48k Spectrum
and Spectrum Plus

ASTRONOMER II

MANUAL

cp software

ASTRONOMER II

– What stars will I see tonight (or any night), and which constellations are in this part of the sky?

– Where is the planet Mercury? How will its relationship to earth change in the coming months?

– What time will the sun rise tomorrow, and what phase is the moon?

– Where is Halley's Comet at the moment, and when will be the best time to see it?

These are the kind of questions ASTRONOMER II will tackle for you, calculating, displaying on screen and making hard copy to a ZX Printer, saving screens to tape for other printers, and saving star and planet positions to tape or microdrive.

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Written by Paul Marshall.

A) LOADING AND GETTING STARTED

1. Set up your 48k Spectrum as normal. A ZX printer may be included and Interface One will not interfere.

2. Type **LOAD ""** and then press ENTER. Start the cassette player at a volume and tone setting you have found effective. See the Sinclair computer manual in case of difficulty.

3. The program will load in less than five minutes.

4. When the 'press and key to continue' message appears do this to go to the 'main menu', which has a yellow background.

5. First time users may now like to try out the demonstration.

6. press keys 1 to 6 to choose the options. The routines are described in detail later in this manual; you should refer to those sections for a **full list of the available commands.**

7. When you have finished an option press the 'X' key to return to the main menu.

B) DEMONSTRATION

ASTRONOMER II is designed to work up to standards suitable for the serious amateur astronomer. Like any science it will take the beginner some time to master the basics. **If you are new to astronomy** we suggest you start by following this demonstration on your computer, matching it to the instructions below. Just follow the directions and do not be concerned if some of the technical words are obscure -they are explained in the next chapter. At every stage ASTRONOMER II will clearly ask for your choices: all you need to do is press a key corresponding to the option you want.

(1) Load the program and press a key to reach the main menu. Press '1' to select option 1 and examine the **preset time and location.** you will need this and the following results when you draw star maps. By answering 'Y' to every question you will see that the location is in London and the time is 19h 15m GMT on 1st January 1984. Press 'X' to return to the main menu, or 'C' to copy the page.

(2) Let us find the position of the planet Saturn at the current time. Press '2' to choose option 2, then '7' to select Saturn. Press '3' on the screen with the blue background to choose a single calculation and the required information will appear (RA 14th 50m 4s and declination — 13° 57′ 8″). Then press 'X' to return to the main menu, or C to copy the page.

(3) Now let us find the position of the moon. Press '2' to select option 2 again, the '2' for the moon. Continue as before by pressing '3' and note down the moon's right ascension and declination for use later on (they should be 17h 32m 13s and -24° 41′ 31″ respectively). Notice that the moon's age is 28 days, so it is nearly new and only a thin crescent is visible. Press 'C' to copy the page or 'X' to exit to exit to main menu.

(4) Press '4' to draw night sky views. To save time the positions of the stars have already been calculated. Press '2' to choose the eastern view and wait thirty seconds. The constellation Orion is rising at azimuth E to SE and altitude 20°. To make it clearer type 'ori' followed by ENTER and the outline will be drawn in. To the north of Orion lies the constellation Gemini which may be outlined by typing 'gem' followed by ENTER. Enter 'gem' again to rub out the lines just drawn. Notice the small cluster of stars at azimuth SE, altitude 55°. This is called the Pleiades, and we will examine the cluster more closely using the star atlas later on. To change views enter 'map' then press '1' to see the northern view. The Plough or Great Bear (Ursa Major) lies between the N and NE at altitude 20°, and can be drawn in by entering 'uma'. The Pole Star Polaris is at the end of the tail of the Little Bear, Ursa Minor, which may be outlined by entering 'umi'.

(5) To leave this section enter 'exi' which returns you to the main menu. Press '5' to choose the star atlas. Without holding down CAPS SHIFT use the cursor keys 5, 6, 7 & 8 to move the flashing square so that its centre is at RA 15h and declination −10°, then press ENTER. The star chart will be finished after thirty seconds and the region visible includes part of the constellation Libra. Prove this by entering 'lib'. Then enter 'sat' to plot the position of Saturn that we calculated earlier, as a small cross. Enter 'map' to change charts and move the cursor's centre to RA 4h, declination +20° and press ENTER. The small group of stars at RA 3h 45m, declination +24° is the Pleiades, that we saw earlier at a smaller scale. You may also like to compare it with the cover photograph of the same stars taken using a large telescope. The head of the Bull, Taurus, can be outlined by entering 'tau' and the stars scattered around it form the open cluster called the Hyades. Now return to the main menu by entering 'exi'.

(6) To use the other routines press '6'. To examine diagrams of the Solar System press '1' and then choose the inner planets by pressing 'I'. Enter 1–1–1984 as the starting date and 10 days as the interval. Notice that when the time is 1984.44 (i.e. during June 1984) the sun and the third and second planets (earth and Venus) are in a straight line: we say that Venus is in conjunction. When you have seen enough of the animation hold down 'X' to return to the main menu.

(7) If you would like to find the times of moonrise and moonset first press '6' to select option 6 again, and then '2'. Enter the moon's RA and declination which you calculated earlier and you will see that moonrise is at about 7h 8m GMT and moonset is at 14h 34m 7s GMT. Pressing any key will then allow you to exit to the main menu.

REFERENCE SECTION

C) PRINCIPLES OF ASTRONOMY

As you get into the study of astronomy you will need to understand the fundamental technical ideas. Here is a summary for you to refer to.

Angle

Angles are usually measured in degrees (given the symbol °) and as you know a full circle is 360°, a right-angle or quarter turn is 90° and so on. Degrees are divided into sixty minutes (known as minutes of arc to distinguish them from minutes of time and given the symbol ′) and each minute is divided into sixty seconds (written as ″). For example an angle of twenty three degrees, forty five minutes and fifteen seconds is written as 23° 45′ 15″. To make things more complicated one of the angles that astronomers use to specify the position of an object, called the 'right ascension', is traditionally measured in hours, minutes and seconds. Because the world spins through 360° in 24 hours each hour is worth 15°, each minute is worth 15°/60 which is 1/4° or 15′, and so on. In this program the notation h,m,s is used to distinguish the two ways of defining angles. For instance 23° 45′ 15″ = 1h 35m 1s.

Positions on the ground

In order to give a position on the earth's surface we need two angles, the longitude and the latitude. The latitude tells us how far north we are, being +90° at the north pole, 0° at the equator and -90° at the south pole. In the same way the longitude tells us how far east or west we are from the 'Greenwich Meridian', a north-south line that passes through Greenwich, London, UK. ASTRONOMER II uses the convention that west longitudes are positive whilst east ones count as negative. You can find your longitude and latitude sufficiently accurately for most purposes by looking in an atlas. For example New York is at longitude 74° latitude 41° and Sydney has longitude 151°, latitude -34°.

Positions in the sky

Positions amongst the heavens are given in a similar way using the celestial analogues of longitude and latitude, called '**right ascension**' and '**declination**' respectively. The declination may vary from +90° to −90°, but the right ascension goes from 0h to 24h as mentioned earlier. These so-called 'equatorial' co-ordinates are used in the star atlas. See the diagram at the end of this manual.

Of course the earth constantly rotates under the stars so that a particular right ascension and declination will move relative to the horizon during the day. If we want to specify the direction of an object relative to the local horizon (at a particular time and place) we use the 'horizon' system. The '**altitude**' is the vertical angle the object makes with the horizon: an altitude of 0° corresponds to a body just rising or setting whereas an altitude of 90° corresponds to a body exactly overhead ('at the zenith'). '**Azimuth**' describes how far around the horizon the body is, for instance whether it is over the northern point, the eastern point and so on. These are the co-ordinates displayed in the night sky views.

Time

Astronomers around the world use Greenwich Mean Time (GMT, often known as Universal Time or UT) when specifying the time. Your Local Mean Time (LMT, used for day to day activities) may differ from this, usually by an exact number of hours, because you live in a different time-zone from Greenwich or because 'daylight-saving' or 'summer' time is in operation. For example British Summer Time is one ahead of GMT:

$$\text{BST}=\text{GMT}+1\text{h} \quad \text{or} \quad \text{GMT}=\text{BST}-1\text{h}.$$

You can find out your time-zone from an atlas or diary, or you may make a rough correction using the fact that LMT is approximately GMT−(longitude/15°). Every hour the BBC World Service broadcasts a GMT time-signal which is the surest way to establish how much to add or subtract to GMT times to get LMT ones.

[For experts only.] During the year the sun appears to move eastwards compared to the stars, arriving back in the same place after one year. This means that in the course of one year, when the earth turns 365.2422 times relative to the sun, it has actually turned 366.2422 times with respect to the stars. Thus time measured relative to the stars, called 'sidereal time', runs faster than GMT. Sidereal time is used internally by this program to calculate rising & setting times and night sky views but you may find it useful for setting up a telescope or performing your own calculations, so the **local** sidereal time is given by option 1. For example the right ascension of a body is equal to the sidereal time of its transit across the meridian (a line drawn from the zenith through the north or south pole to the horizon) i.e. when it is at its highest altitude. This is an illustration of the close relationship between time and astronomical co-ordinates, and the reason why right ascension is measured in the same units as time.

D) SOME BASIC IDEAS ABOUT THE STARS & CONSTELLATIONS

There are altogether about 6000 stars that, under the best possible conditions, are visible to the naked eye world-wide. At any one time, in the absence of scattered light from the moon or built-up areas, about 2000 should be seen. Their brightness is measured pm a scale of '**magnitudes**', where a difference of 5 magnitudes corresponds to ratio of brightness of 100. This means that one magnitude corresponds to a ratio of the fifth root of 100, or about 2.5. The faintest stars visible without binoculars or a telescope have a magnitude of 6 whilst the brightest have magnitudes around 0 or 1, and four even have negative values such as Sirius, the brightest of all at —1.6. ASTRONOMER II contains a database of over 1000 of the brightest stars, down to magnitude 4.75, which may be plotted by the star atlas or night sky views.

From earliest times people have grouped the stars together in **constellations,** often identifying them with mythological figures. Many constellations of the southern hemisphere were named much later, after the seventeenth century, and have been given titles that are more technical than poetic. Subsequently the International Astronomical Union (IAU) rationalised the Latin names of all the constellations and there are now 88 in total, for reference listed in the following table. A few, mostly visible only in the southern hemisphere, are very obscure, contain no bright stars and are not recognized by ASTRONOMER II: these are marked by an asterisk next to the official IAU abbreviation. Those with a classical education may notice that the abbreviation. Those with a classical education may notice that the abbreviations are in fact derived form the genitive of the latin name. **You will need to use these abbreviations when drawing constellation shapes in both options 4 and 5.**

THE CONSTELLATIONS

abbreviation	constellation	English translation
AND	Andromedae	Andromeda
*ANT	Antlia	The Air Pump
APS	Apus	The Bird of Paradise
AQR	Aquarius	The Water Bearer
AQL	Aquila	The Eagle
ARA	Ara	The Altar
ARI	Aries	The Ram
AUR	Auriga	The Charioteer
BOO	Bootes	The Herdsman
*CAE	Caelum	The Burin
CAM	Camelopardalis	The Giraffe
CNC	Cancer	The Crab
CVN	Canes Venatici	The Hunting Dogs
CMA	Canis Major	The Greater Dog
CMI	Canis Minor	The Lesser Dog
CAP	Capricornus	The Goat
CAR	Carina	The Keel (of Argo)
CAS	Cassiopeia	Cassiopeia
CEN	Centaurus	The Centaur
CEP	Cepheus	Cepheus
CET	Cetus	The Whale
CHA	Chamaeleon	The Chameleon
CIR	Circinus	The Compasses
COL	Columba	The Dove
COM	Coma Berenices	Berenice's Hair
CRA	Corona Austrina	The Southern Crown
CRB	Corona Borealis	The Northern Crown
CRV	Corvus	The Crow
CRT	Crater	The Cup
CRU	Crux	The Cross
CYG	Cygnus	The Swan
DEL	Delphinus	The Dolphin
DOR	Dorado	The Goldfish
DRA	Draco	The Dragon
*EQU	Equuleus	The Foal
ERI	Eridanus	The River Eridanus
FOR	Fornax	The Furnace
GEM	Gemini	The Twins
GRU	Grus	The Crane
HER	Hercules	Hercules
*HOR	Horologium	The Clock
HYA	Hydra	The Water Snake

HYI	Hydrus	The Lesser Water Snake
IND	Indus	The Indian
LAC	Lacerta	The Lizard
LEO	Leo	The Lion
LMI	Leo Minor	The Lesser Lion
LEP	Lepus	The Hare
LIB	Libra	The Balance
LUP	Lupus	The Wolf
LYN	Lynx	The Lynx
LYR	Lyra	The Lyre
*MEN	Mensa	The Table
*MIC	Microscopium	The Microscope
MON	Monoceros	The Unicorn
MUS	Musca	The Fly
*NOR	Norma	The Level
OCT	Octans	The Octant
OPH	Ophiuchus	The Serpent-Holder
ORI	Orion	The Hunter
PAV	Pavo	The Peacock
PEG	Pegasus	Pegasus
PER	Perseus	Perseus
PHE	Phoenix	The Phoenix
PIC	Pictor	The Painter
PSC	Pisces	The Fishes
PSA	Piscis Austrinus	The Southern Fish
PUP	Puppis	The Stern (of Argo)
PYX	Pyxis	The Compass
RET	Reticulum	The Net
SGE	Saggita	The Arrow
SGR	Sagittarius	The Archer
SCO	Scorpius	The Scorpion
SCL	Sculptor	The Sculptor
SCT	Scutum	The Shield
SER	Serpens	The Serpent
*SEX	Sextans	The Sextant
TAU	Taurus	The Bull
TEL	Telescopium	The Telescope
TRI	Triangulum	The Triangle
TRA	Triangulum Australe	The Southern Triangle
TUC	Tucana	The Toucan
UMA	Ursa Major	The Greater Bear
UMI	Ursa Minor	The Lesser Bear
VEL	Vela	The Sail (of Argo)
VIR	Virgo	The Virgin
VOL	Volans	The Flying Fish
*VUL	Vulpecula	The Fox

E) DETAILED DESCRIPTION OF THE OPTIONS 1 TO 6

The six options available from the main menu are now described, and you may find it useful to refer to the demonstration section as well. Remember that to choose an option all you need to do is press the key corresponding to the choice you want.

►OPTION 1: CHANGING TIME OR LOCATION

This section is used to set up the co-ordinates of the time and place that you are interested in, which are then used by the other options (for instance to choose the night sky in option 4). To change an entry just press the 'N' key when asked if the entry is acceptable, otherwise press the 'Y' key. Notice that it is not necessary to press the CAPS SHIFT key as well, and remember that west longitudes and north latitudes are positive while east longitudes and south latitudes are negative. To enter negative angles put a minus sign in front of the degrees only, that is, enter −15° 26′ 37″ just as you see it. You should type −15 then ENTER, 26, ENTER, 37 and ENTER. If you make a mistake use CAPS SHIFT and '0' to rub out, as usual on the Spectrum.

Please note that ASTROMOMER II uses the British convention for giving dates which is the day followed by the month followed by the year, and that the year should be written out in full to distinguish, say, 1883 from 1983. For example the 27th September 1984 is written as 27-9-1984.

When you have gone through the four entries of longitude, latitude, time and date the local sidereal time will be displayed. You should then press either the 'R' key to review the data or 'X' to exit back to the main menu.

►OPTIONS 2 & 3: POSITIONS OF BODIES IN THE SOLAR SYSTEM

These two sections are used to calculate the equatorial co-ordinates of the sun, moon and planets (option 2) and asteroids and comets (option 3) which may then be plotted onto the star charts or views. After you have selected the body in which you are interested you are given a further choice of how you would like the information presented. Choice 3 uses the time and place from section 1 to calculate a single position whilst choices 1 and 2 allow you to tabulate positions over a range of time, either to the screen or a Printer, just as you would find in a book of tables. These positions are accurate to within a few minutes of arc, and sometimes are much better.

For the sun and planets **choice 3** gives the additional information of distance and 'semi-diameter'. The distance is measured in 'astronomical units' (AU) which are equal to the radius of the earth's orbit: 1 AU is 149.6 million km or 93.0 million miles. The semi-diameter is half the angular size of the planet as seen from the earth. For instance both the moon and sun are about 1/2° across (semi-diameter 15′), but the planets show such tiny disks that their semi-diameters are measured in seconds of arc, ″ (1/3600 of a degree). For the moon the age (the number of days since new moon) is given, and the phase is also drawn on the screen.

All this information may be copied to a Printer if desired.

►OPTION 4: THE NIGHT SKY VIEWS

This section will draw the stars which are above the horizon for the time and place selected in the first section. A special machine-coded routine is used to speed up the complex trigonometric calculations for each star as much as possible, but it still takes almost eleven minutes to perform the arithmetic for the 1090 stars included in the views. You may leave and re-enter this section as often as you like without having to recalculate the positions provided you do not alter the current time or location, which are set using option 1.

How the views are displayed

For the purpose of display the night sky is divided into five sections. View 5 is that directly overhead (i.e. with an altitude greater than 60°), with the zenith at the centre, and takes two minutes to plot out. Views 1 to 4 take thirty seconds to draw and show the stars above the four cardinal points of the horizon, N, S, E and W. For the same reasons that it is impossible to represent the curved surface of the world on a flat map without distortion, the night sky views are slightly distorted towards their edges. By relating the views to the actual night sky you should become accustomed to this very quickly. When being plotted the stars are divided into three brightness ranges: those stars brighter than magnitude 1, those between 1 and 2.5 and those fainter than magnitude 2.5.

Commands

Commands may be entered once the prompt 'please enter command' appears. Commands consist of three-letter abbreviations, should be typed in without using the CAPS SHIFT key and should be followed by ENTER. If you make a mistake use CAPS SHIFT and '0' to delete the offending character.

Any IAU abbreviation of a constellation name (except ones with an asterisk – see the section about stars & constellations) may be entered and provided that the constellation is within the field of view the program will draw in the outline. You will notice that considerable imagination is needed to 'see' certain of the mythological characters in their constellations, and they should perhaps be regarded as formal or conventional arrangements. The best way to learn the constellations is to pick the more conspicuous or familiar ones, use them as sign-posts to point towards the less well known ones and above all to go outdoors and relate the views to the actual sky.

Further commands include **ALL** to outline all the constellations in alphabetical order, **COP** to copy the screen to a Printer, **MAP** to choose a new view or map and **EXI** to exit to the main menu. In addition, any body in the Solar System **whose position has already been calculated for the current time and date** using options 2 or 3 may be plotted onto a view. A small cross is blinked onto the screen and then left there (provided the object is within the field of view). The effects of any command may be undone simply by repeating it. A list of all the valid commands and their effects is now given.

SUMMARY OF COMMANDS FOR OPTIONS 4 & 5

any IAU abbreviation	draws constellation outline (see section D)
ALL	outlines all constellations
COP	copies screen to Printer
MAP	changes map or view
EXI	exits to the main menu
SUN	plots the sun's position
MOO	plots the moon
MER	Mercury
VEN	Venus
MAR	Mars
JUP	Jupiter
SAT	Saturn
URA	Uranus
NEP	Neptune
PLU	Pluto
CER	Ceres
PAL	Pallas
JUN	Juno
VES	Vesta
HAL	Halley's Comet
ENC	Encke's Comet

▶ OPTION 5: THE STAR ATLAS

The atlas is designed to give you a closer look at selected regions of the sky, in 362 overlapping star charts. To choose a particular chart move the blinking square cursor around on the screen by means of the cursor control keys (but without pressing CAPS SHIFT), until the cursor covers the region of interest and then press ENTER. The two polar areas are covered by circular charts but otherwise a rectangular projection of the equatorial (right ascension and declination) co-ordinates is displayed, and takes thirty seconds to draw. To help you relate these co-ordinates to the positions of the major constellations a diagram has been included at the end of this manual where they are indicated by their standard abbreviations. The wavy line is called the 'ecliptic' and marks the course of the sun relative to the stars during the year. It has been drawn in because the moon and planets are found close to this track as well. This printed diagram is a duplicate of the one on the screen, so that to view a particular constellation all you need to do is move the flashing cursor until it covers an area on the screen that includes the constellation's name. Obviously the larger constellations spread over more than one star chart so you may have to move to neighbouring ones to see all the outline.

Once the chart has been drawn the same commands as are available in the preceeding option may be used here, and have the same effects.

▶ OPTION 6: OTHER ROUTINES

● ANIMATED DIAGRAMS OF THE SOLAR SYSTEM

First of all you are asked whether you would like to see the four inner planets (in order of increasing distance from the sun: Mercury, Venus, Earth, Mars) or the five outer planets (in order Jupiter, Saturn, Uranus, Neptune, Pluto), then to give the starting date for the animation, then the interval in days (from 1 to 9999) between the 'frames' of the animation.

The planets' orbits are roughly in the same plane and so may reasonably be drawn on a flat surface, and are ellipses with the sun at one focus (the diagrams show that the orbits are not simply concentric circles). In the interests of speed the same precision for the calculations of options 2 and 3 is not used but the results are good enough to estimate the rough times of **oppositions** and **conjunctions**, since the time in years and decimals of a year is shown at the lower right hand side of the screen. Because the earth's orbit is too small to see on the scale used for the outer planets the direction of a line drawn from the sun through the earth is indicated by a moving bar.

Only planets whose orbits lie outside that of the earth's (i.e. Mars, Jupiter, Saturn, Uranus, Neptune and Pluto) can be 'in opposition', which means that they are on the opposite side of the earth to the sun and therefore lie on a straight line with the earth and the sun. At these times the planets rise around 6 pm and are roughly at their closest approaches to earth, so these are good times for observing them with a telescope. These planets may also lie on a straight line with the sun and earth but be on the far side of the sun, when we say they are 'in conjunction'.

The planets Mercury and Venus may be in this position when they are in 'superior conjunction', by contrast to 'inferior conjunction' when they lie **between** the earth and the sun.

The Solar System diagrams may be copied to a Printer by holding down the 'C' key, exited for the main menu by holding down the 'X' key or frozen by holding down any other key.

● RISING & SETTING TIMES

This second routine that may be accessed by option 6 of the main menu is used for calculating the times of rising and setting of any object as seen from the current position (set in option 1), given its equatorial co-ordinates. The result is corrected for atmospheric refraction but remember that an ideally flat horizon, such as that at sea, has been assumed and that on land the object concerned may have to rise above distant horizon features.

▶ OPTION 6 SAVING AND PRINTING

When you want to copy a screen to a printer you will be asked to press T for saving the screen to a tape recorder, or P to dump the screen to a ZX Printer. If you have a different printer you may load screens back from tape (see the Sinclair manual, chapter 20) after deleting ASTRONOMER, and then use your own favourite screen dump routine. Names of screen files on tape may be up to nine characters long, and the keyword "SCREEN$" will be added at the end.

Serial printers may be connected via Interface One, and the baud rate is set using option 6, by pressing 3 for "select printer". Choose a baud rate of zero for a ZX Printer, and remember that screens can only be copied **directly** to ZX Printers or compatible models.

Please note that some options using printers or microdrives require you to have Interface I connected. The program may crash if you try to use such options without the appropriate hardware attached.

You may save data for the stars and planets to avoid having to recalculate their positions for night sky views should you want to return to a particular time and location. Use option 6 and press 4 for "save or load star data". Once again filenames can be up to nine characters long. Two blocks of data will be saved, either to tape or microdrive, with the suffices "a" and "b". (If you make a mistake enter an empty filename to start again). When loading "star data", enter the appropriate file-name (without the "a" or "b" suffices), and the time and location will be reset to the values in use when the file was saved.

A microdrive cartridge will normally hold six pairs of "star data" files, as each pair occupies about 14K.
WARNING: If you are using a tape recorder, ensure that the tape is in the correct place before loading back files.

▶ F) SOME TECHNICAL NOTES FOR EXPERTS

The GMT to LST conversion is accurate to better than 1s.

When calculating the positions of planets and asteroids full account has been taken of their elliptical motion leading to results that are accurate to within a few minutes of arc for dates in the last third of the twentieth century, whilst the sun's position is accurate to within a few seconds. The moon's motion is especially fast and complex but a number of perturbations have been considered and the results should be correct to within about ten minutes of arc. The comets' orbits are strongly perturbed by the major planets so that the results cannot be considered so accurate, particularly when examining times far in the future or past. Nevertheless you may see, for example, that Halley's comet did make a close approach to the earth around 1066 as recorded in the Bayeux Tapestry.

If you wish to move ahead large periods of time (such as a century or more) from the present day you should realise that the night sky views and planetary positions are calculated without including the effects of precession or those of the stars' proper motion.

The position of the moon which is calculated for the current time and location is corrected for horizontal parallax at the observer's longitude and latitude (assuming zero height above sea-level, normally a very small error), so the results are suitable for a crude investigation of eclipses. The positions calculated when **tabulating** data are geocentric and uncorrected for parallax, so they may be compared directly with ephemeris data. The 'age' is the time after new moon that a fictitious or notional moon, moving at a constant speed such that the period between new moons is 29.53 days, would have spent in order to show the same phase as the real moon.

Horizontal parallax is negligible for all the other bodies in the Solar System and the positions quoted are geocentric whilst tabulated data are calculated for 0h GMT each day and are therefore of the same form as published tables.

The semi-diameters of the planets used in this program are equatorial rather than polar: this difference is significant only for Jupiter and Saturn where because of considerable flattening the polar diameters are smaller by factors of 1.07 and 1.12.

Rising and setting times for celestial bodies are corrected for the effects of atmospheric refraction, which means that objects are visible even if their true altitudes are slightly less than zero. If you need particularly precise rising and setting times for objects whose equatorial co-ordinates change appreciably during the day (such as the sun or moon) adopt the following procedure, here exemplified for sunrise. Calculate the sun's position at any time during the day using option 2 and note it down. Use option 6 to find an approximate rising time, then feed this new time back into option 2 and repeat the procedure. The differences between successive estimates of sunrise will quickly become very small, when the final estimate may be taken to be the time of sunrise.

Strictly speaking all calculations in ASTRONOMER II are carried out using Ephemeris Time (ET) which is extremely close to GMT. Differences arise because the motion of the earth, which defines GMT, is not absolutely regular but has tiny and unpredictable fluctuations. The difference DT given by

$$DT = ET - GMT$$

was almost zero during the nineteenth century and has increased by roughly 0.7 seconds a year during the twentieth, but normally the effect of DT is too small to worry about.

HOW THE SKY IS CHARTED

showing approximate positions of the constellations.