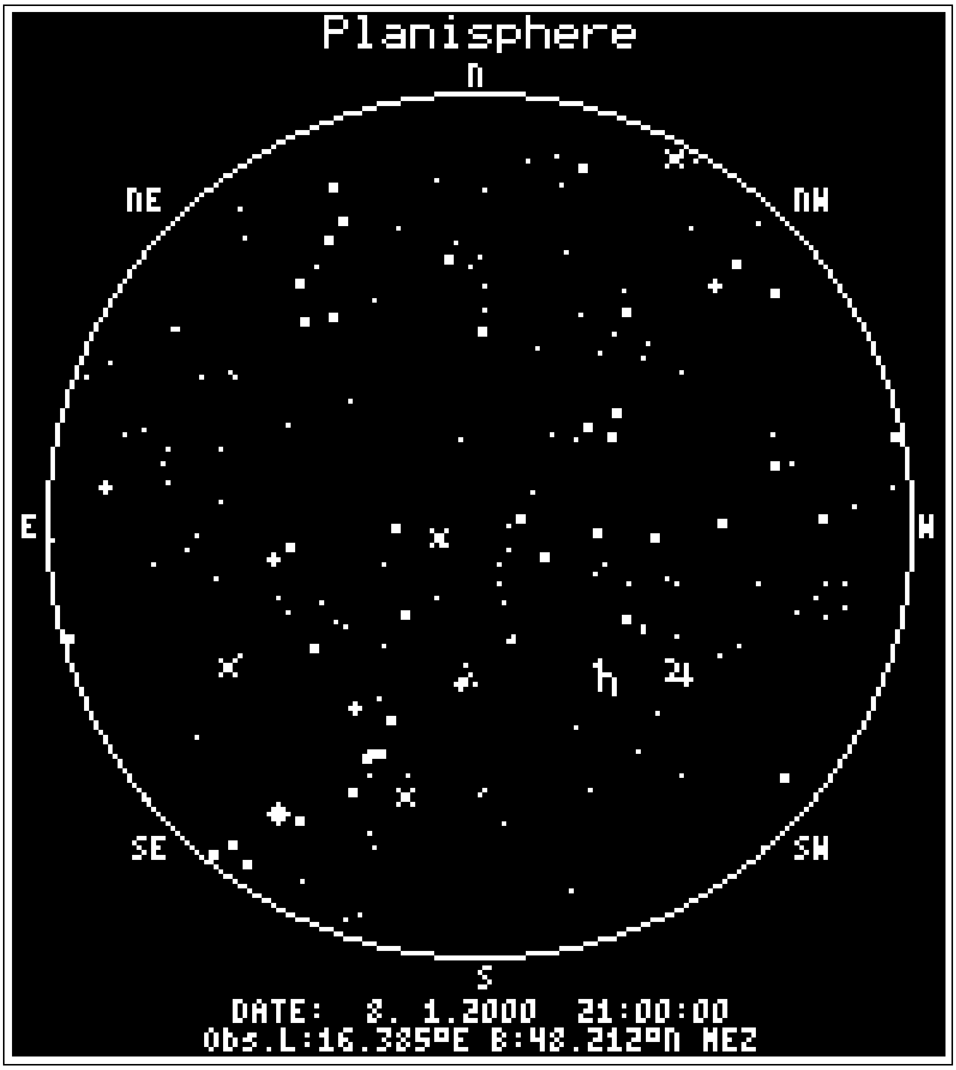
Urania

The Astronomical Companion

for the

HP-48 and HP-49

Pocket Calculator series



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Version 2.1

Georg Zotti

Vienna, 2000

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The manual represents URANIA's state as of March 19, 2000.

This manual was typeset in LaTeX 2ε with the author's `hp48` macro and font package. The PDF version uses the POSTSCRIPT version of the `cm` fonts (scalable, better for screen reading), the POSTSCRIPT version uses the `ec` fonts, rendered for 600*dpi* print.

Introduction

Urania — The Ideal Companion for the Amateur Astronomer

The size and capabilities of the HP48 and HP49 calculator series allow to make them the ideal tool for calculations somewhere far off civilization, desktop PCs and power lines, under a dark night sky. URANIA makes it unnecessary for the observer to look up positions in printed planetary ephemerides or look into tables of data transformation: all this and much more is calculated to good accuracy using modern theories of planetary motion.

On the other hand, URANIA cannot replace star maps and atlases or good PC programs, which can of course keep far more data and can find them faster. URANIA is not a tool for learning astronomy. Basic knowledge of astronomical terminology will be required to use URANIA.

License of use

As a registered user you are allowed to use all the programs provided in the package on a single calculator. You may not split or decompile the libraries, nor are you allowed to give copies of the software to others.

The example programs provided with source code in User-RPL are freeware. You might give them away, but most of them are only usable with the libraries.

QVSOP *and its source are included in the package. It is officially distributed under the GNU license, so you may use it for own projects or distribute it at no cost. See the included GNU public license for details.*

You are allowed and even encouraged to make a backup copy of the software on disk or other medium and store it in a safe place.

The programs were developed and tested to be as easy to use and error free as possible. Still, no program can be guaranteed to be free of errors, so no responsibility can be taken for resulting damage, which could be loss of memory in the worst case. The licensee is responsible for misuse and resulting consequences. Program errors could especially occur if certain user data deviate from the expected form. Data are checked, so this should be handled, but you are warned to backup your calculator's memory before making "experiments".

A sentence about this manual: It is assumed that the user is familiar with the HP48/HP49 and its usage, as well as with astronomical terminology. Detailed explanation of those are certainly beyond the scope of this manual.

Installation

The libraries have ID numbers in the range 1600 . . . 1611. To avoid ugly conflicts between software, *please make absolutely sure you have no other libraries with the same IDs installed.* Even if you do not install the RNGC libraries or QVSOP, parts of AARes and Urania will try to access commands in the libraries with the respective numbers and will fail if they execute commands in libraries not from the Urania suite. They will however not fail if no library with that number is installed.

The core libraries are `AARes.lib` and `Urania.lib`. You should also upload your desired version of either `SomeTools.lib` or `AstroTools.lib`: if you don't intend to write programs that use the internal commands, but want to use the data managing programs for sites, comets and asteroids, take `SomeTools.lib`. If you want to get all from Urania, however, take `AstroTools.lib`. These libraries have the same library ID number. Programs that use commands from `SomeTools.lib` will also run with `AstroTools.lib`, so you may later upgrade to `AstroTools.lib`. Optionally, load `Moon.lib` and `SAMoon.lib`, and store them in a port of your choice.

If you have the HP-48GX with a large (512kB or more) RAM card in slot 2 or a HP-49G, you can also upload up to three more libraries which allow you to access the data of the Revised New General Catalogue: `RNGC1.lib`, `RNGC2.lib` and `RNGC2.lib`. The first and smallest contains the most important data like position and magnitude, type, constellation. The other two contain the original abbreviated Dreyer and RNGC descriptions, respectively.

Note (HP48): Installing the basic version of Urania (i.e. Urania and its resource library, AARes) requires at least a 128kB RAM card. If the libraries are stored in a higher port (2 or above, GX), the programs will be slower than if installed in port 1, but there exist other libraries (by other authors) which require to be installed in port 1, so you might not have any space left there (or have no RAM card at all installed there).

The libraries are installed as usual, although their sometimes huge sizes may force some preparations.

1. (HP48:) Make sure you have at least one port memory bank available on your RAM card(s).
2. Make sure you have enough free system memory. Make a backup and reset the calculator, if necessary.
3. Upload the desired library onto your calculator.
4. Recall the library onto the stack and purge the original variable.
5. Select a port number of a free port (HP49: usually 2) and **STO** the library there.
6. Press and hold down **ON**, and press $\square_C$. A "warmstart" brings the libraries into action. Note that AARes, QVSOP and the RNGC libraries don't autoattach to the home directory: They are only used internally by Urania, so there is no need to add additional labels to the library menu. If you like, do it manually: Type, e.g., `« 1602 ATTACH »` to include a `RNGC` label into the library menu.
7. Select (or create) a directory of your choice, e.g. `ASTRO`, and enter it. Now you may upload the data files `COMET.DAT` and `ASTEROID.DAT`, as well as the auxiliary programs `SITE`, its list of sites, `SITE.DAT`, and `DATA`. These allow on-board management of your observing sites and data of comets and asteroids, instead of editing the files on a PC and uploading them. (You might of course use that method.) `SITE` and `SITE.DAT` are not really necessary in low memory conditions, but `DATA` is very helpful for the often changing comets. You might edit the program sources a bit to make the programs smaller, or delete some entries from the data lists. Run `SITE` to select or enter your site of observation. Your directory should now contain four variables: `Long`, `Lat`, `Alt`, `Zone`. These contain, respectively, your Geographic Longitude, counted eastward from Greenwich (this means negative values for the Americas!), Latitude, Altitude in meters above sea level, and Time Zone.

Should you enter a new site with SITE, enter the time zone without daylight saving time, this will be asked for while selecting the site. If you prefer not to use SITE, enter these four variables manually, or most commands of URANIA will refuse to work.

Variable name	Values	Format	Contents
Long	−180 … 360	DD.ddd	Geogr. Longitude east of Greenwich e.g.Vienna: +16.385
Lat	−90 … 90	DD.ddd	Geogr. Latitude (North=positive) e.g. Vienna: +48.212
Alt	−397 … ?	m.ddd	Altitude (Meters) e.g. Vienna: 194
Zone	−12 … 12	HH.ddd	Time Zone, so $UT := \text{Time}_{\text{Zone}} - \text{Zone}$ e.g. Vienna: +1 (Daylighttime: +2)

There are more variables, called GRS.DAT, Press, Temp, ΔT.USR, ε.USR, DSTAR.DAT, VSTAR.DAT and DSO.DAT. A detailed description of these will be given later.

Warning

Please make sure there are no directories with the same names as the URANIA variables. You might be using, e.g., a Temp directory within the HOME directory. This might lead to serious problems and unpredictable results. You will have to rename it to, e.g., TEMP or Tmp instead.

HP49G compatibility notes

Unfortunately, early models of the HP-49G were delivered with unfinished software in ROM. URANIA will show strange results with those early versions, and requires ROM version 1.16 or newer. The latest ROM version can be downloaded from `http://www.hp.com/calculators/graphing/rom/`.

URANIA was originally developed for the HP48, so it is highly optimized for RPN Mode, and is almost untested in Algebraic Mode. You should take the time to get customed to RPN mode, it is usually more efficient also in daily usage of the HP-49G!

On the HP49, make sure the user variables contain *real numbers*, not *infinite precision integers*! Also, input arguments must be real, not integers. To get e.g. 0, type 0.. Or put your HP49 into "approximate mode" to input any number as real. To toggle exact and approximate modes, either use the [MODE] menu or, with ROM 1.16 and later, hold down [↱] and press [ENTER].

Chapter 1

Overview

Valid range of dates: $-4712\ldots+9999$
Some programs give information about the position and magnitude of celestial objects of all kinds, for the current date or for any desired time within the abovementioned time range. Other programs calculate, e.g., the beginning of the seasons, position of Jupiter's moons, eclipses, allow extended date arithmetics, date of Easter, coordinate transformations, and even a celestial map can be drawn.

1.1 The Libraries

1.1.1 Library 1610 — AARes

This is the general resource library for most programs in the other libraries. No user commands are available.

1.1.2 Library 1609 — Urania

- `PLANET` .... Menu for planets, Moon, Sun, minor planets and comets.
- `STAR` .... Menu for bright, binary and variable stars.
- `DSO` .... Menu for Messier and other Deep Sky Objects.
- `Map` .... Draws either a Planisphere or a horizontal cylindric map.
- `θCLK` .... Running clock display of current Zone Time and Mean Local Sidereal Time.
- `HCLK` .... Running clock display of object position.

- `ECLMAP` .... Ecliptical map of the planets.
- `SEASONS` ... Calculates the beginning of the seasons for any year.
- `ECLIPSES` . Calculates the most important data for eclipses of Sun and Moon.
- `APSIDES` ... Calculates the great planets' nearest passages through Perihelion and Aphelion.
- `EQTM` .... Calculates the *Equation of Time*.
- `LIGHT` ..... Calculates times of sunrise, sunset, twilight stages and moonrise and moonset.

- `↑↓¤` .... calculates rising, setting and culmination of given point.
- `θLOC` .... Calculates Mean Sidereal Time for any date.
- `PARANG` .... Calculates the Parallactic Angle of an object.
- `ECLHOR` .... Calculates the intersections of the ecliptic with the horizon.
- `REFR+` ..... Adjusts a geometric (calculated) altitude h for refraction.
- `REFR-` ..... Adjusts an apparent (observed) altitude h_0 for refraction.

Coordinate Transformation

αδλβ .... Transformation Equatorial → Ecliptical.
λβαδ .... Transformation Ecliptical → Equatorial.
HδAa .... Transformation Hour Angle/Declination → Horizontal.
AaHδ .... Transformation Horizontal → Hour Angle/Declination.
αδlb .... Transformation Equatorial → Galactic.
lbαδ .... Transformation Galactic → Equatorial.

Date and Time Utilities

ZT▶JD ..... Time of Zone → Julian Day.
JD▶ZT ..... Julian Day → Time of Zone.
UT▶JD ..... Universal Time → Julian Day.
JD▶UT ..... Julian Day → Universal Time.
▶Y.FP ..... Calculates year with fractional part from date/time.
Y.FP▶ ..... Calculates date/time from year with fractional part.
▶Y.D .... Calculates Day Number within the Year.
Y.D▶ .... Calculates date from day number within year.
Date+ ..... Calculates new date from a date and a day count.
ΔDAY .... Calculates the difference between two dates in days.

WDAY .... Tags date with week day.
EASTER .... Calculates Easter date for every year.

Stellar Magnitudes and Distances

Σmag .... Calculates combined magnitude of, e.g., a Binary system.
δmag .... Calculates difference in mag classes from brightness ratio.
magR .... Calculates brightness ratio from two magnitudes.
Mabs .... Calculates absolute Magnitude of a star.
LY▶PC ..... Conversion Light Years to Parsec.
PC▶LY ..... Conversion Parsec to Light Years.

Other commands

SPHDIST ... Calculates Great Circle Angular Distance between two points on a sphere.
GEODIST ... Calculates distance between two sites on the surface of the Earth.
→HMd .... Conversion degrees with decimals to degrees, minutes, fractions of minutes.
HMd→ .... Conversion degrees, minutes, fractions to degrees with decimals.
ABOUT.UR . Gives program information about Urania.

1.1.3 Library 1608 — Moon

POSITN.M . Access to URANIA / PLANET / MOON.
PHYSIC.M . Access to URANIA / PLANET / MPHY.

PHASES.M . Times of main phases.
δMAXIMA.M Times and amounts of greatest northern / southern declinations.
APSIDES.M Times of passages through Apogee or Perigee.
NODES.M ... Times of passages through the nodes.
☉ALTITD.M Calculates the Altitude of the Sun above a given location on the Moon's surface.
SPEED.M ... Calculates angular speed of the Moon in ecl. Longitude and in Elongation from the Sun.

1.1.4 Library 1607 — UTools

Auxiliary libraries. Allows safe User-RPL access to the internal programs and algorithms for fast and memory saving development of further programs. Also used by auxiliary programs (DATA, SITE). There are two versions:

UTools (–) Very small, only basic support for DATA, SITE for memory conscious non-programmers.

UTools (+) This is a must-have for owners of [6]. You can access almost every useful command!

Basic version (UTools (–))

MAPS .... Find map numbers in SKY ATLAS 2000.0 and URANOMETRIA 2000.0.
Cst? ...... Find constellation for coordinates (J2000.0).
MESSIERd . Quick access to data of Messier objects.
RNGCd ..... Quick access to data of NGC objects, if installed.
DMY→JD .... Calculates Julian Day from Day, Month, Year.
JD→DMY .... Splits Julian Day to Day, Month, Year.
CHOOSE.T . Modified CHOOSE for HP-48GX/HP-49G or replacement for HP-48SX.

Extended version (UTools (+))

More Coordinate Transformations

αδε→λβ .... Coordinate transformation with given obliquity of ecliptic.
λβε→αδ .... Coordinate transformation with given obliquity of ecliptic.

Some Math functions

ATN2 .... Arcus Tangent in the correct quadrant.
R→P .... Conversion Rectangular → Polar coordinates.
P→R .... Conversion Polar → Rectangular coordinates.

Calendar helper functions

JD→T .... Calculates frequently used value T.
T→εo .... Mean obliquity of the ecliptic.
JD→ΔT ..... Returns ΔT in days.
LEAPYR .... Checks if given year is leap year.
SPLITDATE Splits date from HP format.
BINDDATE . Creates HP date format.

Precession, Nutation

PreQ .... Precession, fast version.
Pre4 .... Precession between arbitrary equinoxes in the FK4 system.
Pre5 .... Precession between arbitrary equinoxes in the FK5 system.
PreEc ..... Precession between arbitrary equinoxes in ecliptical coordinates.
ApPos ..... Apparent position of object in the FK5 system, incl. Precession, Nutation, Aberration.
Nutation . Nutation.

Objects in the Solar System, Planetary positions

SunPos .... Ecliptical position of the Sun.
MoonPos ... Ecliptical position of the Moon.
PlanPos ... Heliocentric Position of the planets Mercury to Pluto.
OrbEl ..... Orbital elements of the Planets.
RedOrbEl . Reduction of ecliptical orbital elements between two equinoxes.
magPhØ .... Apparent visual magnitude, Phase, Diameter of the Planets.
KEPLER .... Solves the Equation of Kepler.

F25.2 ..... Rectangular coordinates of the Sun.
F25.3 ..... Correction of the rectangular coordinates of the Sun.
F29.12 .... Combines formulæ (29.1) and (29.2).
F33.14 .... Combines formulæ (33.1) to (33.4) (Parabolic Motion).
F34.1 ..... Near-parabolic hyperbolical motion.
F32.1 ..... Just that formula.
F32.24 .... Combines formulæ (32.2) to (32.4).
F32.78 .... Combines formulæ (32.7) and (32.8).
F32.9 ..... Heliocentric rectangular coordinates.
F32.10 .... Geocentric equatorial coordinates.
F36.1 ..... Geocentric rectangular coordinates of Pluto.
GEOOBS .... Geocentric rectangular coordinates of observer.
COPAR ..... Correction for Parallax.
COPEC ..... Topocentric Correction for Parallax in ecliptical coordinates.
ILLMOON ... Phase angle of the Moon and position angle of illuminated limb.
ILLANG .... Position angle of the illuminated limb of the Moon or any planet.

Various helper functions

- INTER ..... Interpolation routines from Chapter 3.
- CIRCSIZE . Diameter of the smallest circle around 3 points on a sphere.
- STRAIGHT? Helps when looking for the time of alignment of 3 bodies on a line (i.e. great circle).

Data access, formatting, etc.

- Scroll.T . Final stage for programs with graphic output to the text or graphic screen.
- Display.T Calls the internal display programs.
- MOONGROB . Small Moon phase symbols.
- PLANGROB . Small planet symbols.
- FINDSTAR . Program to select a bright star.
- GETSTRDAT Access to the 328 bright star data.
- STARNAMES Access to alternate names of the bright stars.
- CstName ... Names of the constellations.
- MoName .... Names of the months.
- WdName .... Names of the week days.
- DAT$ .... Creates nicely formatted date string.
- TIM$ .... Creates nicely formatted time string.
- PAD$ .... Pads string with leading spaces to the desired length.
- MAKE$22 ... Formats a short string for centered display when displayed with DISP.
- REAL$ ..... Formats a real number with given number of decimal places.
- Zone$ ..... Returns formatted time zone information from Zone.
- DSTAR.PCK Packs data for Binary Stars into format for DSTAR.DAT.
- VSTAR.PCK Packs data for Variable Stars into format for VSTAR.DAT.
- DSO.PCK ... Packs data for DeepSky objects into format for DSO.DAT.
- DRWCIRCLE Draws circles in text display or PICT.

1.1.5 Library 1606 — SAMoon

- SAMOON .... Shows a graphic display of Saturn with its 8 largest moons.

Library IDs 1605, 1604, and 1603 are reserved for further expansion!

1.1.6 Library 1602 — RNGC1

- DSO.NGC ... Replacement menu for URANIA/DSO.
- BROWS.NGC NGC browser for objects in "numerical vicinity".

1.1.7 Library 1601 — RNGC2

This library contains the object descriptions given by Dreyer in his original NGC catalogue.

1.1.8 Library 1600 — RNGC3

This library contains the object descriptions given in the Revised NGC catalogue (RNGC).

1.1.9 Library 1611 — QVSOP

This "Quick VSOP" library provides faster planetary positions for the years 1998 ... 2025.

- `QVSOP` ..... Calculates L, B, R for all giant planets.
- `rng.QVSOP` Returns info about range of years in this QVSOP lib.
- `err.QVSOP` Returns vector of maximum error.
- `src.QVSOP` Returns info about QVSOP source.

1.2 More programs

These may be stored in a port to save user memory:

- `PHENO` ..... calculates some planetary phenomena during a year.
- `ANA` .... Draws Analemma of the Equation of Time for a year and the position of the Sun on it.
- `DATA` .... Program to edit data of comets and asteroids.
- `SITE` .... Program to edit your sites of observation.

Some more programs are included which demonstrate the use of UTools (+). See their respective source code for detail!

1.3 Variables used with Urania

Variables marked with a (*) are essential, the others are optional.

1.3.1 Observing Site

- `Long` .... (*) Geographic Longitude, $-180\ldots360°$, positive east of Greenwich.
- `Lat` .... (*) Geographic Latitude, $-90\ldots90°$, positive north of equator.
- `Alt` .... (*) Altitude above sea level, meters.
- `Zone` .... (*) Time zone, positive east of Greenwich.

1.3.2 Overriding default data

- `ΔT.USR` .... Customizable ΔT.
- `ε.USR` ..... Customizable obliquity of the ecliptic.

1.3.3 Additional data

- `Temp` .... Influence refraction with non-default temperature.
- `Press` ..... Influence refraction with non-default air pressure.
- `GRS.DAT` ... Jovigraphic longitude of Jupiter's Great Red Spot.
- `ASTEROID.DAT` (*) Data list for Asteroids.
- `COMET.DAT` (*) Data list for Comets.
- `DSTAR.DAT` Data list for more Binary Stars.
- `VSTAR.DAT` Data list for more Variable Stars.
- `DSO.DAT` ... Data list for more Deep Sky Objects.

Chapter 2

Detailed description of the programs

All programs needing time input to work were designed so that if there are too few arguments on the stack, i.e. date and time missing, those data are read from the internal clock. This saves the user from unnecessary keystrokes.

To be consistent with other HP programs, input and output format for calendar dates depends on the current state of system flag −42: *MM.DDYYYY* if flag is clear, *DD.MMYYYY* if set. This is the same format that is used by the calculator, with one exception: The calculator reads dates like *DD.MM* as being within the current year. URANIA commands interpret this date as *DD.MM*0000.

Time inputs are always in 24 hours format, *HH.MMSSddd*. Display of output then depends on system flag −41 (12/24 hours).

Sometimes the display is too small to show all data at once. Then you may use the cursor keys to scroll the display. `PICT` is not used for display, so user graphics are saved. However, if you want to keep the display, you may **STO** its contents into `PICT`.

For each command a stack diagram will be shown. Input values are needed on the stack or in the command line before a command is started. If those values appear in brackets, they can be omitted (altogether, but not one of two, except where explicitly specified!), and the missing date or time is taken from the internal clock.

`Date` means a calendar date in the current HP date format, as explained above.

Degrees are used either with minutes, seconds and decimal seconds (*DD.MMSSddd*) or in decimal degrees (*DD.dddd*).

Equatorial and Hour Angle coordinates use the hour-minute-seconds (*HH.MMSS*) resp. degree-minute-second (*DD.MMSS*) format, the other coordinate systems use decimal degrees *DD.dddd*.

Note about calendar dates: Historically speaking, there was no year 0: The year before 1 A.D. was 1 B.C. However, to make astronomical and calendrical calculations easier, it is usual to introduce the year 0, and it is the same as 1 B.C. So, −1 is 2 B.C., −2 is 3 B.C., etc. This should be kept in mind when dealing with historical calculations. Also, note that dates before 1582-10-15 are regarded as dates in the Julian Calendar, all later dates are in the Gregorial Calendar. In some countries, the Julian Calendar was in use far longer, e.g., Great Britain and colonial America used it until 1752, Russia even until 1917.

2.1 The Libraries

2.1.1 Library 1609 — Urania

Finder Programs: PLANET, STAR and DSO For the finder commands, some lines of output are always given (in the lower part of the display).

↑:	Time and Azimuth of rise	AZ(NESW):	Azimuth
↓:	Time and Azimuth of set	ALTITUDE:	Apparent altitude (incl. refraction)
⨯:	Time and Azimuth of transit	HOUR ANG.:	Hour Angle

You may scroll down the display with the [▼] key to find the map numbers for the object in Sky Atlas 2000.0 [10] and Uranometria 2000.0 [11], as well as, for reference purposes, DATE, TIME, JD, ΔT used, OBS:L = Longitude, B = Latitude, UT±(ZONE) or ZONENAME

Near the object name you always find the constellation where the object is located.

The finder programs leave equatorial coordinates on the stack, to allow following the object's motion with the Hour Angle Clock, HCLK.

PLANET .... Menu for planets, Moon, Sun, minor planets and comets.

Includes also the program for Jupiter's moons and access to SAMOON in the SAMOON library.

Page 1:	MERC	VENU	MARS	JUPIT	SATUR	HACLK
Page 2:	URAN	NEPT	PLUTO	ASTER	COME	HACLK
Page 3:	SUN	MOON	MPHY	JUMO	SAMO	HACLK
Page 4:	URANI					

For all commands except HACLK:

2:	(Date)	→	data	→	2:	$\alpha_{HH.MMSS}$
1:	(Time)	→	display	→	1:	$\delta_{DD.MMSS}$

MERC, VENU, MARS, JUPIT, SATUR, URAN, NEPT, PLUTO

L, B, R	Heliocentric ecliptical Longitude, Latitude and Distance (AU) from the Sun.
λ, β, Δ	Geocentric ecliptical Longitude, Latitude and Distance (AU and Light Minutes) from Earth
EL	Elongation from the Sun

Data valid for equinox of date, except PLUTO, here position is computed for equinox $J2000.0$.

α2000, δ2000	Equatorial coordinates for equinox $J2000.0$
αDAT, δDAT	Equatorial coordinates for equinox of Date
MAG	Apparent visual magnitude
⌀	Apparent polar diameter
ILL	Illuminated fraction of disk, percent

PLUTO There is still no complete theory of Pluto's motion. Therefore, this calculation is only valid for the years 1885 ... 2099! For other times, you will need osculating orbital elements and treat Pluto like an asteroid.

ASTER Selection of an asteroid from the external list ASTEROID.DAT

T	Orbital period
λ2000, β2000	Geocentric ecliptical coordinates for equinox $J2000.0$
R, Δ	Distance from Sun resp. Earth (AU and Light Minutes)
α2000, δ2000	Geocentric equatorial coordinates for equinox $J2000.0$
αDAT, δDAT	Geocentric equatorial coordinates for equinox of Date
EL	Elongation from the Sun
PH.ANG	Phase angle Sun–Asteroid–Earth
MAG	Apparent visual magnitude

COME Selection of a comet from the external list COMET.DAT

T	Orbital period if elliptic orbit; else orbit type given
λ2000, β2000	Geocentric ecliptical coordinates for equinox $J2000.0$
R, Δ	Distance from Sun resp. Earth (AU and Light Minutes)
α2000, δ2000	Geocentric equatorial coordinates for equinox $J2000.0$
αDAT, δDAT	Geocentric equatorial coordinates for equinox of `Date`
EL	Elongation from the Sun.
MAG	Apparent visual magnitude

Should a comet move on an extremely hyperbolic track (say, with $e \geq 1.3$), the algorithm for the calculation might fail. In this case, the program will abort, and no calculation is possible for such rare comets.

SUN Physical ephemeris data are given (after Carrington).

λ, β, Δ	Geocentric ecliptical coordinates and distance for equinox of `Date`
CENTR	Heliographic Longitude L and Latitude B of the center of the Sun's disk
PA(AXIS)	Position Angle of the northern end point of the rotational axis, measured from the northernmost point eastward along the Sun's limb.
ROTATION NR.	Rotation number after Carrington
BEGIN	Begin of this rotation

MOON

λ, β	Geocentric ecliptical coordinates for equinox of `Date`
Δ, ⌀	Geocentric distance and angular diameter
ILL, EL	Illuminated percentage with small icon; Elongation from the Sun
π	Equatorial horizontal parallax
GCα2000, GCδ2000	Geocentric equatorial coordinates for equinox $J2000.0$.
GCα, GCδ	Geocentric equatorial coordinates for equinox of `Date`
TCα2000, TCδ2000	Topocentric equatorial coordinates for equinox $J2000.0$.
TCα, TCδ	Topocentric equatorial coordinates for equinox of `Date`

MPHY Physical Ephemeris: Libration, Position Angle (PA) of Axis, Elongation, Phase Angle, Illuminated Fraction, PA of the bright limb, subsolar point, Colongitude of the Sun, Longitude of Morning and Evening Terminator. Control output: Date, Time, geographic site, time zone.

JUMO CM I, CM II: Longitude of central medidians I and II of the *visible* disk, thus regarding the small light defect inflicted by the phase angle of Jupiter to the Sun. The 4 Galilean Moons can be identified with the given symbols. Numbers listed near the names give the apparent jovicentric (X-) distances of the moons from Jupiter's center in units of Jupiter's radius. In the graphic below the moons are drawn as seen in an astronomical (inverting) telescope. In the enlarged graphic in the upper right corner you can see Jupiter's disk, possibly with a transiting moon or with the Great Red Spot (GRS), if visible. To enable this, you have to put a real number representing the jovigraphic longitude of the GRS into the global variable GRS.DAT.

In this program, light time is taken into account.

With the [+]/[−] keys, you can advance/go back in time by one minute at a time, by pressing [↰]-[+] or [↰]-[−] you can advance/go back in 10-minute steps.

SAMO Access to SAMoon / SAMOON. See there for description

HACLK Direct Access to the Hour Angle Clock. See HACLK.

URANI Back to Urania main menu.

Note: A note about accuracy: Accuracy of, say, one arc second would be too much for a pocket calculator. Urania calculates planetary positions better than some PC programs, but the many constant numbers for the last tiny corrections would more than fill the library. Also, run time would be increased to undesirable magnitudes.

Here a compromise solution had to be found. The coordinates should be accurate as displayed, with a possible (small) error in the last digit. For historical questions, however, long time changes in motion are still taken into account. See discussion in 2.1.3 UTools (+)/PlaPos. Also, light time is not corrected for in most programs. This should, if at all, only be (slightly) noticeable with Mercury and Venus near inferior conjunction.

STAR .... Menu for bright, binary and variable stars.

Page 1: BRIGH BINAR VAR HACLK

Page 2: URANI

For all programs in the menu, except HACLK

2:	(Date)	→	data	→	2:	$\alpha_{HH.MMSS}$
1:	(Time)	→	display	→	1:	$\delta_{DD.MMSS}$

BRIGH 328 bright stars are available. Selection is done in 2 steps: First, a name or part of it is entered. All matching stars are listed, of which you select the right one. The following criteria were considered when the stars were selected for the list:

1. All stars to 3.0^{mag}
2. At least one star of every constellation
3. Stars with proper names, as listed in Lit. [4], and some more.
4. Some fainter stars that are important within constellation figures.

By this, the catalogue of stars fainter than 3.0^{mag} gets very sparse, but still every constellation can be found in the sky. Star names are saved in the following format: "β Cst Name1 Name2 ..", where β is the Bayer Designation (α, β, γ, ...), Cst is the usual 3-letter constellation designation and Name1 etc. are the proper names, e.g.: "α CrB Alphecca Gemma ". The program lets you input a name or part of it. Here, also different spelling is considered, so e.g. "Beteigeuze" and "Betelgeuse" are both valid. Names with more than 1 part are written in one part, e.g. DenebKaitos. Upper-/lowercase input is both valid. To find all stars of a constellation, just enter the 3 letter constellation code. (There may be some stars of other constellations in this selection, of course.) The provided menu with the greek letters may help.

In the final selection, choose from all found stars or retry. Following data are listed:

MAG(V)	Apparent magnitude (in the V-Band of the UBV system)
M(ABS)	Absolute Magnitude. This is the Magnitude of the star seen from a distance of 10 Parsec (32,6 Light Years). It is a measure of true luminosity.
B-V	Spectroscopic color index: this number gets higher with increased "redness" of the star
SP	Spectral type and luminosity class
DIST	Distance in Parsec and Light Years
COORD.	The coordinates are shown for standard epoch and equinox $J2000.0$ and for epoch and equinox of Date. Here, also proper motion as well as Nutation and Aberration are considered. Compared with other sources, only the last displayed digit might show differences.

BINAR, VAR Selection of binary resp. variable stars from lists. There is a default database built into the library. If you like more/other objects, edit the provided lists (DSTAR.DAT or VSTAR.DAT, resp., see below) and upload them on your calculator.

α2000, δ2000	Equatorial coordinates for equinox $J2000.0$
αDAT, δDAT	Equatorial coordinates for equinox of date, including Nutation and Aberration.

BINAR Orbital elements are not included for memory reasons. Separation and Position Angle are of $J2000.0$.

SEP	Separation of the components
PA	Position angle of the fainter component, measured from North towards the East
MAG	Apparent magnitudes of the components
SP	Spectral types of the components

VAR

TYPE	One of 35 Variable types. See 2.3 for a list
PER	Period measured in days
MAG	Maximum and minimum magnitudes of the star
SP	Spectral class

HACLK Direct Access to the Hour Angle Clock. See HACLK.

URANI Back to URANIA main menu.

DSO .... Menu for Messier and other Deep Sky Objects.

If you have RNGC1 installed, DSO will call DSO.NGC. See 2.1.5 for more information.

Page 1: MESSI OTHER HACLK
Page 2: URANI

MESSI

3: (Date)	→		→		
2: (Time)	→	data	→	2:	$\alpha_{HH.MMSS}$
1: Messier Number	→	display	→	1:	$\delta_{DD.MMSS}$

OTHER

2: (Date)	→	data	→	2:	$\alpha_{HH.MMSS}$
1: (Time)	→	display	→	1:	$\delta_{DD.MMSS}$

Selection from objects in a built-in list or DSO.DAT, similar to STAR / BINAR, VAR : If external list DSO.DAT is not found, a list stored in the library is used.

Data for MESSI and OTHER

Name, Constellation

Comments, e.g. NGC numbers for Messier objects or proper names

OBJECT TYPE	Abbreviated type description
MAG	Apparent magnitude
DIM	Dimension: Arc seconds for Planetary Nebulae, arc minutes for others
DIST	Distance in Parsec and Light Years
α2000, δ2000	Equatorial coordinates for equinox $J2000.0$
αDAT, δDAT	Equatorial coordinates for equinox of date

HACLK Direct Access to the Hour Angle Clock. See HACLK.

URANI Back to URANIA main menu.

Map .... Draws either a Planisphere or a horizontal cylindric map.

2: (Date)	→	graphic
1: (Time)	→	display

On this map you find the stars which are currently above the horizon, along with the planets (Mercury to Saturn) and the Sun. The Moon is drawn with an approximate phase icon. In addition, there are marks for the cardinal directions, site of observer and time. On the horizontal map you will also find grid lines for 0°, 30°, 60° and 90° of altitude and every 45° in azimuth.

Notes:

- Selection criteria for the star catalogue (see STAR / BRIGH) sometimes lead to relatively bright unnamed stars being not drawn, while faint main stars of small constellations appear unnaturally bright.
- Above 60° altitude, constellations in the horizontal map appear strongly distorted. Therefore, for all-sky observation, the planisphere should be preferred.
- Maps for dates before 1950 and after 2050 will take more time, because Precession will be accounted for.

BCLK .... Running clock display of current Zone Time and Mean Local Sidereal Time.

Stack is not changed. Program quits when any key pressed, stack is saved. Rapidly pressing ON a second time can interrupt this clearup.

HCLK .... Running clock display of object position.

Provides Date, Time, Mean Local Sidereal Time, and current Hour Angle, Declination, Azimuth and Altitude of the object at the given coordinates.

This command can be of great value for telescope owners with aligned setting circles. Includes refraction. Stack is not changed. (Or a 0 is added to stack level 1 if called only with R.A. of the object.)

2:	$\alpha_{HH.MMSS}$	→	2:	$\alpha_{HH.MMSS}$
1:	$\delta_{DD.MMSS}$	→	1:	$\delta_{DD.MMSS}$

or

		→	2:	$\alpha_{HH.MMSS}$
1:	$\alpha_{DD.MMSS}$	→	1:	0

Program quits when any key pressed, stack is saved. Rapidly pressing ON a second time can interrupt this clearup.

Note: Calculation and output formatting takes more than a second, so the display is slow, and occasionally there will be a "jump" by 2 seconds.

ECLMAP .... Ecliptical map of the planets.

Three types of map can be plotted:

1. Ecliptic, 360...0° Longitude, 10° Latitude, Sun, Moon (with approx. phase) and planets (Mercury to Neptune).
2. Elongation from the Sun: This map is mainly a quick overview where the planets can be found in relation to the Sun. Visibility conditions can be thus found quickly. Marks for EVENING resp. MORNING indicate when the objects drawn below those marks are best visible.
   (a) Centered on the Sun.
   (b) Centered on the *Gegenschein* (the point opposite the Sun). The horizontal lines represent the ecliptic and ecliptical latitudes +5 and −5.

```
2:  (Date) → graphic
1:  (Time) → display
```

This program can be quite handy for a quick visibility check!

SEASONS ... Calculates the beginning of the seasons for any year.

The results will be displayed on the screen and may be copied to PICT via STO.

```
1:  (Year) → data display
```

Times include correction $\Delta T = ET - UT$

Note: An error in the computed position of the Earth on its orbit of only 2.5″ will result here in an error of one minute (of time). The results of this program should, therefore, be only few minutes off. Several tests showed an error of usually less than two minutes.

ECLIPSES . Calculates the most important data for eclipses of Sun and Moon.

At the start of the program, you may select the types of eclipse to find. Now, dates of possible eclipses are checked. If there is no eclipse, mean date and time (*DT*) of the event are shown briefly, and calculation resumes. If an eclipse occurs, a screen full with data is shown. With the [+]/[−] keys, you can advance into the future or go back in time, respectively. If you press [↰][+]/[↰][−], you advance by 10 intervals at a time (i.e., 10 or 5 months, resp.). You may scroll the display with the cursor keys, and [STO] the datasheet to PICT.

Lunar Eclipses: Date, Time (*DT*) of the eclipse, Type, event in ascending or descending node. Position of the Moon in mid-eclipse (north/south of shadow center): The γ (gamma) value is the smallest distance of the Moon's center to the axis of Earth's shadow in units of Earth's equator radius. Radii of umbra/penumbra in units of Earth's equator radius in Moon's distance. Maximal magnitude of eclipse in umbra or penumbra, resp. Times (for Zone) of the various phases.

Solar Eclipses: Date, Time (*DT*) of the eclipse, Type, event in ascending or descending node. Area of visibility on the Earth: Moon's umbra sweeps across the Earth's surface in a narrow track of only a few *km* width. γ (Gamma) here is the smallest distance of the axis of the Moon's shadow from the center of the Earth in units of Earth's equator radius. In connection with the time of maximal eclipse, the area of visibility can be deduced[1]. Radii of umbra/penumbra on the fundamental plane (the plane through the center of the Earth perpendicular to the shadow's axis). Time (of Zone) of maximum eclipse.

```
1:  (Start date of search) → data display
```

Note: According to Meeus, accuracy allows also for historic research, though with some coution: very small eclipses and odd cases of eclipses maybe not found or wrongly typed.

APSIDES ... Calculates the great planets' nearest passages through Perihelion and Aphelion.

```
1:  (Date) → data display
```

The displayed dates usually bracket input date.

[STO] copies result to PICT

Note: The errors are: Earth: 3 ... max. 6 hours between [1980...2019]; Mars: hours; Jupiter: 2 weeks; Saturn: 1 month; Uranus, Neptune: up to several months. These errors are due to the simple algorithm used here which uses undisturbed orbits.

EQTM .... Calculates the *Equation of Time*.

Equation of Time is the difference in Right Ascension between True (apparent) and Mean (fictitious) Sun. If the value is positive, the True Sun crosses the meridian before the Mean Sun — a Sundial is "early".

```
2:  (Date) →
1:  (Time) → 1:  :Eq.of Time (HMS): HH.MMSSd
```

[1] Example: 24.10.1995, 4:34 *DT*, $\gamma = 0.352$: Visible in subtropical northern latitudes of the Middle and Far East. (In Europe, the Sun is still below the horizon.) More exact calculations are rather lengthy, so they are omitted here and left to greater computers, or future add-on packages.

LIGHT ..... Calculates times of sunrise, sunset, twilight stages and moonrise and moonset.

Displays times and azimuths of sunrise, sunset, begin and end of civil, nautical and astronomical twilight, which are defined by the Sun's altitude of −6°, −12° and −18°, respectively, together with the Sun's azimuth at those times. Plus, times and azimuths of moonrise and moonset are also given.

1: (Date) → text display

This program can really help planning your DeepSky observing sessions!

↑↓¤ .... calculates rising, setting and culmination of given point.

This command works even for objects in motion!

Input:

3:	α		3:	α		3:	$\{ \alpha_1\ \alpha_2\ \alpha_3 \}$		3:	$\{ \alpha_1\ \alpha_2\ \alpha_3 \}$
2:	δ	or	2:	δ	or	2:	$\{ \delta_1\ \delta_2\ \delta_3 \}$	or	2:	$\{ \delta_1\ \delta_2\ \delta_3 \}$
1:	(Date)		1:	{Date_2 h_0 }		1:	(Date_2)		1:	{Date_2 h_0 }

With just real numbers for α and δ, the object is assumed not to be in motion (e.g., a star), and the times are calculated more quickly. With 2 lists of 3 real numbers each, also times for moving objects (such as the Moon or fast comets and asteroids) can be calculated more accurately. If a list is found on level 1, h_0 is the altitude of the object. Symbols here are: α_1, δ_1 Right ascension ($HH.MMSSS$), declination ($DD.MMSS$) of the previous day, α_2, δ_2 RA, decl. of the day in question and α_3, δ_3 RA, decl. of the following day, each time for $0^h DT$. These values can be calculated with other programs or taken from an almanac.

Result:

3:	$rise_{HH.MM}$		1:	"POLE!"		1:	"always"		1:	"never"
2:	$set_{HH.MM}$	or	2:	"Not"	or	2:	"visible"	or	2:	"visible"
1:	$culm_{HH.MM}$		3:	"defined"		3:	$culm_{HH.MM}$		3:	$culm_{HH.MM}$

Depending on the position of the object on the celestial sphere and of the observer on the Earth, the result can be different. Times are rounded to the nearest minute: more would be useless, also because of refraction by the atmosphere.

The tag also gives the object's azimuth (counted from North eastward) to the nearest degree.

Note: Sometimes, the program will find setting time on the previous day or rising time on the following day. The difference of about 4 minutes in this case should be no real problem.

θLOC .... Calculates Mean Sidereal Time for any date.

2:	(Date) →			
1:	(Time) →	1:	:Sid.Time:	$\theta_{HH.MMSS}$

PARANG .... Calculates the Parallactic Angle of an object.

This is the angle q between the vertical and the North-South-Axis. It is the amount of apparent rotation of an object (e.g., the Moon, a planet or constellation) far from the meridian. (For example, the setting crescent of the Moon in the evening sky of temperate northern latitudes is noticeably tilted.)

2:	$H_{HH.MMSS}$ →		
1:	$\delta_{DD.MMSS}$ →	1:	$q_{DD.ddd}$

`ECLHOR` .... Calculates the intersections of the ecliptic with the horizon.
Also gives the inclination of the ecliptic to the horizon.

		→	3:	:↑:	$\lambda_{\texttt{rising},DDD.ddddd}$
2:	(Date)	→	2:	:↓:	$\lambda_{\texttt{setting},DDD.ddddd}$
1:	(Time)	→	1:	:∡:	$I_{DDD.ddddd}$ Angle between ecliptic and s. horizon

`REFR+` ..... Adjusts a geometric (calculated) altitude h for refraction.
In this altitude, h_o, we can see the object.

`REFR-` ..... Adjusts an apparent (observed) altitude h_0 for refraction.
Returns the Geometric Altitude h.

1:	$h_{DD.ddd}$	↔	1:	$h_{0,DD.ddd}$

Those commands assume by default air temperature of $10°C$ and pressure of $1010mbar$. You might store real numbers as Celsius temperature in the global variable `Temp` and pressure in $mbar$ in `Press` to account for different atmospheric conditions.

Note: These commands are not true reverse operations, the formulæ used are just simplified models of the effects of the atmosphere. Three decimal places are given, but please bear in mind that below approx. 5° far lower precision should be assumed. Altitudes below −4° are not touched: the algorithm is not meaningful there.

Coordinate Transformation For equatorial coordinates and hour angle, $HH.MMSS$ resp. $DD.MMSS$ format is used, decimal degrees elsewhere. No correction for refraction etc. is performed.

`αδλβ` .... Transformation Equatorial → Ecliptical.

`λβαδ` .... Transformation Ecliptical → Equatorial.

2:	$\alpha_{HH.MMSS}$	↔	2:	$\lambda_{DD.dddd}$
1:	$\delta_{DD.MMSS}$	↔	1:	$\beta_{DD.dddd}$

These commands by default use the obliquity of the ecliptic for the epoch $J2000.0$. If you want to use the ecliptic for a different epoch, just put a year number (also with decimals; use `▶Y.FP` to build it) as real number into the global variable `ε.USR`. The commands calculate the mean obliquity for this date and store the value back into `ε.USR`, tagged with the year. A tagged real is assumed to be an obliquity tagged with the year. Further transformations then don't have to recalculate the obliquity. Note that you cannot store a tagged number yourself![2]

`HδAa` .... Transformation Hour Angle/Declination → Horizontal.

`AaHδ` .... Transformation Horizontal → Hour Angle/Declination.

2:	$H_{HH.MMSS}$	↔	2:	$A_{NESW,DD.dddd}$
1:	$\delta_{DD.MMSS}$	↔	1:	$a_{DD.dddd}$

`αδlb` .... Transformation Equatorial → Galactic.

`lbαδ` .... Transformation Galactic → Equatorial.

2:	$\alpha_{1950.0,HH.MMSS}$	↔	2:	$l_{DD.dddd}$
1:	$\delta_{1950.0,DD.MMSS}$	↔	1:	$b_{DD.dddd}$

Note: Tranformation is valid for equatorial coordinates of System $B1950.0$! For coordinates of other equinoxes, at least precession must be accounted for. For this you may use the programs `PreQ`, `Pre4` or `Pre5` from UTools (+).

[2] Or, if you know how to, you might not read this manual ...

Date and Time Utilities The Julian Calendar is used for dates until October $4^{th}, 1582$. The following day is October $15^{th}, 1582$ in the Gregorian Calendar, introduced at that date. Therefore, 10 days should be invalid. In URANIA, those 10 days (October $5 \ldots 14, 1582$) are simply interpreted as days of the Julian Calendar, i.e., 1582 Oct. 05 = 1582 Oct. 15. In some countries, the Julian Calendar was in use far longer, e.g., in the UK and colonial America until 1752.

ZT▶JD ..... Time of Zone → Julian Day.
JD▶ZT ..... Julian Day → Time of Zone.

2: (Date)	↔		
1: (Time)	↔	1:	$JD_{DDDDDDD.ddddd}$

UT▶JD ..... Universal Time → Julian Day.
JD▶UT ..... Julian Day → Universal Time.

2: Date	↔		
1: Time (UT)	↔	1:	$JD_{DDDDDDD.ddddd}$

▶Y.FP ..... Calculates year with fractional part from date/time.
Y.FP▶ ..... Calculates date/time from year with fractional part.

2: (Date)	↔		
1: (Time)	↔	1:	$YYYY.ddddddd$

Year 1582 is accounted for!

▶Y.D .... Calculates Day Number within the Year.
Y.D▶ .... Calculates date from day number within year.

2: (Date)	↔		
1: (Time)	↔	1:	$\pm YYYY.DDDdddd$

with Day number DDD (and fraction ddd), Year number $YYYY$, and the sign of the year. Valid also for century years, Jul./Greg. Calendar, even 1582. If neither date nor time are given, current time is assumed. If only date is given, time is assumed as 0.

Date+ ..... Calculates new date from a date and a day count.
This command works similar to the built-in command DATE+, but you can also use dates before Oct.$15^{th}, 1582$.

2: Date	→		
1: $\pm n_{\text{days}}$	→	1:	Date

△DAY .... Calculates the difference between two dates in days.
This command works similar to the built-in command DDAYS, but you can also use dates before Oct.$15^{th}, 1582$.

2: $\text{Date}_{\text{start}}$	→		
1: Date_{end}	→	1:	$\pm n_{\text{days}}$

Please note that while you can omit the year with DATE+ and DDAYS to use the current year, Date+ and △DAY understand year 0 in this case.

WDAY .... Tags date with week day.

1: (Date)	→	1:	:Day_of_Week: Date

EASTER .... Calculates Easter date for every year.
Before 1582, the date is calculated in the Julian Calendar, from 1583 on in the Gregorian Calendar.

1: (Year)	→	1:	:Easter: Date

Stellar Magnitudes and Distances

Σmag .... Calculates combined magnitude of, e.g., a Binary system.

2:	mag_1	$\rightarrow$		
1:	mag_2	$\rightarrow$	1:	mag_{comb}

δmag .... Calculates difference in mag classes from brightness ratio.

1:	brightness ratio	$\rightarrow$	1:	δ_{mag}

The result is rounded to 2 decimal places.

Example: If a star is 7 times brighter than another, the difference is 2.11^{mag}.

magR .... Calculates brightness ratio from two magnitudes.

2:	mag_1	$\rightarrow$		
1:	mag_2	$\rightarrow$	1:	$I_{brighter}/I_{fainter}$

The result is always ≥ 1 and rounded to 3 decimal places. Example: Vega (0.14^{mag}) is 6.19 times brighter than Polaris (2.12^{mag}).

Mabs .... Calculates absolute Magnitude of a star.

2:	$mag_{apparent}$	$\rightarrow$		
1:	$d_{distance,pc}$	$\rightarrow$	1:	$Mag_{absolute}$

or

2:	$Mag_{absolute}$	$\rightarrow$		
1:	$-d_{distance,pc}$	$\rightarrow$	1:	$mag_{apparent}$

Application: e.g., to convert catalog data

LY▶PC ..... Conversion Light Years to Parsec.

PC▶LY ..... Conversion Parsec to Light Years.

1:	$dist_{LY}$	$\leftrightarrow$	1:	$dist_{pc}$

Other commands

SPHDIST ... Calculates Great Circle Angular Distance between two points on a sphere.

4:	l_1	$\rightarrow$		
3:	b_1	$\rightarrow$		
2:	l_2	$\rightarrow$		
1:	b_2	$\rightarrow$	1:	Angular distance

This program works for all angular modi (DEG/RAD/GRAD)!

GEODIST ... Calculates distance between two sites on the surface of the Earth.

4:	$l_{1,DD.dddd}$	$\rightarrow$		
3:	$b_{1,DD.dddd}$	$\rightarrow$		
2:	$l_{2,DD.dddd}$	$\rightarrow$		
1:	$b_{2,DD.dddd}$	$\rightarrow$	1:	dist_km

As always, longitudes are positive east of Greenwich, latitudes are positive north of the equator.

Accounts for the oblateness of the Earth's globe. The error is of the magnitude of the square of the oblateness of the Earth, approx. 0.001124% (!) The result is rouded to 5 significant places.

Note: This command works regardless of the current angular mode, input has to be done in decimal degrees.

→HMd .... Conversion degrees with decimals to degrees, minutes, fractions of minutes.

HMd→ .... Conversion degrees, minutes, fractions to degrees with decimals.

1: *DD.dddd* ↔ 1: *DD.MMdd*

ABOUT.UR . Gives program information about URANIA.

Shows version number, registration information and address of author. No stack changes.

2.1.2 Library 1608 — Moon

POSITN.M . Access to URANIA / PLANET / MOON.

Included here for convenience and completeness. Here, however, no coordinates are left on the stack.

2:	(Date)	→	data
1:	(Time)	→	display

PHYSIC.M . Access to URANIA / PLANET / MPHY.

Physical Ephemeris: Libration, PA of axis, elongation, phase angle, illuminated fraction, PA of bright limb, subsolar point, colongitude of the Sun, longitude of morning and evening terminator.

Reference data: Date, time, geogr. site, time zone.

2:	(Date)	→	data
1:	(Time)	→	display

Commands PHASES.M, δMAXIMA.M, APSIDES.M and NODES.M

Usage for those commands:

1: (Date) → data display

Advance/go back in time with [+] / [−].

PHASES.M . Times of main phases.

8 events are shown at a time.

The mean error in the present time (1980 . . . 2020) amounts to 3.72 seconds, the maximal is 17.4 seconds.

Usually, 1 event before and 7 after the calling date are found.

δMAXIMA.M Times and amounts of greatest northern / southern declinations.

8 events are shown at a time.

The mean error in the present time (1977 . . . 2022) amounts to approx. 3 minutes and 10″, the maximal is 10 minutes/ 26″. Usually, 1 event before and 7 after the calling date are found.

APSIDES.M Times of passages through Apogee or Perigee.

4 events are shown at a time, including appropriate distances and horizontal parallax.

The maximal error for the present time (1977...2022) is 31 minutes/ 0.124″ of Parallax (corresponding to $12km$ of distance) in Perigee, 3 Minutes/ 0.051″ of Parallax ($6km$ distance) in Apogee. Usually, 1 event before and 3 after the calling date are found.

NODES.M ... Times of passages through the nodes.

8 events are shown at a time.

The error for the present time (1980...2020) is in most cases less than 2 minutes, also in ancient times it is not significantly larger. Usually, 1 event before and 7 after the calling date are found.

☼ALTITD.M Calculates the Altitude of the Sun above a given location on the Moon's surface.

4:	$\eta_{DD.ddd}$ (selenogr. Long., 0=center, west=pos.)	→		
3:	$\theta_{DD.ddd}$ (selenogr. Lat., north=positive)	→		
2:	(Date)	→		
1:	(Time)	→	1:	:Alt.of Sun: *DD.ddd*

SPEED.M ... Calculates angular speed of the Moon in ecl. Longitude and in Elongation from the Sun.

2:	(Date)	→	2:	:Δλ(HMS): *DD.MMSS*_°/h
1:	(Time)	→	1:	:ΔElong: *DD.MMSS*_°/h

Based on: [5], p. 154

2.1.3 Library 1607 — UTools

Sometimes, a user may need more or a different style of presentation than the data presented by Urania. To avoid rewriting basic code and filling the calculator's memory, UTools allows access to most internal commands of Urania. A layer of protection common for User-RPL commands avoids undesired results if used with wrong arguments, so usage should be safe. It is mainly intended for owners of [6], who can directly look up what the programs do. Owners of [7] note that many formula numbers are off by a few chapters. Detailed description of all programs is far beyond the scope of this manual. From the remarks listed here you will get some insight into how Urania was programmed and also notes about accuracy.

The calculator should be in DEG mode for most operations. Also note that many of these commands work after the GIGO principle[3].

There are two versions of the library: `SomeTools.lib` contains UTools (−), i.e., the most important commands which are also used by SITE and DATA. `AstroTools.lib` contains all the listed commands (UTools (+)).

Basic version:

The following commands are available in both versions of the library, UTools (−) and UTools (+):

MAPS .... Find map numbers in Sky Atlas 2000.0 and Uranometria 2000.0.

2:	$\alpha_{J2000.0,HH.MMSS}$	→	2:	:SkyAtlas: "MM"
1:	$\delta_{J2000.0,DD.MMSS}$	→	1:	:U.metria: "VV, MMM"

where MM resp. MMM is the map number, VV is the volume (I, II or I&II).

Cst? ...... Find constellation for coordinates ($J2000.0$).

[3] Garbage In — Garbage Out

2:	$\pm\alpha_{J2000.0,HH.MMSS}$	$\rightarrow$		
1:	$\delta_{J2000.0,DD.MMSS}$	$\rightarrow$	1:	:Const: "Constellation"

Negative α: returns 3-letter-abbreviation for constellation.

The constellation lines were defined for standard equinox 1875.0, so precession for the given position is applied first, then the lookup is performed: α is brought to $[0\ldots24]$ by a MOD operation, δ outside of $[-90\ldots90]$ is treated as being -90 or 90, resp.

Uses RAPPAPORT's algorithm from [8].

MESSIERd . Quick access to data of Messier objects.

		$\rightarrow$	2:	:α2000: $\alpha_{J2000.0,HH.MMSS}$
1:	n	$\rightarrow$	1:	:δ2000: $\delta_{J2000.0,DD.MM}$

or

		$\rightarrow$	8:	"Messier Nr Cst"
		$\rightarrow$	7:	"Name"
		$\rightarrow$	6:	:α2000: $\alpha_{J2000.0,HH.MMSS}$
		$\rightarrow$	5:	:δ2000: $\delta_{J2000.0,DD.MM}$
		$\rightarrow$	4:	:mag: $mm.m$
		$\rightarrow$	3:	:Type: "ObjType"
		$\rightarrow$	2:	:Dim: "Dimensions"
1:	$-n$	$\rightarrow$	1:	:Dist: d_{pc}

RNGCd ..... Quick access to data of NGC objects, if installed.

		$\rightarrow$	2:	:α1975: $\alpha_{J1975.0,HH.MMSS}$
1:	n	$\rightarrow$	1:	:δ1975: $\delta_{J1975.0,DD.MM}$

or

		$\rightarrow$	8:	"NGC Nr"
		$\rightarrow$	7:	:α1975: $\alpha_{J1975.0,HH.MMSS}$
		$\rightarrow$	6:	:δ1975: $\delta_{J1975.0,DD.MM}$
		$\rightarrow$	5:	:mag: $mm.m$
		$\rightarrow$	4:	:Type: "ObjType"
		$\rightarrow$	3:	:Const: "Cst"
		$\rightarrow$	2:	:Dreyer: "Description"
1:	$-n$	$\rightarrow$	1:	:RNGC: "Description"

The RNGC catalog gives the objects' J1975.0 coordinates. Precession should be applied where necessary.

DMY→JD .... Calculates Julian Day from Day, Month, Year.

3:	$DD.dddd$	$\rightarrow$		
2:	MM	$\rightarrow$		
1:	$YYYY$	$\rightarrow$	1:	JD

JD→DMY .... Splits Julian Day to Day, Month, Year.

		$\rightarrow$	3:	$DD.dddd$
		$\rightarrow$	2:	MM
1:	JD	$\rightarrow$	1:	$YYYY$

CHOOSE.T . Modified CHOOSE for HP-48GX/HP-49G or replacement for HP-48SX.

3:	"Prompt" (e.g., "SELECT:") →		
2:	{ Obj_1 Obj_2 ... Obj_n }	→ 2:	Obj_k (only if pressed ENTER or OK)
1:	Pos_{start}	→ 1:	1 (ENTER / OK) / 0 (ON / CANCL)

If any Obj_m is a list, the first element from that list is shown.

HP48SX: No window is shown and only one line is shown at a time, but you can still work with it.

GX/HP49: FullScreen-CHOOSE! With negative Pos_{start} you may force the usual small CHOOSE-Box.

After calling, Element Pos_{start} from the list on Pos. 2 is displayed. With ▲ or ▼ you may select other elements from the list, as indicated by small arrows on the right (GX) or left (SX) side. When you have found the element, press ENTER or OK to continue the calling program. If no selection seems appropriate, ON resp. CANCL will return just 0. CHOOSE.T thus works very similar to CHOOSE on the GX models.

Extended version:

The following commands are only available in the larger library, UTOOLS (+).

More Coordinate Transformations

αδε→λβ .... Coordinate transformation with given obliquity of ecliptic.

3:	$\alpha_{HH.MMSSdd}$ →		
2:	$\delta_{DD.MMSSdd}$ →	2:	$\lambda_{DD.dddd}$
1:	$\varepsilon_{DD.dddd}$ →	1:	$\beta_{DD.dddd}$

λβε→αδ .... Coordinate transformation with given obliquity of ecliptic.

3:	$\lambda_{DD.ddd}$ →		
2:	$\beta_{DD.ddd}$ →	2:	$\alpha_{HH.MMSSdd}$
1:	$\varepsilon_{DD.ddd}$ →	1:	$\delta_{DD.MMSSdd}$

Some Math functions

ATN2 .... Arcus Tangent in the correct quadrant.

Often a formula is given like $tan(\varphi) = A/B$. You can use this command to find φ in the correct quadrant. This command works in every angular mode.

2:	A →		
1:	B →	1:	φ, deg/rad/grad

R→P .... Conversion Rectangular → Polar coordinates.

P→R .... Conversion Polar → Rectangular coordinates.

These should have been built in!

2:	x ↔	2:	r
1:	y ↔	1:	φ, deg/rad/grad

These commands works in every angular mode.

Calendar helper functions

JD→T .... Calculates frequently used value T.

From: (11.1)

T usually represents Julian Centuries from $J2000.0$.

1: JD → 1: T

T→ε0 .... Mean obliquity of the ecliptic.

From: (21.2) and (21.3)

1: T → 1: ε_0

Accuracy: $J2000.0 \pm 2000$Years :$\leq 1''$ (21.2). Data beyond this time are then calculated after (21.3), this will take more time, but bring results of only few arc seconds error. Valid time: $J2000.0 \pm 10000$Years.

JD→ΔT ..... Returns ΔT in days.

From: Chapter 9

1: JD → 1: ΔT

Because ΔT changes very irregularly and is known from 1620 better than is computable, values from 1620 to 1800 are taken from table 9.1. For earlier times, ΔT is calculated with formula (9.1), values for the years 1800 to 1987 with the formulæ at the end of the chapter. Difference to true ΔT for 1800–1987: $< 1s$. For dates 1995–Sept. 2030, ΔT is computed from 4 preliminary values for 1990, 1993, 2000 and 2010 with the interpolation formula of Lagrange (near (3.13)). From Oct. 2030, (9.1) is used again.

If a global variable ΔT.USR contains a real number, this number is interpreted as ΔT in seconds — a "User-ΔT" for all cases. (May be interesting esp. for historians, and certainly for calculating e.g. eclipse times.) ΔT.USR may also be a program, *as long as it fulfills this stack diagram:*

	→	2:	JD
1: JD	→	1:	$\Delta T_{\text{Seconds}}$

No check is done for a wrong program!

Use it to correct Date (UT) in Date (DT): $DT = UT + \Delta T$

LEAPYR .... Checks if given year is leap year.

1: *Year* → 1: 0 (common year) / 1 (leap year)

SPLITDATE Splits date from HP format.

Independent of flag −42.

	→	3:	DD
	→	2:	MM
1: Date	→	1:	$YYYY$

BINDDATE . Creates HP date format.

Result is in current date mode, dependent on flag −42.

3: DD	→		
2: MM	→		
1: $YYYY$	→	1:	Date

Precession, Nutation from Chapters 20, 21.

PreQ .... Precession, fast version.

Only for coordinates $J2000.0$ and only for few centuries around $J2000.0$.

3:	$\alpha_{J2000.0,HH.MMSS}$	→		
2:	$\delta_{J2000.0,DD.MMSS}$	→	2:	$\alpha_{T,HH.MMSS}$
1:	$T_{\texttt{new}}$	→	1:	$\delta_{T,DD.MMSS}$

Pre4 .... Precession between arbitrary equinoxes in the FK4 system.

Equinox correction is not performed.

4:	$\alpha_{\texttt{old},HH.MMSS}$	→		
3:	$\delta_{\texttt{old},DD.MMSS}$	→		
2:	$T_{\texttt{old}}$	→	2:	$\alpha_{\texttt{new},HH.MMSS}$
1:	$T_{\texttt{new}}$	→	1:	$\delta_{\texttt{new},DD.MMSS}$

Pre5 .... Precession between arbitrary equinoxes in the FK5 system.

4:	$\alpha_{\texttt{old},HH.MMSS}$	→		
3:	$\delta_{\texttt{old},DD.MMSS}$	→		
2:	$T_{\texttt{old}}$	→	2:	$\alpha_{\texttt{new},HH.MMSS}$
1:	$T_{\texttt{new}}$	→	1:	$\delta_{\texttt{new},DD.MMSS}$

PreEc ..... Precession between arbitrary equinoxes in ecliptical coordinates.

(20.5)ff.

4:	$\lambda_{\texttt{old},DD.MMSS}$	→		
3:	$\beta_{\texttt{old},DD.MMSS}$	→		
2:	$T_{\texttt{old}}$	→	2:	$\lambda_{\texttt{new},DD.MMSS}$
1:	$T_{\texttt{new}}$	→	1:	$\beta_{\texttt{new},DD.MMSS}$

ApPos ..... Apparent position of object in the FK5 system, incl. Precession, Nutation, Aberration.

Chapter 22.

4:	$\alpha_{\texttt{old},HH.MMSS}$	→		
3:	$\delta_{\texttt{old},DD.MMSS}$	→		
2:	$T_{\texttt{old}}$	→	2:	$\alpha_{\texttt{new},HH.MMSS}$
1:	$T_{\texttt{new}}$	→	1:	$\delta_{\texttt{new},DD.MMSS}$

Nutation . Nutation.

From Chapter 21

2:	T	→	2:	$\Delta\psi_{DD.ddd}$
1:	0(fast)/1(accurate)	→	1:	$\Delta\varepsilon_{DD.ddd}$

Fast: Most important terms used. Accuracy: $\Delta\psi$: $0''.5$, $\Delta\varepsilon$: $0''.1$

Accurate: All terms with coefficients $\geq 0''.0021$ ($\Delta\psi$) resp. $\geq 0''.0010$ ($\Delta\varepsilon$). Accuracy: $\Delta\psi$: $0''.2$, $\Delta\varepsilon$: $0''.05$ (approx.)

Objects in the Solar System, Planetary positions

SunPos .... Ecliptical position of the Sun.

Both fast and accurate versions are available, from Chapter 24.

		→ 3:	$\odot_{DDD.ddd}$	True Long. of Sun, w/o Nut., Aberr.
2:	T	→ 2:	$\beta_{DD.ddd}$	Latitude (0 for fast version)
1:	0 (fast)/ 1(accurate)	→ 1:	R_{AU}	Radius vector

MoonPos ... Ecliptical position of the Moon.

Both fast and more accurate versions are available, from Chapter 45.

Fast: Only the most important terms are used. This command is useful, e.g., for overview graphs, where an error of up to $1/2°$ is tolerable.

Accurate: All terms from the chapter. Accuracy: $10''$ in longitude, $4''$ in latitude.

		→ 4:	$\lambda_{DD.ddd}$	geocentr. ecl. Longitude
		→ 3:	$\beta_{DD.ddd}$	geocentr. ecl. Latitude
2:	T	→ 2:	Δ_{1000km}	Distance/1000km
1:	0 (fast)/1 (accurate)	→ 1:	$\pi_{DD.ddd}$	equatorial horizontal parallax

PlanPos ... Heliocentric Position of the planets Mercury to Pluto.

		→ 3:	$L_{DD.ddd}$	Heliocentr. Longitude
2:	$\pm n_{\texttt{Planet}}$	→ 2:	$B_{DD.ddd}$	Heliocentr. Latitude
1:	T	→ 1:	R_{AU}	Radius vector

$n_{\texttt{Planet}}$

0 Earth for $J2000.0$, accurate version.

1 ... 8 Mercury to Neptune

9 Pluto, always full precision, regardless of sign

Sign of $\pm n_{\texttt{Planet}}$ decides about accuracy:

Negative Fast version after [5], Chapter 25. Here, undisturbed, long time variable orbits are used for Mercury to Neptune. (Orbital elements taken from [6].)

Positive Accurate version: [6], Ch.31. The complete theory VSOP87 with all terms would consume far too much memory. Not all terms have therefore been used. To estimate accuracy following the remarks at the end of Chapter 31:

	A_0	A_1	A_2	A_3	A_4	A_5
L, B [$''$]	10	5	2	1	0.5	0.2
R [AU]	0.0002	0.0001	0.00005	0.00002	0.00001	0.000005

Positions of the Earth are calculated with even higher accuracy.

Pluto Heliocentric position of Pluto, valid for the years 1885...2099; Chapter 36. There is no complete theory of motion for Pluto. Its motion, however, can be described for a limited range of time. Beyond 1885...2099 the program will abort with an error. You will have to use *osculating elements* and regard Pluto as an asteroid. This program uses the full accuracy of $0''.6$ in l, $0''.2$ in b and $0.00002AU$ in r. The positions are for $J2000.0$.

OrbEl ..... Orbital elements of the Planets.

From Chapter 30

		→	6:	$L_{DD.ddd}$	mean Longitude
		→	5:	a_{AU}	semimajor axis
		→	4:	e	Excentricity
		→	3:	$i_{DD.ddd}$	Inclination
2:	$n_{\texttt{Planet}}$	→	2:	$\Omega_{DD.ddd}$	Long of asc. node
1:	T	→	1:	$\pi_{DD.ddd}$	Long. of perihelion

n_{Planet} is [1=Mercury ... 8=Neptune]

RedOrbEl . Reduction of ecliptical orbital elements between two equinoxes.
Chapter 23.

5:	i_0	→		
4:	ω_0	→		
3:	Ω_0	→	3:	i
2:	Initial equinox [e.g. 1950.0]	→	2:	ω
1:	Final equinox [e.g. 2000.0]	→	1:	Ω

magPhØ .... Apparent visual magnitude, Phase, Diameter of the Planets.
From Chapter 40, 44, 53.
Magnitudes after the first set of formulae (40), giving visual magnitudes and not spectroscopic (V) magnitudes. Equatorial diameter values after 53.(B), except for Venus (A), because of its atmosphere.

		→	9:	L
		→	8:	B
		→	7:	R
		→	6:	λ
5:	$\{\ L\ B\ R\ \}$	→	5:	β
4:	$\{\ x\ y\ z\ \}$	→	4:	Δ
3:	$\{\ \lambda\ \beta\ \Delta\ \}$	→	3:	*mag*
2:	T	→	2:	*Phase* [0 ... 1]
1:	$n_{\texttt{Planet}}$	→	1:	$\varnothing_{\texttt{arcsec}}$

n_{Planet} from [1=Mercury ... 9=Pluto]

KEPLER .... Solves the Equation of Kepler.
$E = M + e * \sin(E)$. Formulae (29.7), (29.8) (Method 2)
Accuracy: 10^{-6} degrees.

2:	M	Mean Anomaly	→			
1:	e	Excentricity	→	1:	E	Excentric Anomaly

The following commands just have their formula numbers as name. I guess they are pretty useless without the book ...

F25.2 ..... Rectangular coordinates of the Sun.
Given in the ecliptical dynamical reference system VSOP of $J2000.0$.

		→	4:	$\odot$
		→	3:	X
		→	2:	Y
1:	T	→	1:	Z

F25.3 ..... Correction of the rectangular coordinates of the Sun.

From the ecliptical dynamical reference system VSOP of $J2000.0$ to the equatorial reference system FK5, $J2000.0$

3:	X	$\rightarrow$	3:	X_0
2:	Y	$\rightarrow$	2:	Y_0
1:	Z	$\rightarrow$	1:	Z_0

F29.12 .... Combines formulæ (29.1) and (29.2).

3:	a_{AU}	Semimajor Axis	$\rightarrow$			
2:	e	Num. Excentricity	$\rightarrow$	2:	$\nu_{DD.ddd}$	true anomaly
1:	$M_{DD.ddd}$	Mean Anomaly	$\rightarrow$	1:	r_{AU}	radius vector

F33.14 .... Combines formulæ (33.1) to (33.4) (Parabolic Motion).

Accuracy: 10^{-6} degrees.

2:	q_{AU}	Perihelion distance	$\rightarrow$	2:	$\nu_{DD.ddd}$	true anomaly
1:	$(t-T)$	Days from Perihelion	$\rightarrow$	1:	r_{AU}	radius vector

F34.1 ..... Near-parabolic hyperbolical motion.

3:	e	good:0.999 to 1.3(?)	$\rightarrow$			
2:	q_{AU}	Perihelion distance	$\rightarrow$	2:	$\nu_{DD.ddd}$	true anomaly
1:	$(t-T)$	Days from Perihelion	$\rightarrow$	1:	r_{AU}	radius vector

Should the object run on an extremely hyperbolic track ($e > 1.3$), it might abort with the message `Algorithm Failed`.

F32.1 ..... Just that formula.

			$\rightarrow$	3:	x
2:	$\{\ L_0\ B_0\ R_0\ \}$	(Earth data)	$\rightarrow$	2:	y
1:	$\{\ L\ B\ R\ \}$	(Planetary data)	$\rightarrow$	1:	z

Values L, B, R must be given in degrees.

F32.24 .... Combines formulæ (32.2) to (32.4).

3:	x	$\rightarrow$	3:	$\lambda_{DD.ddd}$
2:	y	$\rightarrow$	2:	$\beta_{DD.ddd}$
1:	z	$\rightarrow$	1:	Δ_{AU}

F32.78 .... Combines formulæ (32.7) and (32.8).

		$\rightarrow$	6:	A
		$\rightarrow$	5:	a
		$\rightarrow$	4:	B
3:	Ω	$\rightarrow$	3:	b
2:	i	$\rightarrow$	2:	C
1:	ε	$\rightarrow$	1:	c

F32.9 ..... Heliocentric rectangular coordinates.

4:	$\{ A\ a\ B\ b\ C\ c \}$		$\rightarrow$		
3:	ω	argument of perihelion	$\rightarrow$	3:	x
2:	ν	true anomaly	$\rightarrow$	2:	y
1:	r_{AU}	radius vector	$\rightarrow$	1:	z

F32.10 .... Geocentric equatorial coordinates.

			$\rightarrow$	3:	$\alpha_{HH.MMSS}$
2:	$\{ X\ Y\ Z \}$	(Sun)	$\rightarrow$	2:	$\delta_{DD.MMSS}$
1:	$\{ x\ y\ z \}$	(Planet)	$\rightarrow$	1:	Δ_{AU}

F36.1 ..... Geocentric rectangular coordinates of Pluto.

3:	$l_{DD.ddd}$	$\rightarrow$	3:	x
2:	$b_{DD.ddd}$	$\rightarrow$	2:	y
1:	r_{AU}	$\rightarrow$	1:	z

GEOOBS .... Geocentric rectangular coordinates of observer.
From Chapter 10; Φ = Lat

$\rightarrow$	2:	$\rho * \sin \Phi'$
$\rightarrow$	1:	$\rho * \cos \Phi'$

COPAR ..... Correction for Parallax.
From Chapter 39.

3:	$H_{HH.MMSS}$	Hour Angle	$\rightarrow$		
2:	$\delta_{DD.MMSS}$	Declination	$\rightarrow$	2:	$H'_{HH.MMSS}$
1:	$\pi_{DD.dddd}$	Hor. Parallax	$\rightarrow$	1:	$\delta'_{DD.MMSS}$

COPEC ..... Topocentric Correction for Parallax in ecliptical coordinates.
From Chapter 39.

5:	$\{ \lambda_{DD.dd}\ \beta_{DD.dd} \}$	Ecl. coordinates	$\rightarrow$		
4:	$s_{DD.ddd}$	geoc. Semidiameter (or 0)	$\rightarrow$		
3:	$\pi_{DD.ddd}$	Hor. Parallax	$\rightarrow$	3:	$\lambda'_{DD.ddd}$
2:	$\varepsilon_{DD.ddd}$	obliquity of ecliptic	$\rightarrow$	2:	$\beta'_{DD.ddd}$
1:	$\theta_{DD.ddd}$	Sidereal Time	$\rightarrow$	1:	$s'_{DD.ddd}$ (or 0)

If not used, s may be set to zero.

ILLMOON ... Phase angle of the Moon and position angle of illuminated limb.
From Chapter 46.

2:	$\{ \alpha_{\odot,HMS}\ \delta_{\odot,DMS}\ R_{AU} \}$	Sun	$\rightarrow$	2:	$i_{[0..180°],DD.ddd}$
1:	$\{ \alpha_{HMS}\ \delta_{HMS}\ \Delta_{1000km} \}$	Moon	$\rightarrow$	1:	$\chi_{NESW,DD.ddd}$

ILLANG .... Position angle of the illuminated limb of the Moon or any planet.
Formula (46.5).

4:	$\alpha_{\odot,HMS}$	Sun	$\rightarrow$		
3:	$\delta_{\odot,DMS}$	Sun	$\rightarrow$		
2:	α_{HMS}	Moon/Planet	$\rightarrow$		
1:	δ_{DMS}	Moon/Planet	$\rightarrow$	1:	$\chi_{NESW,DD.ddd}$

Various helper functions

INTER ..... Interpolation routines from Chapter 3.

This program interpolates values or finds roots (zero points) and extrema for data curves with 2, 3, 4 or 5 tabular values. Not all functions are available for all types of input. The following diagrams show which functions are available and how to call them. Given lists {a b}, {c d e}, {f g h i} or {j k l m n}, we get:

2: { list with 2 or 3 or 5 y values } →		
1: -10 (code for ''solve root'')	→ 1:	x_0

x_0 is given in interval steps from $a = 0$ to $b = 1$ or $d = 0$ or $l = 0$ to both sides.

2: { list with 3 or 5 y values }	→ 2:	x_e, step from d resp. l
1: 10 (code for ''find extremum'')	→ 1:	y_e, value of extremum

x_e is given in interval steps from $a = 0$ to $b = 1$ or from $d = 0$ or $l = 0$ to both sides.

2: { list with 2, 3, 4 or 5 values } →		
1: x_i, value in range $-1 \ldots +1$	→ 1:	y_i, value of curve at x_i

x_i should be $0 \ldots 1$ for interpolation of 2 values, of course, and is irrelevant for interpolation of 4 values, which always finds the y value between g and h.

With these programs you can, e.g., find conjunctions between celestial bodies. Calculate (or take from an ephemeris) 5 distances around the time of event, put them into a list, enter 10 INTER. The stack will contain the smallest distance and appropriate instant of time, in steps of the ephemeris.

Attention must be taken when interpolating degree values: You have to avoid the jump at 360° = 0°. Work with values either around 360° or around 0°!

CIRCSIZE . Diameter of the smallest circle around 3 points on a sphere.

From: Chapter 19

3: { l_1 b_1 }	→ 1:	:1 Obj.within:	DD.dddd (One object within the circle)
2: { l_2 b_2 }	→ or		
1: { l_3 b_3 }	→ 1:	:Obj.on circle:	DD.dddd (All 3 objects on perimeter)

l_n, b_n are the spherical coordinates of the 3 points, given in any angular mode (DEG/RAD/GRAD). The result will be the angular diameter of the circle in the same mode.

The objects should not be more than 6° separated from each other!

STRAIGHT? Helps when looking for the time of alignment of 3 bodies on a line (i.e. great circle).

From: Formula (18.1)

3: { l_1 b_1 } →		
2: { l_2 b_2 } →		
1: { l_3 b_3 } →	1:	result of (18.1)

l_n, b_n are the spherical coordinates of the 3 points, given in any angular mode (DEG/RAD/GRAD).

Result is = 0 if 3 objects are on a Great Circle; the greater that value is, the farther the objects are from this alignment.

Data access, formatting, etc.

`Scroll.T` . Final stage for programs with graphic output to the text or graphic screen.

Using this program you may:

1. Scroll around with the cursor keys.
   - With left-shifted cursor keys you scroll the screen by approx. one display width/height.
   - With right-shifted cursor keys you jump to the respective edge.
2. Copy current screen into `PICT` with [STO]. This is useful for programs with output to the text display (User-RPL commands `DISP`, `→LCD` etc.). If you already look at `PICT`, the screen will look garbled a few moments when pressing this key, but nothing harmful will happen.
3. Turn off the calculator with [OFF] (normal behavior)
4. Leave this environment with [ON].
5. If, in your program, you use local variables `'k'`, `'step'` and `'End'`, you can get similar behavior to `JUMO` and `ECLIPSES` of Urania and the programs of Moon:

`k`	Real, a counter
`step`	Real, increment
`End`	Flag, Program end flag, [STO] stores `TRUE` in here
	[+] / [−] in-/decrement `k` by `step`,
	[↰]-[+] resp. [↰]-[−] by 10 ∗ `step`

   Flag here means a System-RPL Flag `TRUE` or `FALSE`. On both the HP-48 and the HP-49, you may get `TRUE` with `« #03A81h SYSEVAL »`, `FALSE` with `« #03AC0h SYSEVAL »`.

   This functionality should only be used by experienced programmers.

At end of program, the text display is rebuilt. No stack change.

`Display.T` Calls the internal display programs.

May be used to build specialized custom menus.

`1: %branch →`

`%branch` is 1 ... 9 for the planets (3 for Moon), 10 Sun, 11 Asteroids, 12 Comets, 13 Jupiter's Moons, 14 Bright Star, 15 Binary Star, 16 Variable Star, 17 Messier Object, 18 Other DSO, 19 NGC object

`MOONGROB` . Small Moon phase symbols.

`1:` $n_{[1...10]}$ → `1: GROB` 3×5, 4×5 `or` 5×5

Valid numbers for n:

1: New Moon

2: New Light	3: Old Light
4: waxing crescent	5: waning crescent
6: First Quarter	7: Last Quarter
8: waxing gibbous	9: waning gibbous

10: Full Moon

`PLANGROB` . Small planet symbols.

`1:` $n_{[1...10]}$ → `1: GROB` 3×5, 5×5, 5×8, 6×6, 7×7 `or` 5×9

Valid numbers for n:

1: Mercury	2: Venus	3: Earth	4: Mars	5: Jupiter
6: Saturn	7: Uranus	8: Neptune	9: Pluto	10: Sun

FINDSTAR . Program to select a bright star.
This UI component is used in STAR / BRIGH.

```
→ 2:  "β Cst Name1 "
→ 1:  Number
```

or, in case of abort with ON:

```
→ 1:  0
```

β is the Bayer designation, Cst is the constellation shortcut and Name1 is the Name shown in STAR / BRIGH. This program returns the internal number of the star. This number is meaningful only with the two following programs.

GETSTRDAT Access to the 328 bright star data.

1: +Number	→	1: { "Spectral Type" Proper motion α (s/yr) Proper motion δ ($''/yr$) $\delta_{2000.0,DD.MMSS}$ $\alpha_{2000.0,HH.MMSSd}$ $B-V$, Color index M, absolute Magnitude (89.9 if unknown) Distance, pc (0, if unknown) mag, apparent (V) magnitude }

or

1: -Number	→	1: { mag, apparent (V) magnitude $\delta_{2000.0,DD.MMSS}$ $\alpha_{2000.0,HH.MMSSd}$ }

With a negative number $-1\ldots-328$, a reduced set will thus be returned.

STARNAMES Access to alternate names of the bright stars.

```
1:  Number → 1:  "β Cst Name1 Name2 ...  "
```

For some stars there are several names and different spellings. Here you can access the names recognized but not returned by FINDSTAR.

CstName ... Names of the constellations.

1: $\pm n_{[1\ldots88]}$	→	1: "Cst"

Valid numbers for n:

+	1	2	3	4	5	6	7	8	9	10
0	"And"	"Ant"	"Aps"	"Aql"	"Aqr"	"Ara"	"Ari"	"Aur"	"Boo"	"Cae"
10	"Cam"	"Cap"	"Car"	"Cas"	"Cen"	"Cep"	"Cet"	"Cha"	"Cir"	"CMa"
20	"CMi"	"Cnc"	"Col"	"Com"	"CrA"	"CrB"	"Crt"	"Cru"	"Crv"	"CVn"
30	"Cyg"	"Del"	"Dor"	"Dra"	"Equ"	"Eri"	"For"	"Gem"	"Gru"	"Her"
40	"Hor"	"Hya"	"Hyi"	"Ind"	"Lac"	"Leo"	"Lep"	"Lib"	"LMi"	"Lup"
50	"Lyn"	"Lyr"	"Men"	"Mic"	"Mon"	"Mus"	"Nor"	"Oct"	"Oph"	"Ori"
60	"Pav"	"Peg"	"Per"	"Phe"	"Pic"	"PsA"	"Psc"	"Pup"	"Pyx"	"Ret"
70	"Scl"	"Sco"	"Sct"	"Ser"	"Sex"	"Sge"	"Sgr"	"Tau"	"Tel"	"TrA"
80	"Tri"	"Tuc"	"UMa"	"UMi"	"Vel"	"Vir"	"Vol"	"Vul"		

If $n < 0$, the first three letters only (as shown here), otherwise, the full names are returned.

MoName .... Names of the months.

1: $\pm n_{[1...12]}$	→	1: "Month"	

Valid numbers for n:

1: January	2: February	3: March	4: April	5: May	6: June
7: July	8: August	9: September	10: October	11: November	12: December

If $n < 0$, the first three letters only are returned.

WdName .... Names of the week days.

1: $\pm n_{[1...7]}$	→	1: "WeekDay"

Valid numbers for n:

1: Monday	2: Tuesday	3: Wednesday	4: Thursday
5: Friday	6: Saturday	7: Sunday	

If $n < 0$, the first two letters only are returned.

DAT$ .... Creates nicely formatted date string.

3: *DD*	→	1: "MM/DD/YYYY"	(Flag -42 clear)
2: *MM*	→	or	
1: *YYYY*	→	1: "DD.MM.YYYY"	(Flag -42 set)

TIM$ .... Creates nicely formatted time string.

1: Time	→	1: "HH:MM:SSN"	(Flag -41 clear)
or	→	1: "HH:MM:SS"	(Flag -41 set)
1: -Time	→	1: "HH:MMN"	(Flag -41 clear)
	→	1: "HH:MM"	(Flag -41 set)

Time should be valid (0 ... 23.5959 in *HH.MMSS* format), and will be MODed otherwise. N is A or P for AM or PM, resp. Times will be *truncated*.

PAD$ .... Pads string with leading spaces to the desired length.

2: "String"	→	
1: $\texttt{length}_{\texttt{final}}$	→	1: "String"'

If "String" is longer than $\texttt{length}_{\texttt{final}}$, "String" remains unchanged.

MAKE$22 ... Formats a short string for centered display when displayed with DISP.

```
1:  "String"  →  1:  "String"' centered, with max. 22 chars length
```

REAL$ ..... Formats a real number with given number of decimal places.

This is especially helpful on the HP-49 to get rid of the trailing decimal dot.

```
2:  number  →
1:  places  →  "number"
```

Zone$ ..... Returns formatted time zone information from Zone.

```
→  1:  "Zone"
```

DSTAR.PCK Packs data for Binary Stars into format for DSTAR.DAT.

1: {	$\alpha_{HH.MMd}$	
	$\delta_{\pm DD.MM}$	
	$m_{1,V;MM.m}$	
	$m_{2,V;MM.m}$	
	$PA_{\text{deg},DDD}$	
	$Sep_{\text{arcsec},SSSS.s}$	→ 1: (±HHMMd.DDMMDDD,
}		MMmMMm.SSSSs)

VSTAR.PCK Packs data for Variable Stars into format for VSTAR.DAT.

1: {	$\alpha_{HH.MMd}$	
	$\delta_{\pm DD.MM}$	
	$m_{min,V;MM.m}$	
	$m_{max,V;MM.m}$	
	$Period_{\text{days},DDDD.dd}$	
	TT Type code	→ 1: (±HHMMd.DDMMTT,
}		MMmMMm.DDDDdd)

TT is described under 2.3/VSTAR.DAT.

DSO.PCK ... Packs data for DeepSky objects into format for DSO.DAT.

1: {	$\alpha_{HH.MMd}$	
	$\delta_{\pm DD.MM}$	
	$m_{V;mm.d}$	
	$dist_{DD.ddd}$	
	T Type code	
	xxx long dim.	
	yyy short dim.	→ 1: (±HHMMd.DDMMmmd,
}		xxxyyy.DDdddT)

Please see the notes under 2.3/DSO.DAT.

DRWCIRCLE Draws circles in text display or PICT.

It is significantly faster than using ARC or such.

3:	{ #x #y }	2 Binary Integers (User Binary), Position of center	→
2:	$\pm r$	Radius, pixels; if negative, a white circle is plotted	→
1:	0 / 1	text display) / PICT	→

2.1.4 Library 1606 — SAMoon

This is an optional addon library which does not autoattach, so no menu label will usually be visible in the library menu.

If installed, the SAMoon library provides a command most comfortably started from Urania/ PLANET / SAMO .

SAMOON .... Shows a graphic display of Saturn with its 8 largest moons.

```
2:  (Date) → graphic
1:  (Time) → display
```

In this program, light time is taken into account.

The moons are plotted as dots with adjacent first characters of their respective names. Titan is plotted with a larger 2x2 dot to distinguish it from Tethys. Below (scroll with ▼/▲ keys, both unshifted and shifted), you will find some numerical data:

β:	Saturnicentric Latitude of Earth
β':	Saturnicentric Latitude of the Sun
P:	Geocentric Position Angle of the northern semiminor axis of the ring's ellipse, measured from North towards the East
↔:	apparent major axis of the rings, arc seconds
↕:	apparent minor axis of the rings, arc seconds
↔EQ:	apparent equatorial diameter of the planet's disk, arc seconds
↔POL:	apparent polar diameter of the planet's disk, arc seconds
MAG:	apparent visual magnitude of Saturn

Below, you will find distances, position angles counted from Saturn's North pole towards the East, and visual magnitudes of the moons. In the menu area of the display, you find two small symbols on the left side. The first is an arrow pointing up or down, indicating upright or inverting telescope. The second is a small symbol of either a straight barrel or a zenith prism, indicating straight or mirror view. You may switch the four modi with menu keys $\square_A$ (invert) or $\square_B$ (mirror). The program starts always inverted-straight.

With the + / − keys, you can advance/go back in time by 10 minutes at a time, by pressing ↰ + or ↰ − you can move in 1 minute steps, and by pressing ↱ + or ↱ − you can jump by 1 hour.

The × / ÷ keys may be used to zoom in/out. Unshifted keypresses zoom in/out by 3 steps, left-shifted by single steps. ↱ × zooms in to maximum, ↱ ÷ zooms very far out. Going farther is possible, but usually pointless.

To make updates faster while using the program, positions of Earth and Saturn are calculated only at program start. When you change the time within the program, only the moons are recalculated. To recalculate everything, just press ENTER.

If, after a zoom, some moon image disturbs the data area, you might press · to redraw the screen.

To save the graphic to PICT, just press STO. If you want only the graphic stored (without the data), press ↰ STO. The date line will always be copied into the stored graphic.

2.1.5 Library 1602 — RNGC1

DSO.NGC ... Replacement menu for Urania/DSO.

If the library is installed, this command will be automagically called by Urania/DSO to provide 2 more commands.

Page 1: MESSI NGC NBRW OTHER HACLK

Page 2: URANI

NGC

3:	(Date)	→		→	
2:	(Time)	→	data	→ 2:	$\alpha_{HH.MMSS}$
1:	NGC Number	→	display	→ 1:	$\delta_{DD.MMSS}$

Data Number, Constellation

OBJECT TYPE	Short type description
DREYER, RNGC	Description from those sources
MAG	Apparent magnitude, if available
α2000, δ2000	Equatorial coordinates for equinox $J2000.0$
αDAT, δDAT	Equatorial coordinates for equinox of date

NBRW Calls BROWS.NGC. See below for details.

BROWS.NGC NGC browser for objects in "numerical vicinity".

1: (NGC number)	→ 1: NGC number

The browser will list the objects in the numerical vicinity of the entered number. Number, object type and constellation are displayed. If the program is aborted with CANCL or ON, the number on the stack remains unchanged. If you accept with OK or ENTER, the currently highlighted number is returned.

Note: This command works only on the HP-48GX and HP49G.

2.1.6 Library 1601 — RNGC2

This library contains the object descriptions given by Dreyer in his original NGC catalogue. It does not autoattach, and contains no user commands. If it is installed, it will be used by DSO.NGC and other commands.

2.1.7 Library 1600 — RNGC3

This library contains the object descriptions given in the Revised NGC catalogue (RNGC). It does not autoattach, and contains no user commands. If it is installed, it will be used by DSO.NGC and other commands.

2.1.8 Library 1611 — QVSOP

This "Quick VSOP" library provides faster planetary positions for the years 1998 ... 2025.

This library was developed with the help of Keith Farmer. If installed, it will speed up calculations of the positions of the gas planets for AARes. It is not required, should you have too little memory available.

It does not autoattach, because it is mainly used by AARes. You might attach it manually (type 1611 ATTACH) should you need the provided commands.

QVSOP is independent of the rest of Urania, and is provided in source code and libraries for both the HP48 and HP49.

QVSOP ..... Calculates L, B, R for all giant planets.

2:	DD.dd	→ 2:	$[L_5\ B_5\ R_5\ L_6\ B_6\ R_6\ L_7\ B_7\ R_7\ L_8\ B_8\ R_8]$
1:	YYYY	→ 1:	1

or

	→	3:	DD.dd
2: DD.dd	→	2:	YYYY
1: YYYY	→	1:	0

$YYYY$ must be in the range given by range.QVSOP to give a "good" result. L_n may be greater than 360°!

rng.QVSOP Returns info about range of years in this QVSOP lib.

→ 2:	first year
→ 1:	last year

err.QVSOP Returns vector of maximum error.
This may be useful to estimate accuracy of the results.

→ 1: [[ΔL_5 ΔB_5 ΔR_5] [ΔL_6 ...] ... [... ΔR_8]]

Values are given in degrees. A value of −1 means "unknown"

src.QVSOP Returns info about QVSOP source.

→ 1: info string

2.2 More programs

These may be stored in a port to save user memory:

PHENO ..... calculates some planetary phenomena during a year.
Opposition, Conjunctions, greatest Elongations are found.

1: (Year) →

ANA .... Draws Analemma of the Equation of Time for a year and the position of the Sun on it.
If you draw the Equation of Time against the Sun's declination for a whole year, the result is this famous "figure-8". It represents the position of the True Sun at Mean Noon. This graph is scaled: The vertical line represents the meridian, the horizontal line declinations of 20°, 10°, 0°, −10°, −20°. The length of the lines corresponds to ±20 minutes. The greater dots on the track mark the first days of the months, the thick dot represents the Sun for the required date.
Below the Analemma (press ▼) you find the date for the plotted position of the Sun.

1: (Date) → graphic display

Note: You should watch the change of the shape during the millennia!

Uses lower precision than EQTM.

DATA .... Program to edit data lists ASTEROID.DAT and COMET.DAT.
Allows adding/changing/deleting object data. To add data, you will need orbital elements listed, e.g., in astronomical magazines or newsgroups.

SITE .... Program to edit the list SITE.DAT and select observing sites.
Allows choosing/adding/deleting sites.

Some more programs are included which demonstrate the use of UTools (+). See their respective source code for detail!

2.3 Variables used with Urania

Variables marked with a (*) are essential, the others are optional. Missing or bad (*)-marked variables will result in an error.

2.3.1 Observing Site

Long .... (*) Geographic Longitude, $-180\ldots360°$, positive east of Greenwich.

Format *DD.ddd*

Lat .... (*) Geographic Latitude, $-90\ldots90°$, positive north of equator.

Format *DD.ddd*

Alt .... (*) Altitude above sea level, meters.

Only used for computing topocentric position of the Moon.

Zone .... (*) Time zone, positive east of Greenwich.

E.g. $CET = +1$, $CEDT = +2$; Format: *HH.ddd* or `{:NAME: HH.dd}` In the latter case, `NAME` gives the time zone name, like *CET*, *CEDT*, *PST*, *PDT*, etc. Some programs give time zone information and will show either this string, or a default zone designation as UT±*n*. This label should not be longer than 7 characters.

2.3.2 Overriding default data

ΔT.USR .... Customizable ΔT.

ΔT, the time difference between Universal Time *UT* and Dynamical Time *DT* (until 1984 called Ephemeris Time, *ET*) is by default taken from a list or calculated. If you wish to use a different value, store a real number for ΔT in seconds under this name. (Interesting for historians or for future years) ΔT.USR can also be a program, *as long as it behaves as shown in the stack diagram*:

		→	2:	JD
1:	JD	→	1:	$\Delta T_{\texttt{seconds}}$

Note: No check is done for a bad program!

Usage: Correction $\texttt{Date}_{UT}$ to $\texttt{Date}_{DT}$: $DT = UT + \Delta T$

ε.USR ..... Customizable obliquity of the ecliptic.

The coordinate transformation programs αδλβ and λβαδ by default use $\varepsilon_{0,2000}$. If you need a different value, store a year (with decimals) under this name; the programs will calculate $\varepsilon_{0,Year}$ and store this value back, tagged with the year. The following transformations will then be faster.

2.3.3 Additional data

Temp .... Influence refraction with non-default temperature.

Press ..... Influence refraction with non-default air pressure.

Refraction is calculated for air temperature of $10°C$ and air pressure of $1010mbar$. For other conditions, you may store a Celsius temperature in Temp and air pressure (mbars) in Press. Both numbers must be real.

GRS.DAT ... Jovigraphic longitude of Jupiter's Great Red Spot.

If a real number is found under this name, it is used by PLANET/JUMO to plot the Great Red Spot, if visible.

GRS.DAT contains the jovigraphic longitude, in degrees. This value can be found, for example, in the "Observer's Pages" of the monthly magazine Sky&Telescope. In 1996, a good value was 51, for January 2000, those pages give 66.

GRS.DAT can also be a program, *as long as it behaves as shown in the stack diagram*:

	→	2: JD
1: JD	→	1: real number = $Longitude_{GRS}$

Note: No check is done for a bad program!

ASTEROID.DAT (*) Data list for Asteroids.

Format: {	{	"Name"	max. 22 characters
		Equinox	e.g. 1950, 2000
		T	Epoch, e.g. 1995.6789
		M_0	Mean Anomaly for date T; degrees
		ω	Argument of Perihelion; degrees
		Ω	Longitude of ascending Node; degrees
		i	Inclination; degrees
		a	Semimajor Axis of orbit, *AU*
		e	Numerical Excentricity of orbit, < 1
		H	Magnitude parameter, mean abs. magnitude
		G	Magnitude/inclination parameter
	}		
	{	"Name" ... }	Next entry
	...		More entries
}			

Data for some asteroids are provided in the package.

COMET.DAT (*) Data list for Comets.

Format: {	{	"Name"	max. 22 characters
		Equinox	e.g. 1950, 2000
		T	Perihelion date, e.g. 1995.6789
		ω	Argument of Perihelion; degrees
		Ω	Longitude of ascending Node; degrees
		i	Inclination; degrees
		q	Perihelion distance, *AU*
		e	Numerical Excentricity of the orbit, [0 ... 1.3]
		H_{10}	Reduced magnitude
	}		
	{	"Name" ... }	Next entry
	...		more entries
}			

Data for some comets are provided in the package.

DSTAR.DAT Data list for more Binary Stars.

Format: { {	"Name Notes":22	Visible for selection and in line 1
	"Spec1 Spec2"	Spectral types, e.g. "A0 G2"
		Packed data:
	(HHMMd.DDMMDDD,	$\alpha_{2000,HH.MMd}$, $\delta_{2000,DD.MM}$
		Position Angle, DDD
	mmdmmd.SSSSd)	mag_1, $mm.d$; mag_2, $mm.d$
		distance, arcseconds, $SSSS.d$
}		
{ … }		
}		

VSTAR.DAT Data list for more Variable Stars.

Format: { {	"Name Notes":22	Visible for selection and in line 1
	"Spec"	Spectral type, e.g. "K5 III"
		Packed data:
	(HHMMd.DDMMTT,	$\alpha_{2000,HH.MMd}$, $\delta_{2000,DD.MM}$
		TT, Type, Code see below
	mmdmmd.DDDDdd)	mag_{max}, $mm.d$; mag_{min}, $mm.d$
		Period, Days, $DDDD.dd$
}		
{ … }		
}		

Type codes:

0 =	"?"	1 =	"BY Dra"	2 =	"δCep I"	3 =	"δ Cep II"	4 =	"Ecl"
5 =	"Ecl(Algol)"	6 =	"Ecl(β Lyr)"	7 =	"Ecl(W UMa)"	8 =	"Ell"	9 =	"FK Com"
10 =	"FU Ori"	11 =	"Irr I"	12 =	"Irr L"	13 =	"Mira"	14 =	"Nova"
15 =	"PV Tel"	16 =	"R CrB"	17 =	"RR Lyr"	18 =	"RS CVn"	19 =	"RV Tau"
20 =	"S Dor"	21 =	"SN I"	22 =	"SN II"	23 =	"SemiReg"	24 =	"SX Ari"
25 =	"U Gem"	26 =	"UV Cet"	27 =	"Z And"	28 =	"Z Cam"	29 =	"ZZ Cet"
30 =	"α CVn"	31 =	"α Cyg"	32 =	"β Cep"	33 =	"γ Cas"	34 =	"δ Sct"

DSO.DAT … Data list for more Deep Sky Objects.

Format: { {	"Name CST":22	For selection & line 1: Name, Constellation
	"Comment"	E.g: NGC Number, name, appearance
		Packed data:
	(HHMMd.DDMMmmd,	$\alpha_{2000,HH.MMd}$, $\delta_{2000,DD.MM}$
		mag, $mm.d$
	xxxyyy.DDdddT)	xxx size, long axis, ′ resp. ″
		yyy size, short axis, ′ resp. ″
		$DD.ddd$ Distance, see below
		T Type, see below
}		
{ … }		
}		

Type, distance and size are related:

Type	Output in DSO	Meaning	Units of Distance	Units of Dimension
0	N.A.	Not available	Pc	arc minutes
1	ASTERISM	Star group	kPc	arc minutes
2	OPEN CL.	Open Cluster	kPc	arc minutes
3	GLOB. CL.	Globular Cluster	kPc	arc minutes
4	DIFF.NEB.	Diffuse Nebula	kPc	arc minutes
5	PLAN.NEB.	Planetary Nebula	kPc	arc seconds
6	ELL.GAL.	Elliptical Galaxy	MPc	arc minutes
7	SPIR.GAL.	Spiral Galaxy	MPc	arc minutes
8	BAR.SPIR.	Barred Spiral	MPc	arc minutes
9	IRR.GAL.	Irregular Galaxy	MPc	arc minutes

Default data contained in URANIA are provided.

Thanks

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Data

In the package you will find the files `BSTARS.U48`, `VSTAR.DAT`, `DSTAR.DAT` and `DSO.DAT`. These data are included in URANIA. Data of the bright stars are included for reference only, the other lists can be expanded and uploaded as explained earlier.

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