, :PLANET, :a, :e, :Ω, :ν, :ω]]
subsetPositions = dfBodies[:, [:PLANET, :X_COORD, :Y_COORD, :Z_COORD, :ℓ,
rename!(subsetPositions, :X_COORD => :X)
rename!(subsetPositions, :Y_COORD => :Y)
rename!(subsetPositions, :Z_COORD => :Z)
show(subsetBodies, allcols=true)
println("\n\n")
show(subsetPositions, allcols=true)
```

8×7 DataFrame

Row	M	PLANET	a	e	Ω	ν	ω
	Float64	String	Float64	Float64	Float64	Float64	Float64
1	212.971	Mercury	5.7909e10	0.205646	48.9655	202.489	29.3223
2	33.6687	Venus	1.08209e11	0.00674756	77.1617	34.1004	55.1614
3	174.7	Earth	1.49598e11	0.0166865	180.378	174.873	283.861
4	177.981	Mars	2.2794e11	0.0934542	49.9699	178.319	287.074
5	203.384	Jupiter	7.78292e11	0.0485853	100.995	201.291	274.199
6	250.468	Saturn	1.42937e12	0.0553604	114.13	244.635	339.976
7	11.713	Uranus	2.8695e12	0.0474636	74.2736	12.885	97.2584
8	17.3924	Neptune	4.49675e12	0.00864801	132.37	17.6917	272.728

8×7 DataFrame

Row	PLANET	X	Y	Z	ℓ	ℓ_corrb
	String	Float64	Float64	Float64	Float64	Float64
1	Mercury	1.24997e10	-6.69984e10	-6.56379e9	-79.432	280.568 -5.50105
2	Venus	-1.04412e11	2.5217e10	6.37187e9	166.422	166.422 3.39486
3	Earth	2.40838e10	-1.50165e11	1.76457e7	-80.8884	279.112 0.0066478
4	Mars	-2.26446e11	1.03818e11	7.75461e9	155.37	155.37 1.78299
5	Jupiter	-6.53688e11	-4.83554e11	1.66543e10	-143.508	216.492 1.1734
6	Saturn	1.3594e12	-5.29636e11	-4.44706e10	-21.2865	338.714 -1.74593
7	Uranus	-2.72807e12	-2.10813e11	3.4689e10	-175.581	184.419 0.726346
8	Neptune	2.03772e12	3.96482e12	-1.28728e11	62.7991	62.7991 -1.65407

In [ ]:

```
MercurySPICE = Dict(
    "PLANET" => "Mercury",
    "Ω" => 48.26394929,
    "ω" => 29.27515022,
    "a" => 68126020.15398264E3, #Convert from KM
    "e" => 0.20565023,
    "M" => 216.96933818,
    "i" => 7.00184025,
    "X" => 14911091.80597833E3,
    "Y" => -66118957.10648166E3,
    "Z" => -6772425.47931979E3,
    "ℓ" => -77.29130718,
    "ℓ_corr" => polarReferentialFix(-77.29130718),
    "b" => -5.70597146,
    "ν" => 205.2995670038993,
    "R" => 6.778207702727926E10
)

VenusSPICE = Dict(
    "PLANET" => "Venus",
    "Ω" => 76.53136424,
    "ω" => 55.23916999,
    "a" => 107611084.49418102E3,
    "e" =>      0.00676238,
    "M" => 35.04145354,
    "i" => 3.39427835,
    "X" => -104794789.27783182E3,
    "Y" => 23615111.32284366E3,
    "Z" => 6370740.54597109E3,
    "ℓ" => 167.30073594,
    "ℓ_corr" => 167.30073594,
    "b" => 3.39397305,
    "ν" => 35.50022680504404,
    "R" => 1.074549503179932E11
)

EarthSPICE = Dict(
    "PLANET" => "Earth",
    "Ω" => 180.37840376,
    "ω" => 282.44577374,
    "a" => 152082619.11011820E3,
    "e" => 0.01751289,
    "M" => 175.94943770,
    "i" => 0.00672579,
    "X" => 23561118.31566819E3,
    "Y" => -150246452.29559687E3,
    "Z" => 17654.89506852E3, # For me there's no reason for earth to be z
    "ℓ" => -81.06449477,
    "ℓ_corr" => polarReferentialFix(-81.06449477),
    "b" => 0.00665092,
    "ν" => 176.0882921447710,
    "R" => 1.517150540821351E11
)

MarsSPICE = Dict(
    "PLANET" => "Mars",
    "Ω" => 49.39843323,
    "ω" => 286.91935417,
    "a" => 249239379.40676948E3,
    "e" => 0.09351113,
    "M" => 178.47274288,
    "i" => 1.84548902,
    "X" => -225897389.2228340E3
```

```
    "X" => -2258975E3.2228534E3,
    "Y" => 105028364.72766489E3,
    "Z" => 7728701.20609896E3,
    "ℓ" => 155.06447561,
    "ℓ_corr" => 155.06447561,
    "b" => 1.77697751,
    "ν" => 178.7280093491614,
    "R" => 2.491828348843164E11
)

JupiterSPICE = Dict(
    "PLANET" => "Jupiter",
    "Ω" => 100.58171490,
    "ω" => 274.90404577,
    "a" => 813294159.49340240E3,
    "e" => 0.04738841,
    "M" => 202.30773215,
    "i" => 1.30343505,
    "X" => -659099013.85965610E3,
    "Y" => -476188208.77358800E3,
    "Z" => 16731227.13450408E3,
    "ℓ" => -144.15250724,
    "ℓ_corr" => polarReferentialFix(-144.15250724),
    "b" => 1.17878243,
    "ν" => 199.9601671373209,
    "R" => 8.128464215333256E11

)

SaturnSPICE = Dict(
    "PLANET" => "Saturn",
    "Ω" => 113.47181865,
    "ω" => 338.79130237,
    "a" => 1453474979.37304350E3,
    "e" => 0.05327919,
    "M" => 251.78553602,
    "i" => 2.48725019,
    "X" => 1350310213.83293800E3,
    "Y" => -535972188.34747136E3,
    "Z" => -44528446.49176982E3,
    "ℓ" => -21.64937666,
    "ℓ_corr" => polarReferentialFix(-21.64937666),
    "b" => -1.75558099,
    "ν" => 245.8333400468297,
    "R" => 1.453559593042406E12
)

UranusSPICE = Dict(
    "PLANET" => "Uranus",
    "Ω" => 73.95336561,
    "ω" => 98.96809742,
    "a" => 2738027824.74679600E3,
    "e" => 0.05082914,
    "M" => 9.66654791,
    "i" => 0.77187598,
    "X" => -2732305452.18072700E3,
    "Y" => -173487143.73558030E3,
    "Z" => 34730880.73453543E3,
    "ℓ" => -176.36689403,
    "ℓ_corr" => polarReferentialFix(-176.36689403),
    "b" => 0.72679545,
    "ν" => 10.71881736629351,
    "R" => 2.737747592415333E12
)
```

```
)

NeptuneSPICE = Dict(
    "PLANET" => "Neptune",
    "Ω" => 132.05175038,
    "ω" => 269.26791696,
    "a" => 4460940793.96299800E3,
    "e" => 0.00585937,
    "M" => 20.48466102,
    "i" => 1.76743947,
    "X" => 2089979961.21707370E3,
    "Y" => 3938941296.74271060E3,
    "Z" => -129298881.91905070E3,
    "ℓ" =>  62.04983143,
    "ℓ_corr" => 62.04983143,
    "b" => -1.66093168,
    "ν" => 20.08143075194107,
    "R" => 4.461423855999846E12
)

dfSPICE = DataFrame(MercurySPICE)
push!(dfSPICE, VenusSPICE)
push!(dfSPICE, EarthSPICE)
push!(dfSPICE, MarsSPICE)
push!(dfSPICE, JupiterSPICE)
push!(dfSPICE, SaturnSPICE)
push!(dfSPICE, UranusSPICE)
push!(dfSPICE, NeptuneSPICE)

dfSPICEcopy = DataFrame(dfSPICE)

subsetBodies = dfBodies[!, [:PLANET, :Ω, :a, :e, :i, :M]]
dfSPICEpos = dfSPICE[!, [:PLANET, :X, :Y, :Z, :ℓ, :ℓ_corr, :b]]
dfSPICE = dfSPICE[!, [:PLANET, :Ω, :a, :e, :i, :M]]
printstyled("\n\nSPICE Data\n", color=:red)
show(dfSPICE, allcols=true)
```

```
SPICE Data
8×6 DataFrame
 Row │ PLANET   Ω         a          e           i          M
     │ String   Float64   Float64    Float64     Float64    Float64
─────┼──────────────────────────────────────────────────────────────
   1 │ Mercury   48.2639  6.8126e10  0.20565     7.00184    216.969
   2 │ Venus     76.5314  1.07611e11 0.00676238  3.39428     35.0415
   3 │ Earth    180.378   1.52083e11 0.0175129   0.00672579 175.949
   4 │ Mars      49.3984  2.49239e11 0.0935111   1.84549    178.473
   5 │ Jupiter  100.582   8.13294e11 0.0473884   1.30344    202.308
   6 │ Saturn   113.472   1.45347e12 0.0532792   2.48725    251.786
   7 │ Uranus    73.9534  2.73803e12 0.0508291   0.771876     9.66655
   8 │ Neptune  132.052   4.46094e12 0.00585937  1.76744     20.4847
```

In [ ]:
```
printstyled("\n\nMy Calculated Data\n", color=:green)
show(subsetBodies, allcols=true, allrows=true)
```

My Calculated Data

8×6 DataFrame

Row	PLANET	Ω	a	e	i	M
	String	Float64	Float64	Float64	Float64	Float64
1	Mercury	48.9655	5.7909e10	0.205646	7.00568	212.971
2	Venus	77.1617	1.08209e11	0.00674756	3.39514	33.6687
3	Earth	180.378	1.49598e11	0.0166865	0.00672579	174.7
4	Mars	49.9699	2.2794e11	0.0934542	1.84935	177.981
5	Jupiter	100.995	7.78292e11	0.0485853	1.29996	203.384
6	Saturn	114.13	1.42937e12	0.0553604	2.48649	250.468
7	Uranus	74.2736	2.8695e12	0.0474636	0.773671	11.713
8	Neptune	132.37	4.49675e12	0.00864801	1.76502	17.3924

Comparsion Between Calculated Orbital Elements and SPICE Generated Orbital Elements

In [ ]:
```
dfDifferenceGENtoSPICE = subsetBodies[!, Not(:PLANET)] .- dfSPICE[!, Not(
dfRateGENtoSPICE = subsetBodies[!, Not(:PLANET)] ./ dfSPICE[!, Not(:PLANE
dfStatisticsRate = describe(dfRateGENtoSPICE)
dfRateGENtoSPICE[!, "PLANET"] = ["Mercury", "Venus", "Earth", "Mars", "Ju
show(dfRateGENtoSPICE, allcols=true, allrows=true)
println("\n")
show(dfStatisticsRate, allcols=true, allrows=true)

function percentualDifference(n1::Float64, n2::Float64)
    return (n1 - n2)/(n1 + n2)
end
```

8×6 DataFrame

Row	Ω	a	e	i	M	PLANET
	Float64	Float64	Float64	Float64	Float64	String
1	1.01454	0.850028	0.999979	1.00055	0.98157	Mercury
2	1.00824	1.00555	0.997808	1.00025	0.960826	Venus
3	0.999998	0.983662	0.952813	1.0	0.992899	Earth
4	1.01157	0.914544	0.999391	1.00209	0.997244	Mars
5	1.00411	0.956962	1.02526	0.997332	1.00532	Jupiter
6	1.0058	0.983416	1.03906	0.999693	0.994767	Saturn
7	1.00433	1.04802	0.933787	1.00233	1.21171	Uranus
8	1.00241	1.00803	1.47593	0.99863	0.849046	Neptune

5×7 DataFrame

Row	variable	mean	min	median	max	nmissing	eltype
	Symbol	Float64	Float64	Float64	Float64	Int64	DataTyp
e							
1	Ω	1.00637	0.999998	1.00507	1.01454	0	Float64
2	a	0.968776	0.850028	0.983539	1.04802	0	Float64
3	e	1.053	0.933787	0.999685	1.47593	0	Float64
4	i	1.00011	0.997332	1.00013	1.00233	0	Float64
5	M	0.999172	0.849046	0.993833	1.21171	0	Float64

Out[ ]:
```
percentualDifference (generic function with 1 method)
```

In [ ]:
```
percentualDiffDF = percentualDifference.(subsetBodies[!, Not(:PLANET)], d
percentualDiffDF .*= 100
```

Out[ ]: 8 rows × 5 columns

	Ω	a	e	i	M
	Float64	Float64	Float64	Float64	Float64
1	0.721586	-8.10646	-0.00104721	0.0273907	-0.930078
2	0.410151	0.276872	-0.109705	0.0126521	-1.99785
3	-0.00011192	-0.823636	-2.41636	0.0	-0.356319
4	0.575052	-4.46349	-0.0304695	0.104556	-0.138007
5	0.205112	-2.19921	1.24713	-0.133573	0.265239
6	0.289342	-0.836144	1.91569	-0.0153299	-0.262319
7	0.216064	2.34453	-3.42402	0.116158	9.57215
8	0.120425	0.399743	19.2222	-0.0685692	-8.16389

Generally, the SPICE values are higher than mine (withot high expression unless in case of Earth's elements)

In [ ]:
```
describe(percentualDiffDF)
```

Out[ ]: 5 rows × 7 columns

	variable	mean	min	median	max	nmissing	eltype
	Symbol	Float64	Float64	Float64	Float64	Int64	DataType
1	Ω	0.317203	-0.00011192	0.252703	0.721586	0	Float64
2	a	-1.67598	-8.10646	-0.82989	2.34453	0	Float64
3	e	2.05043	-3.42402	-0.0157583	19.2222	0	Float64
4	i	0.00541057	-0.133573	0.00632603	0.116158	0	Float64
5	M	-0.251384	-8.16389	-0.309319	9.57215	0	Float64

In [ ]:
```
printstyled("My Data (Positions)\n", color=:blue)
show(subsetPositions, allcols=true)
println("\n\n")
printstyled("SPICE Data (Positions)\n", color=:magenta)
show(dfSPICEpos, allcols=true)
```

My Data (Positions)

8×7 DataFrame

Row	PLANET	X	Y	Z	ℓ	ℓ_corr	b
	String	Float64	Float64	Float64	Float64	Float64	Float64
1	Mercury	1.24997e10	-6.69984e10	-6.56379e9	-79.432	280.568	-5.50105
2	Venus	-1.04412e11	2.5217e10	6.37187e9	166.422	166.422	3.39486
3	Earth	2.40838e10	-1.50165e11	1.76457e7	-80.8884	279.112	0.0066478
4	Mars	-2.26446e11	1.03818e11	7.75461e9	155.37	155.37	1.78299
5	Jupiter	-6.53688e11	-4.83554e11	1.66543e10	-143.508	216.492	1.1734
6	Saturn	1.3594e12	-5.29636e11	-4.44706e10	-21.2865	338.714	-1.74593
7	Uranus	-2.72807e12	-2.10813e11	3.4689e10	-175.581	184.419	0.726346
8	Neptune	2.03772e12	3.96482e12	-1.28728e11	62.7991	62.799	1 -1.65407

SPICE Data (Positions)

8×7 DataFrame

Row	PLANET	X	Y	Z	ℓ	ℓ_corr	b
	String	Float64	Float64	Float64	Float64	Float64	Float64
1	Mercury	1.49111e10	-6.6119e10	-6.77243e9	-77.2913	282.709	-5.70597
2	Venus	-1.04795e11	2.36151e10	6.37074e9	167.301	167.301	3.39397
3	Earth	2.35611e10	-1.50246e11	1.76549e7	-81.0645	278.936	0.00665092
4	Mars	-2.25897e11	1.05028e11	7.7287e9	155.064	155.064	1.77698
5	Jupiter	-6.59099e11	-4.76188e11	1.67312e10	-144.153	215.847	1.17878
6	Saturn	1.35031e12	-5.35972e11	-4.45284e10	-21.6494	338.351	-1.75558
7	Uranus	-2.73231e12	-1.73487e11	3.47309e10	-176.367	183.633	0.726795
8	Neptune	2.08998e12	3.93894e12	-1.29299e11	62.0498	62.049	8 -1.66093

In [ ]:
```
positionsDif = subsetPositions[!,Not(:PLANET)] .- dfSPICEpos[!,Not(:PLANE
positionsDif[!, "PLANET"] = dfSPICEpos[!, "PLANET"]

positionsDif = positionsDif[:, [:PLANET, :X, :Y, :Z, :ℓ, :b]]
```

Out[ ]: 8 rows × 6 columns

	PLANET	X	Y	Z	ℓ	b
	String	Float64	Float64	Float64	Float64	Float64
1	Mercury	-2.41136e9	-8.79454e8	2.08633e8	-2.14065	0.204918
2	Venus	3.83106e8	1.60185e9	1.12778e6	-0.8785	0.000882178
3	Earth	5.22678e8	8.16889e7	-9209.04	0.176137	-3.11621e-6
4	Mars	-5.48924e8	-1.21013e9	2.59061e7	0.305615	0.00601605
5	Jupiter	5.41129e9	-7.36568e9	-7.69184e7	0.644035	-0.0053869
6	Saturn	9.08513e9	6.33634e9	5.788e7	0.362924	0.00964992
7	Uranus	4.23527e9	-3.73263e10	-4.18327e7	0.785682	-0.000449759
8	Neptune	-5.22637e10	2.58776e10	5.70601e8	0.749298	0.00686008

In [ ]:
```
positionsRatio = subsetPositions[!,Not(:PLANET)] ./ dfSPICEpos[!,Not(:PLA
```

Out[ ]: 8 rows × 6 columns

	X	Y	Z	ℓ	ℓ_corr	b
	Float64	Float64	Float64	Float64	Float64	Float64
1	0.838284	1.0133	0.969194	1.0277	0.992428	0.964087
2	0.996344	1.06783	1.00018	0.994749	0.994749	1.00026
3	1.02218	0.999456	0.999478	0.997827	1.00063	0.999531
4	1.00243	0.988478	1.00335	1.00197	1.00197	1.00339
5	0.99179	1.01547	0.995403	0.995532	1.00298	0.99543
6	1.00673	0.988178	0.9987	0.983236	1.00107	0.994503
7	0.99845	1.21515	0.998796	0.995545	1.00428	0.999381
8	0.974993	1.00657	0.995587	1.01208	1.01208	0.99587

In [ ]:
```
positionsPercentDiff = percentualDifference.(subsetPositions[!,Not(:PLANE
positionsPercentDiff .*= 100
```

Out[ ]: 8 rows × 6 columns

	X	Y	Z	ℓ	ℓ_corr	b
	Float64	Float64	Float64	Float64	Float64	Float64
1	-8.7971	0.66066	-1.56441	1.36588	-0.380036	-1.82848
2	-0.183123	3.28031	0.00885047	-0.263242	-0.263242	0.0129946
3	1.09703	-0.0271924	-0.0260875	-0.108758	0.0315632	-0.0234324
4	0.121351	-0.579434	0.167316	0.0984476	0.0984476	0.168992
5	-0.412199	0.767465	-0.230394	-0.223887	0.148965	-0.229017
6	0.335281	-0.594622	-0.0650344	-0.845271	0.0536026	-0.275593
7	-0.0775638	9.71279	-0.0602604	-0.223238	0.21347	-0.0309508
8	-1.26617	0.327409	-0.22114	0.600164	0.600164	-0.20694

PLotting SPICE Data

In [ ]:
```
dfSPICEposRadius = Dict("ℓ" => dfSPICEpos[!,"ℓ"],
"RADIUS" => [i for i in 1:8])
plot(scatterpolar(dfSPICEpos, r=:RADIUS, theta=:ℓ, mode="markers"))
```

Out[ ]:

WebIO not detected.

Please read the troubleshooting guide for more information on how to resolve this issue.

https://juliagizmos.github.io/WebIO.jl/latest/troubleshooting/not-detected/

In [ ]:
```
myPositionsIDX = copy(subsetPositions)
myPositionsIDX[!, "PLANET"] .*= "_CALC" #String concatenation in jl is *
dfSPICEposIDX = copy(dfSPICEpos)
dfSPICEposIDX[!, "PLANET"] .*= "_SPICE"
;
```

In [ ]:
```
FullPosDF = DataFrame()
append!(FullPosDF, dfSPICEposIDX)
append!(FullPosDF, myPositionsIDX)
sort!(FullPosDF, [order(:PLANET)])
;
```

In [ ]:
```
show(dfBodiesCopy, allcols=true)
dfBodiesCopy = dfBodiesCopy[!, [:PLANET, :Ω, :i, :ω, :e, :a, :M, :E, :ν,
rename!(dfBodiesCopy, :Dist_Sun => :R)
rename!(dfBodiesCopy, :X_COORD => :X)
rename!(dfBodiesCopy, :Y_COORD => :Y)
rename!(dfBodiesCopy, :Z_COORD => :Z)
;
```

```
8×16 DataFrame
 Row │ Dist_Sun    E         M         PLANET   X_COORD      Y_COORD
Z_COORD      a           b           e           i           Ω         ν
ω         ℓ           ℓ_corr
     │ Float64     Float64   Float64   String   Float64      Float64
Float64      Float64     Float64     Float64     Float64     Float64   Fl
oat64   Float64   Float64    Float64
─────┼──────────────────────────────────────────────────────────────────
──────────────────────────────────────────────────────────────────────
──────────────────────────────────────────
   1 │ 6.84698e10  207.525   212.971   Mercury   1.24997e10  -6.69984e10
-6.56379e9   5.7909e10   -5.50105    0.205646    7.00568      48.9655  20
2.489    29.3223   -79.432   280.568
   2 │ 1.07602e11   33.8843   33.6687  Venus    -1.04412e11   2.5217e10
6.37187e9   1.08209e11   3.39486    0.00674756  3.39514      77.1617   3
4.1004   55.1614   166.422   166.422
   3 │ 1.52084e11  174.787   174.7     Earth     2.40838e10  -1.50165e11
1.76457e7   1.49598e11   0.0066478  0.0166865   0.00672579  180.378   17
4.873   283.861    -80.8884  279.112
   4 │ 2.49231e11  178.153   177.981   Mars     -2.26446e11   1.03818e11
7.75461e9   2.2794e11    1.78299    0.0934542   1.84935      49.9699  17
8.319   287.074    155.37    155.37
   5 │ 8.13271e11  202.326   203.384   Jupiter  -6.53688e11  -4.83554e11
1.66543e10  7.78292e11   1.1734     0.0485853   1.29996     100.995   20
1.291   274.199   -143.508   216.492
   6 │ 1.45961e12  247.537   250.468   Saturn    1.3594e12   -5.29636e11
-4.44706e10  1.42937e12  -1.74593    0.0553604   2.48649     114.13    24
4.635   339.976    -21.2865  338.714
   7 │ 2.73642e12   12.292    11.713   Uranus   -2.72807e12  -2.10813e11
3.4689e10   2.8695e12    0.726346   0.0474636   0.773671     74.2736   1
2.885    97.2584  -175.581   184.419
   8 │ 4.45967e12   17.5418   17.3924  Neptune   2.03772e12   3.96482e12
-1.28728e11  4.49675e12  -1.65407    0.00864801  1.76502     132.37     1
7.6917  272.728     62.7991   62.7991
```

In [ ]:
```
dfBodiesWOEcc = DataFrame(dfBodiesCopy[!, Not(:E)])
dfSPICEcopySorted = dfSPICEcopy[:, [:PLANET, :Ω, :i, :ω, :e, :a, :M, :ν,
println("\n\n")
#show(dfSPICEcopySorted, allcols=true)
#show(dfBodiesWOEcc, allcols=true)

# Just making things clear. No time to refactor, sry.
completeCalculated = copy(dfBodiesWOEcc)
completeSPICE = copy(dfSPICEcopySorted)
;
```

In [ ]:
```
completeSPICE[!, "PLANET"] .*= "_SPICE" # Concatenation in Julia is made
completeCalculated[!, "PLANET"] .*= "_CALC"
;
```

In [ ]:

```
mergedData = DataFrame()

append!(mergedData, completeSPICE)
append!(mergedData, completeCalculated)

sort!(mergedData, [order(:PLANET)])

show(mergedData, allcols=true)

mergedDataWork = copy(mergedData)
;
```

```
16×15 DataFrame
 Row │ PLANET         Ω         i           ω         e           a           M          ν         R           X            Y            Z            ℓ          ℓ_corr    b
     │ String         Float64   Float64     Float64   Float64     Float64     Float64    Float64   Float64     Float64      Float64      Float64      Float64    Float64   Float64
─────┼──────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────
   1 │ Earth_CALC     180.378   0.00672579  283.861   0.0166865   1.49598e11  174.7      174.873   1.52084e11   2.40838e10  -1.50165e11   1.76457e7    -80.8884  279.112    0.0066478
   2 │ Earth_SPICE    180.378   0.00672579  282.446   0.0175129   1.52083e11  175.949    176.088   1.51715e11   2.35611e10  -1.50246e11   1.76549e7    -81.0645  278.936    0.00665092
   3 │ Jupiter_CALC   100.995   1.29996     274.199   0.0485853   7.78292e11  203.384    201.291   8.13271e11  -6.53688e11  -4.83554e11   1.66543e10  -143.508   216.492    1.1734
   4 │ Jupiter_SPICE  100.582   1.30344     274.904   0.0473884   8.13294e11  202.308    199.96    8.12846e11  -6.59099e11  -4.76188e11   1.67312e10  -144.153   215.847    1.17878
   5 │ Mars_CALC       49.9699  1.84935     287.074   0.0934542   2.2794e11   177.981    178.319   2.49231e11  -2.26446e11   1.03818e11   7.75461e9    155.37    155.37     1.78299
   6 │ Mars_SPICE      49.3984  1.84549     286.919   0.0935111   2.49239e11  178.473    178.728   2.49183e11  -2.25897e11   1.05028e11   7.7287e9     155.064   155.064    1.77698
   7 │ Mercury_CALC    48.9655  7.00568      29.3223  0.205646    5.7909e10   212.971    202.489   6.84698e10   1.24997e10  -6.69984e10  -6.56379e9    -79.432   280.568   -5.50105
   8 │ Mercury_SPICE   48.2639  7.00184      29.2752  0.20565     6.8126e10   216.969    205.3     6.77821e10   1.49111e10  -6.6119e10   -6.77243e9    -77.2913  282.709   -5.70597
   9 │ Neptune_CALC   132.37    1.76502     272.728   0.00864801  4.49675e12   17.3924    17.6917  4.45967e12   2.03772e12   3.96482e12  -1.28728e11   62.7991   62.7991  -1.65407
  10 │ Neptune_SPICE  132.052   1.76744     269.268   0.00585937  4.46094e12   20.4847    20.0814  4.46142e12   2.08998e12   3.93894e12  -1.29299e11   62.0498   62.0498  -1.66093
  11 │ Saturn_CALC    114.13    2.48649     339.976   0.0553604   1.42937e12  250.468    244.635   1.45961e12   1.3594e12   -5.29636e11  -4.44706e10   -21.2865  338.714   -1.74593
  12 │ Saturn_SPICE   113.472   2.48725     338.791   0.0532792   1.45347e12  251.786    245.833   1.45356e12   1.35031e12  -5.35972e11  -4.45284e10   -21.6494  338.351   -1.75558
  13 │ Uranus_CALC     74.2736  0.773671     97.2584  0.0474636   2.8695e12    11.713     12.885   2.73642e12  -2.72807e12  -2.10813e11   3.4689e10   -175.581   184.419    0.726346
  14 │ Uranus_SPICE    73.9534  0.771876     98.9681  0.0508291   2.73803e12    9.66655   10.7188  2.73775e12  -2.73231e12  -1.73487e11   3.47309e10  -176.367   183.633    0.726795
  15 │ Venus_CALC      77.1617  3.39514      55.1614  0.00674756  1.08209e11   33.6687    34.1004  1.07602e11  -1.04412e11   2.5217e10    6.37187e9    166.422   166.422    3.39486
  16 │ Venus_SPICE     76.5314  3.39428      55.2392  0.00676238  1.07611e11   35.0415    35.5002  1.07455e11  -1.04795e11   2.36151e10   6.37074e9    167.301   167.301    3.39397
```

In [ ]:
```
show(mergedDataWork, allcols=true)
```

16×15 DataFrame

Row	PLANET	Ω	i	ω	e	a	M	ν	R	X	Y	Z	ℓ	ℓ_corr	b
	String	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64
1	Earth_CALC	180.378	0.00672579	283.861	0.0166865	1.49598e11	174.7	174.873	1.52084e11	2.40838e10	-1.50165e11	1.76457e7	-80.8884	279.112	0.0066478
2	Earth_SPICE	180.378	0.00672579	282.446	0.0175129	1.52083e11	175.949	176.088	1.51715e11	2.35611e10	-1.50246e11	1.76549e7	-81.0645	278.936	0.00665092
3	Jupiter_CALC	100.995	1.29996	274.199	0.0485853	7.78292e11	203.384	201.291	8.13271e11	-6.53688e11	-4.83554e11	1.66543e10	-143.508	216.492	1.1734
4	Jupiter_SPICE	100.582	1.30344	274.904	0.0473884	8.13294e11	202.308	199.96	8.12846e11	-6.59099e11	-4.76188e11	1.67312e10	-144.153	215.847	1.17878
5	Mars_CALC	49.9699	1.84935	287.074	0.0934542	2.2794e11	177.981	178.319	2.49231e11	-2.26446e11	1.03818e11	7.75461e9	155.37	155.37	1.78299
6	Mars_SPICE	49.3984	1.84549	286.919	0.0935111	2.49239e11	178.473	178.728	2.49183e11	-2.25897e11	1.05028e11	7.7287e9	155.064	155.064	1.77698
7	Mercury_CALC	48.9655	7.00568	29.3223	0.205646	5.7909e10	212.971	202.489	6.84698e10	1.24997e10	-6.69984e10	-6.56379e9	-79.432	280.568	-5.50105
8	Mercury_SPICE	48.2639	7.00184	29.2752	0.20565	6.8126e10	216.969	205.3	6.77821e10	1.49111e10	-6.6119e10	-6.77243e9	-77.2913	282.709	-5.70597
9	Neptune_CALC	132.37	1.76502	272.728	0.00864801	4.49675e12	17.3924	17.6917	4.45967e12	2.03772e12	3.96482e12	-1.28728e11	62.7991	62.7991	-1.65407
10	Neptune_SPICE	132.052	1.76744	269.268	0.00585937	4.46094e12	20.4847	20.0814	4.46142e12	2.08998e12	3.93894e12	-1.29299e11	62.0498	62.0498	-1.66093
11	Saturn_CALC	114.13	2.48649	339.976	0.0553604	1.42937e12	250.468	244.635	1.45961e12	1.3594e12	-5.29636e11	-4.44706e10	-21.2865	338.714	-1.74593
12	Saturn_SPICE	113.472	2.48725	338.791	0.0532792	1.45347e12	251.786	245.833	1.45356e12	1.35031e12	-5.35972e11	-4.45284e10	-21.6494	338.351	-1.75558
13	Uranus_CALC	74.2736	0.773671	97.2584	0.0474636	2.8695e12	11.713	12.885	2.73642e12	-2.72807e12	-2.10813e11	3.4689e10	-175.581	184.419	0.726346
14	Uranus_SPICE	73.9534	0.771876	98.9681	0.0508291	2.73803e12	9.66655	10.7188	2.73775e12	-2.73231e12	-1.73487e11	3.47309e10	-176.367	183.633	0.726795
15	Venus_CALC	77.1617	3.39514	55.1614	0.00674756	1.08209e11	33.6687	34.1004	1.07602e11	-1.04412e11	2.5217e10	6.37187e9	166.422	166.422	3.39486
16	Venus_SPICE	76.5314	3.39428	55.2392	0.00676238	1.07611e11	35.0415	35.5002	1.07455e11	-1.04795e11	2.36151e10	6.37074e9	167.301	167.301	3.39397

Mercury is consistent. Remove from DataFrame.

In [ ]:
```
delete!(mergedDataWork, 7:8)
show(mergedDataWork, allcols=true)
```

```
14×15 DataFrame
 Row │ PLANET         Ω         i           ω          e           a           M          ν          R           X           Y           Z           ℓ          ℓ_corr     b
     │ String         Float64   Float64     Float64    Float64     Float64     Float64    Float64    Float64     Float64     Float64     Float64     Float64    Float64    Float64
─────┼──────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────────
   1 │ Earth_CALC     180.378   0.00672579  283.861   0.0166865   1.49598e11  174.7      174.873   1.52084e11   2.40838e10  -1.50165e11   1.76457e7    -80.8884  279.112    0.0066478
   2 │ Earth_SPICE    180.378   0.00672579  282.446   0.0175129   1.52083e11  175.949    176.088   1.51715e11   2.35611e10  -1.50246e11   1.76549e7    -81.0645  278.936    0.00665092
   3 │ Jupiter_CALC   100.995   1.29996     274.199   0.0485853   7.78292e11  203.384    201.291   8.13271e11  -6.53688e11  -4.83554e11   1.66543e10  -143.508   216.492    1.1734
   4 │ Jupiter_SPICE  100.582   1.30344     274.904   0.0473884   8.13294e11  202.308    199.96    8.12846e11  -6.59099e11  -4.76188e11   1.67312e10  -144.153   215.847    1.17878
   5 │ Mars_CALC       49.9699  1.84935     287.074   0.0934542   2.2794e11   177.981    178.319   2.49231e11  -2.26446e11   1.03818e11   7.75461e9    155.37    155.37     1.78299
   6 │ Mars_SPICE      49.3984  1.84549     286.919   0.0935111   2.49239e11  178.473    178.728   2.49183e11  -2.25897e11   1.05028e11   7.7287e9   155.064    155.064    1.77698
   7 │ Neptune_CALC   132.37    1.76502     272.728   0.00864801  4.49675e12   17.3924    17.6917  4.45967e12   2.03772e12   3.96482e12  -1.28728e11   62.7991    62.7991  -1.65407
   8 │ Neptune_SPICE  132.052   1.76744     269.268   0.00585937  4.46094e12   20.4847    20.0814  4.46142e12   2.08998e12   3.93894e12  -1.29299e11   62.0498    62.0498  -1.66093
   9 │ Saturn_CALC    114.13    2.48649     339.976   0.0553604   1.42937e12  250.468    244.635   1.45961e12   1.3594e12   -5.29636e11  -4.44706e10   -21.2865  338.714   -1.74593
  10 │ Saturn_SPICE   113.472   2.48725     338.791   0.0532792   1.45347e12  251.786    245.833   1.45356e12   1.35031e12  -5.35972e11  -4.45284e10   -21.6494  338.351   -1.75558
  11 │ Uranus_CALC     74.2736  0.773671     97.2584  0.0474636   2.8695e12    11.713     12.885   2.73642e12  -2.72807e12  -2.10813e11   3.4689e10  -175.581   184.419    0.726346
  12 │ Uranus_SPICE    73.9534  0.771876     98.9681  0.0508291   2.73803e12    9.66655   10.7188  2.73775e12  -2.73231e12  -1.73487e11   3.47309e10  -176.367   183.633    0.726795
  13 │ Venus_CALC      77.1617  3.39514      55.1614  0.00674756  1.08209e11   33.6687    34.1004  1.07602e11  -1.04412e11   2.5217e10    6.37187e9    166.422   166.422    3.39486
  14 │ Venus_SPICE     76.5314  3.39428      55.2392  0.00676238  1.07611e11   35.0415    35.5002  1.07455e11  -1.04795e11   2.36151e10   6.37074e9    167.301   167.301    3.39397
```

Earth is consistent, deleting it.

In [ ]:
```
delete!(mergedDataWork, 1:2)
show(mergedDataWork, allcols=true)
```

```
12×15 DataFrame
 Row │ PLANET         Ω         i         ω         e           a           
M          ν          R           X            Y            Z            ℓ
ℓ_corr    b
     │ String         Float64   Float64   Float64   Float64     Float64     
Float64    Float64   Float64     Float64      Float64      Float64      F
loat64    Float64   Float64
─────┼──────────────────────────────────────────────────────────────────────
──────────────────────────────────────────────────────────────────────────
──────────────────────────────────
   1 │ Jupiter_CALC   100.995   1.29996   274.199   0.0485853   7.78292e1
1  203.384    201.291   8.13271e11  -6.53688e11  -4.83554e11   1.66543e10
-143.508   216.492    1.1734
   2 │ Jupiter_SPICE  100.582   1.30344   274.904   0.0473884   8.13294e1
1  202.308    199.96    8.12846e11  -6.59099e11  -4.76188e11   1.67312e10
-144.153   215.847    1.17878
   3 │ Mars_CALC       49.9699  1.84935   287.074   0.0934542   2.2794e11
177.981    178.319   2.49231e11  -2.26446e11   1.03818e11   7.75461e9
155.37    155.37     1.78299
   4 │ Mars_SPICE      49.3984  1.84549   286.919   0.0935111   2.49239e1
1  178.473    178.728   2.49183e11  -2.25897e11   1.05028e11   7.7287e9
155.064   155.064    1.77698
   5 │ Neptune_CALC   132.37    1.76502   272.728   0.00864801  4.49675e1
2   17.3924    17.6917  4.45967e12   2.03772e12   3.96482e12  -1.28728e11
62.7991   62.7991  -1.65407
   6 │ Neptune_SPICE  132.052   1.76744   269.268   0.00585937  4.46094e1
2   20.4847    20.0814  4.46142e12   2.08998e12   3.93894e12  -1.29299e11
62.0498   62.0498  -1.66093
   7 │ Saturn_CALC    114.13    2.48649   339.976   0.0553604   1.42937e1
2  250.468    244.635   1.45961e12   1.3594e12   -5.29636e11  -4.44706e10
-21.2865  338.714   -1.74593
   8 │ Saturn_SPICE   113.472   2.48725   338.791   0.0532792   1.45347e1
2  251.786    245.833   1.45356e12   1.35031e12  -5.35972e11  -4.45284e10
-21.6494  338.351   -1.75558
   9 │ Uranus_CALC     74.2736  0.773671   97.2584  0.0474636   2.8695e12
11.713     12.885   2.73642e12  -2.72807e12  -2.10813e11   3.4689e10   -1
75.581   184.419    0.726346
  10 │ Uranus_SPICE    73.9534  0.771876   98.9681  0.0508291   2.73803e1
2    9.66655   10.7188  2.73775e12  -2.73231e12  -1.73487e11   3.47309e10
-176.367   183.633    0.726795
  11 │ Venus_CALC      77.1617  3.39514    55.1614  0.00674756  1.08209e1
1   33.6687    34.1004  1.07602e11  -1.04412e11   2.5217e10    6.37187e9
166.422   166.422    3.39486
  12 │ Venus_SPICE     76.5314  3.39428    55.2392  0.00676238  1.07611e1
1   35.0415    35.5002  1.07455e11  -1.04795e11   2.36151e10   6.37074e9
167.301   167.301    3.39397
```

Neptune is consistent. Deleting it.

In [ ]:
```
delete!(mergedDataWork, 5:6)
show(mergedDataWork, allcols=true)
```

```
10×15 DataFrame
 Row │ PLANET         Ω         i         ω         e           a
M          ν         R           X           Y           Z           ℓ
ℓ_corr   b
     │ String         Float64   Float64   Float64   Float64     Float64
Float64    Float64   Float64     Float64      Float64      Float64      F
loat64    Float64  Float64
─────┼──────────────────────────────────────────────────────────────────
──────────────────────────────────────────────────────────────────────
──────────────────────────────────
   1 │ Jupiter_CALC   100.995   1.29996   274.199   0.0485853   7.78292e1
1  203.384    201.291   8.13271e11  -6.53688e11  -4.83554e11   1.66543e10
-143.508   216.492   1.1734
   2 │ Jupiter_SPICE  100.582   1.30344   274.904   0.0473884   8.13294e1
1  202.308    199.96    8.12846e11  -6.59099e11  -4.76188e11   1.67312e10
-144.153   215.847   1.17878
   3 │ Mars_CALC       49.9699  1.84935   287.074   0.0934542   2.2794e11
177.981    178.319   2.49231e11  -2.26446e11   1.03818e11   7.75461e9
155.37    155.37    1.78299
   4 │ Mars_SPICE      49.3984  1.84549   286.919   0.0935111   2.49239e1
1  178.473    178.728   2.49183e11  -2.25897e11   1.05028e11   7.7287e9
155.064   155.064   1.77698
   5 │ Saturn_CALC    114.13    2.48649   339.976   0.0553604   1.42937e1
2  250.468    244.635   1.45961e12   1.3594e12   -5.29636e11  -4.44706e10
-21.2865  338.714  -1.74593
   6 │ Saturn_SPICE   113.472   2.48725   338.791   0.0532792   1.45347e1
2  251.786    245.833   1.45356e12   1.35031e12  -5.35972e11  -4.45284e10
-21.6494  338.351  -1.75558
   7 │ Uranus_CALC     74.2736  0.773671   97.2584  0.0474636   2.8695e12
11.713     12.885   2.73642e12  -2.72807e12  -2.10813e11   3.4689e10   -1
75.581   184.419   0.726346
   8 │ Uranus_SPICE    73.9534  0.771876   98.9681  0.0508291   2.73803e1
2    9.66655   10.7188  2.73775e12  -2.73231e12  -1.73487e11   3.47309e10
-176.367   183.633   0.726795
   9 │ Venus_CALC      77.1617  3.39514    55.1614  0.00674756  1.08209e1
1   33.6687    34.1004  1.07602e11  -1.04412e11   2.5217e10    6.37187e9
166.422   166.422   3.39486
  10 │ Venus_SPICE     76.5314  3.39428    55.2392  0.00676238  1.07611e1
1   35.0415    35.5002  1.07455e11  -1.04795e11   2.36151e10   6.37074e9
167.301   167.301   3.39397
```

Saturn is consistent. Deleting it.

In [ ]:
```
delete!(mergedDataWork, 5:6)
show(mergedDataWork, allcols=true)
```

```
8×15 DataFrame
 Row │ PLANET         Ω         i         ω         e           a
M          ν          R           X            Y            Z           ℓ
ℓ_corr   b
     │ String         Float64   Float64   Float64   Float64     Float64
Float64    Float64   Float64     Float64      Float64      Float64     Fl
oat64   Float64  Float64
─────┼──────────────────────────────────────────────────────────────────
──────────────────────────────────────────────────────────────────────
──────────────────────────────
   1 │ Jupiter_CALC   100.995   1.29996   274.199   0.0485853   7.78292e1
1  203.384    201.291   8.13271e11  -6.53688e11  -4.83554e11  1.66543e10
-143.508  216.492  1.1734
   2 │ Jupiter_SPICE  100.582   1.30344   274.904   0.0473884   8.13294e1
1  202.308    199.96    8.12846e11  -6.59099e11  -4.76188e11  1.67312e10
-144.153  215.847  1.17878
   3 │ Mars_CALC       49.9699  1.84935   287.074   0.0934542   2.2794e11
177.981    178.319   2.49231e11  -2.26446e11   1.03818e11  7.75461e9    1
55.37   155.37   1.78299
   4 │ Mars_SPICE      49.3984  1.84549   286.919   0.0935111   2.49239e1
1  178.473    178.728   2.49183e11  -2.25897e11   1.05028e11  7.7287e9
155.064  155.064  1.77698
   5 │ Uranus_CALC     74.2736  0.773671   97.2584  0.0474636   2.8695e12
11.713     12.885   2.73642e12  -2.72807e12  -2.10813e11  3.4689e10   -17
5.581  184.419  0.726346
   6 │ Uranus_SPICE    73.9534  0.771876   98.9681  0.0508291   2.73803e1
2    9.66655   10.7188  2.73775e12  -2.73231e12  -1.73487e11  3.47309e10
-176.367  183.633  0.726795
   7 │ Venus_CALC      77.1617  3.39514    55.1614  0.00674756  1.08209e1
1   33.6687    34.1004  1.07602e11  -1.04412e11   2.5217e10   6.37187e9
166.422  166.422  3.39486
   8 │ Venus_SPICE     76.5314  3.39428    55.2392  0.00676238  1.07611e1
1   35.0415    35.5002  1.07455e11  -1.04795e11   2.36151e10  6.37074e9
167.301  167.301  3.39397
```

In [ ]:

```
dfBodiesToPlot = DataFrame()
dfBodiesToPlot = copy(dfBodiesCopy[!, [:PLANET,:ℓ, :X, :Y]])
dfBodiesToPlot[!, "SOURCE"] .= 1
dfBodiesToPlot[!,"RADIUS"] = [i for i in 1:8]
dfSPICEPlot = copy(dfSPICEcopy[:, [:PLANET, :ℓ, :X, :Y]])
dfSPICEPlot[!, "SOURCE"] .= 2
dfSPICEPlot[!,"RADIUS"] = [i for i in 1:8]

show(dfSPICEPlot, allcols=true)
println("\n\n")
show(dfBodiesToPlot, allcols=true)

plotFrame = DataFrame()
append!(plotFrame, dfBodiesToPlot)
append!(plotFrame, dfSPICEPlot)
```

8×6 DataFrame

Row	PLANET	ℓ	X	Y	SOURCE	RADIUS
	String	Float64	Float64	Float64	Int64	Int64
1	Mercury	-77.2913	1.49111e10	-6.6119e10	2	1
2	Venus	167.301	-1.04795e11	2.36151e10	2	2
3	Earth	-81.0645	2.35611e10	-1.50246e11	2	3
4	Mars	155.064	-2.25897e11	1.05028e11	2	4
5	Jupiter	-144.153	-6.59099e11	-4.76188e11	2	5
6	Saturn	-21.6494	1.35031e12	-5.35972e11	2	6
7	Uranus	-176.367	-2.73231e12	-1.73487e11	2	7
8	Neptune	62.0498	2.08998e12	3.93894e12	2	8

8×6 DataFrame

Row	PLANET	ℓ	X	Y	SOURCE	RADIUS
	String	Float64	Float64	Float64	Int64	Int64
1	Mercury	-79.432	1.24997e10	-6.69984e10	1	1
2	Venus	166.422	-1.04412e11	2.5217e10	1	2
3	Earth	-80.8884	2.40838e10	-1.50165e11	1	3
4	Mars	155.37	-2.26446e11	1.03818e11	1	4
5	Jupiter	-143.508	-6.53688e11	-4.83554e11	1	5
6	Saturn	-21.2865	1.3594e12	-5.29636e11	1	6
7	Uranus	-175.581	-2.72807e12	-2.10813e11	1	7
8	Neptune	62.7991	2.03772e12	3.96482e12	1	8

Out[ ]: 16 rows × 6 columns

	PLANET	ℓ	X	Y	SOURCE	RADIUS
	String	Float64	Float64	Float64	Int64	Int64
1	Mercury	-79.432	1.24997e10	-6.69984e10	1	1
2	Venus	166.422	-1.04412e11	2.5217e10	1	2
3	Earth	-80.8884	2.40838e10	-1.50165e11	1	3
4	Mars	155.37	-2.26446e11	1.03818e11	1	4
5	Jupiter	-143.508	-6.53688e11	-4.83554e11	1	5
6	Saturn	-21.2865	1.3594e12	-5.29636e11	1	6
7	Uranus	-175.581	-2.72807e12	-2.10813e11	1	7
8	Neptune	62.7991	2.03772e12	3.96482e12	1	8
9	Mercury	-77.2913	1.49111e10	-6.6119e10	2	1
10	Venus	167.301	-1.04795e11	2.36151e10	2	2
11	Earth	-81.0645	2.35611e10	-1.50246e11	2	3
12	Mars	155.064	-2.25897e11	1.05028e11	2	4
13	Jupiter	-144.153	-6.59099e11	-4.76188e11	2	5
14	Saturn	-21.6494	1.35031e12	-5.35972e11	2	6
15	Uranus	-176.367	-2.73231e12	-1.73487e11	2	7
16	Neptune	62.0498	2.08998e12	3.93894e12	2	8

In [ ]:
```
plot([scatterpolar(dfSPICEPlot, r=:RADIUS, theta=:ℓ, marker=attr(color=:g
      scatterpolar(dfBodiesToPlot, r=:RADIUS, theta=:ℓ, marker=attr(color
    ])



    #TODO: Check on variation (SPICE's Lat goes from -90 to +90. SPICE's
```

Out[ ]:

WebIO not detected.

Please read the troubleshooting guide for more information on how to resolve this issue.

https://juliagizmos.github.io/WebIO.jl/latest/troubleshooting/not-detected/

In [ ]:
```
plot([scatter(dfSPICEPlot, x=:X, y=:Y, marker=attr(color=:green), mode="m
```

Out[ ]:

WebIO not detected.

Please read the troubleshooting guide for more information on how to resolve this issue.

https://juliagizmos.github.io/WebIO.jl/latest/troubleshooting/not-detected/

In [ ]:
```
mergedDataEarthSolve = copy(mergedData)
delete!(mergedDataEarthSolve, 3:16)
;
```

In [ ]:
```
show(mergedDataEarthSolve, allcols=true)
```

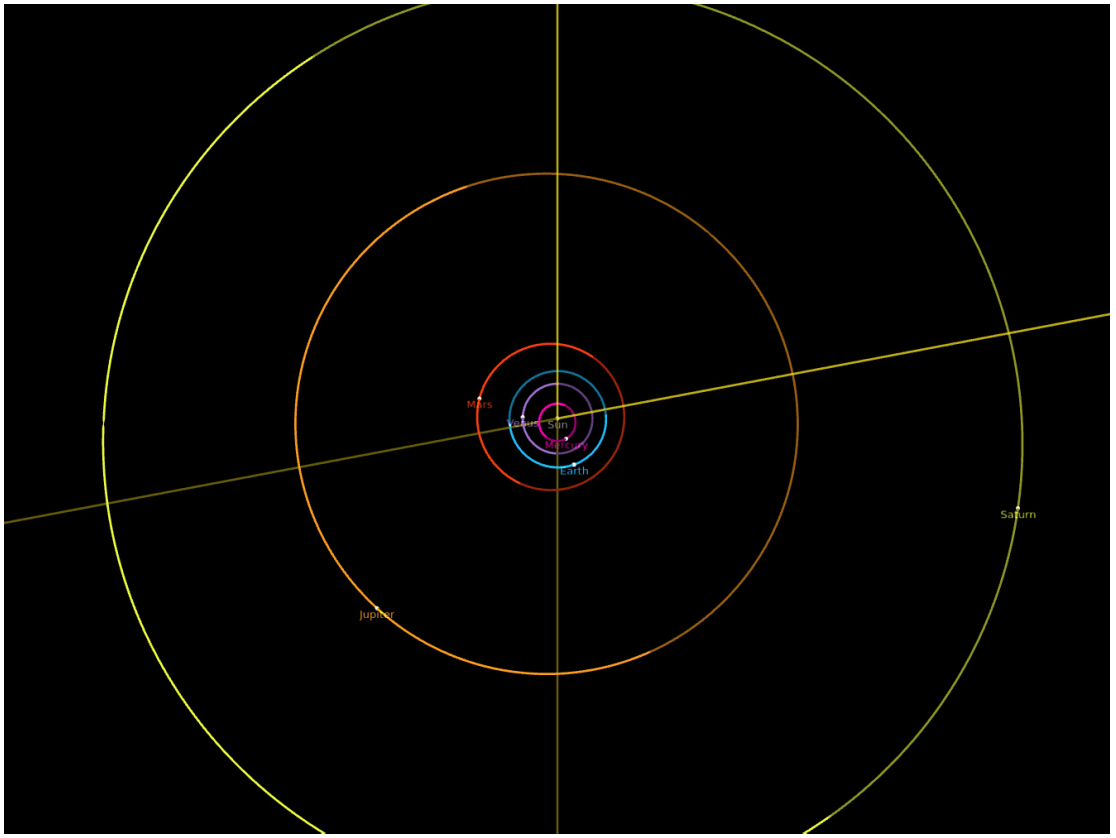
```
2×15 DataFrame
 Row │ PLANET       Ω         i           ω         e           a
M         ν         R           X           Y           Z           ℓ
ℓ_corr    b
     │ String       Float64   Float64     Float64   Float64     Float64
Float64   Float64   Float64     Float64     Float64     Float64     Float64
Float64   Float64
─────┼──────────────────────────────────────────────────────────────────────
──────────────────────────────────────────────────────────────────────
──────────────────────────

   1 │ Earth_CALC   180.378   0.00672579  283.861   0.0166865   1.49598e11
174.7     174.873   1.52084e11   2.40838e10   -1.50165e11   1.76457e7   -80.888
4   279.112   0.0066478
   2 │ Earth_SPICE  180.378   0.00672579  282.446   0.0175129   1.52083e11
175.949   176.088   1.51715e11   2.35611e10   -1.50246e11   1.76549e7   -81.064
5   278.936   0.00665092
```

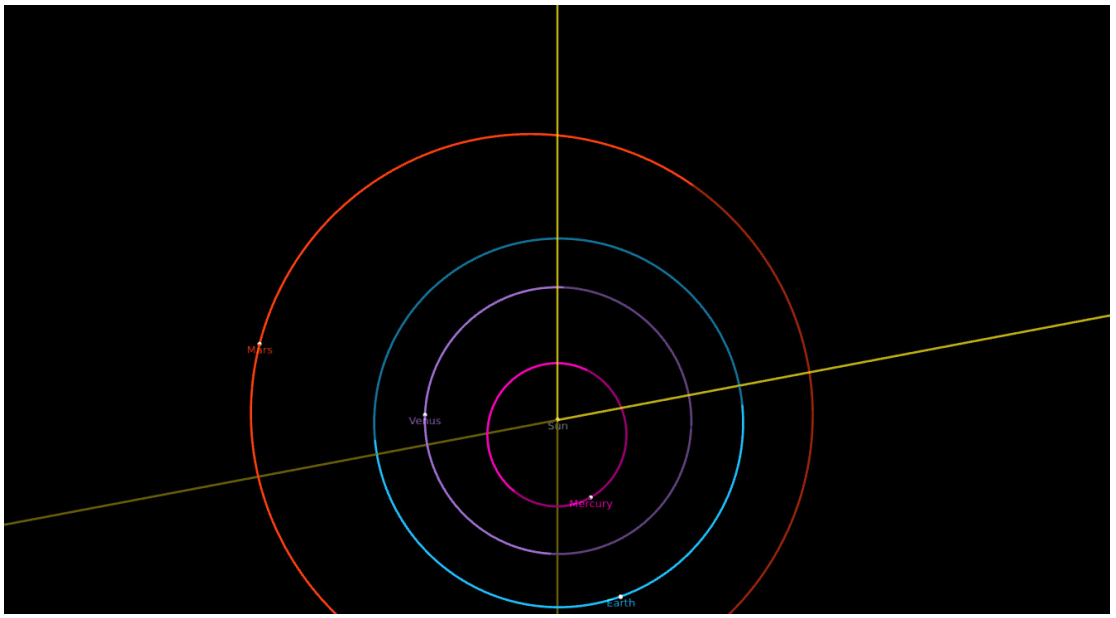
If I consider Earth's inclination = 0.00672579 and Ω = 180.378 instead of 0, it works for every planet.

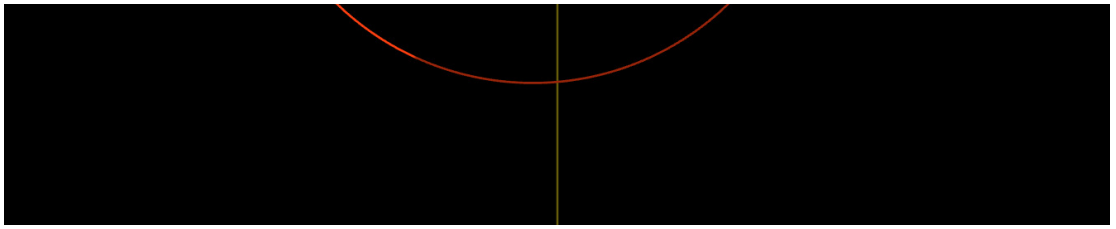
16×15 DataFrame

Row	PLANET	Ω	i	ω	e	a	M	ν	R	X	Y	Z	ℓ	ℓ_corr	b
	String	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64	Float64
1	Earth_CALC	180.378	0.00672579	283.861	0.0166865	1.49598e11	174.7	174.873	1.52084e11	2.40838e10	-1.50165e11	1.76457e7	-80.8884	279.112	0.0066478
2	Earth_SPICE	180.378	0.00672579	282.446	0.0175129	1.52083e11	175.949	176.088	1.51715e11	2.35611e10	-1.50246e11	1.76549e7	-81.0645	278.936	0.00665092
3	Jupiter_CALC	100.995	1.29996	274.199	0.0485853	7.78292e11	203.384	201.291	8.13271e11	-6.53688e11	-4.83554e11	1.66543e10	-143.508	216.492	1.1734
4	Jupiter_SPICE	100.582	1.30344	274.904	0.0473884	8.13294e11	202.308	199.96	8.12846e11	-6.59099e11	-4.76188e11	1.67312e10	-144.153	215.847	1.17878
5	Mars_CALC	49.9699	1.84935	287.074	0.0934542	2.2794e11	177.981	178.319	2.49231e11	-2.26446e11	1.03818e11	7.75461e9	155.37	155.37	1.78299
6	Mars_SPICE	49.3984	1.84549	286.919	0.0935111	2.49239e11	178.473	178.728	2.49183e11	-2.25897e11	1.05028e11	7.7287e9	155.064	155.064	1.77698
7	Mercury_CALC	48.9655	7.00568	29.3223	0.205646	5.7909e10	212.971	202.489	6.84698e10	1.24997e10	-6.69984e10	-6.56379e9	-79.432	280.568	-5.50105
8	Mercury_SPICE	48.2639	7.00184	29.2752	0.20565	6.8126e10	216.969	205.3	6.77821e10	1.49111e10	-6.6119e10	-6.77243e9	-77.2913	282.709	-5.70597
9	Neptune_CALC	132.37	1.76502	272.728	0.00864801	4.49675e12	17.3924	17.6917	4.45967e12	2.03772e12	3.96482e12	-1.28728e11	62.7991	62.7991	-1.65407
10	Neptune_SPICE	132.052	1.76744	269.268	0.00585937	4.46094e12	20.4847	20.0814	4.46142e12	2.08998e12	3.93894e12	-1.29299e11	62.0498	62.0498	-1.66093
11	Saturn_CALC	114.13	2.48649	339.976	0.0553604	1.42937e12	250.468	244.635	1.45961e12	1.3594e12	-5.29636e11	-4.44706e10	-21.2865	338.714	-1.74593
12	Saturn_SPICE	113.472	2.48725	338.791	0.0532792	1.45347e12	251.786	245.833	1.45356e12	1.35031e12	-5.35972e11	-4.45284e10	-21.6494	338.351	-1.75558
13	Uranus_CALC	74.2736	0.773671	97.2584	0.0474636	2.8695e12	11.713	12.885	2.73642e12	-2.72807e12	-2.10813e11	3.4689e10	-175.581	184.419	0.726346
14	Uranus_SPICE	73.9534	0.771876	98.9681	0.0508291	2.73803e12	9.66655	10.7188	2.73775e12	-2.73231e12	-1.73487e11	3.47309e10	-176.367	183.633	0.726795
15	Venus_CALC	77.1617	3.39514	55.1614	0.00674756	1.08209e11	33.6687	34.1004	1.07602e11	-1.04412e11	2.5217e10	6.37187e9	166.422	166.422	3.39486
16	Venus_SPICE	76.5314	3.39428	55.2392	0.00676238	1.07611e11	35.0415	35.5002	1.07455e11	-1.04795e11	2.36151e10	6.37074e9	167.301	167.301	3.39397

NASA Horizon visualization for the orbit on the given day:







This work can be found at: https://github.com/araujoarthur/psastronomyclass/blob/main/A1/V3/A1V4EarthModifiedANL-INCL.ipynb