Indoor Lab 3 - The Ecliptic

Objectives: To explore the effects of Earths orbital motion on what we see in the sky: the Suns passage through the zodiac, the equinoxes and solstices, and the seasons.

1 The Sun's path around the Zodiac

Launch SN and check that it is set up for NY, pointing South. Set the time for March 21 at noon: the Sun will be due South. Switch off the horizon and the daylight so we can see which constellation the Sun is in. It is not so easy to recognize! Switch on View/Constellations/Boundaries and Labels. Of course, its Pisces, one of the Zodiacal con- stellations. During the year the sun passes through all 12 of the Zodiac constellations. To see this, click Find, and double click Sun to lock it in the field of view. Set Options/Orientation/Ecliptic to keep the view aligned with the Sun motion. Then set the time rate appropriately to see the Sun in its journey round the sky. Write down the constellation names in sequence as the Sun passes through.

Pisces____

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2 Ecliptic motion

Angular speed. The exact path of the Sun around the Zodiac is the ecliptic. Click View/Ecliptic Guides/The Ecliptic to switch it on. The angular speed of the Sun along the ecliptic is an important number that we can measure directly. Locate the stars ϵ (epsilon) Piscium and λ (lambda) Aquarii with the cursor. Both lie close to the ecliptic. ϵ Psc is one of the brighter stars associated with the string holding the fish, and λ Aqr lies at the mouth of the watering pot. Line up the Sun with λ, and with single day steps (e.g., by changing the date), count how many days it takes to reach ϵ. Then measure the angle between the stars using the cursor, to the nearest tenth of a degree. Use these numbers to calculate the angular speed of the sun on the ecliptic in °/day, to two decimal places.

Separation ϵ Psc – λ Aqr:____

Time interval: ____

Angular speed of the Sun: ____

Relation to RA-Dec. The relation of the ecliptic to the RA-Dec system is basic to many phenomena. The key relations are given in the table below. The change in Dec by $\pm 23.5°$ is the result of the tilt of Earths spin axis by $\pm 23.5°$ relative to the plane of its orbit. The place where the ecliptic cuts the CE in spring defines the 0 hr marker for the RA system. Turn on the CE and the equatorial grid (View/Celestial Guides), and set the Sun in motion around the ecliptic as in section 1 (make sure it is locked). Verify the entries in the table.

Name	Date	RA	Dec
Vernal Equinox	Mar 21	0	0
Summer Solstice	Jun 21	6	+23.5°
Autumnal Equinox	Sep 23	12	0
Winter Solstice	Dec 22	18	−23.5°

In which general direction does the Sun move, to the East or West?____________________

From the table:

How many hrs (to nearest hr) of RA does the Sun move in a month?____________________

How many minutes (to nearest min) of RA does the Sun move in a day ?____________________

Note: if you convert hrs and mins to degrees, the above should agree approximately with the angular speed you measured in °/day.)

3 The stars and the seasons

One consequence of the motion of the Sun relative to the stars is that different parts of the celestial sphere are seen in the evening sky at different dates during the course of the year. To see this, set up SN in NY for 8 pm, pointing S, with the RA grid lines showing, and with the Sun unlocked; also turn off daylight. For the equinoxes and solstices in turn at 8 pm, draw in and label the brightest star visible in the 100° field, and label the RA line on the meridian with its value.

(a) Mar 21 (b) Jun 21 (c) Sep 23 (d) Dec 22

It will be clear that the stars and constellations visible in the evening change with the seasons, and that the sidereal time (the RA on the Meridian) changes as well. To see the transition from one of these pictures to the next, set up back at the vernal equinox at 8 pm. Change the date one day at a time. You will see that at the same clock time on successive days, the stars and constellations slip round the sky and eventually are no longer seen in the evening.

Each day at the same time the stars slip a little to the (east/west):____________________

If you change the time interval on the clock to 1 sidereal day, i.e. 23 hr and 56 min, you will find that the stars return to exactly the same positions every sidereal day.

4 The Seasons on Earth

An important effect of the changing Dec of the Sun during its journey around the ecliptic is the occurrence of the seasons on Earth. This affects several things: the most noticeable being the length of daylight and the height achieved by the Sun during the day. Set up SN for NY, looking South, for the equinoxes and solstices in turn, and determine the times of sunrise and sunset (to 1 minute accuracy) using the sunrise/sunset buttons. Look east and west to see where the sun actually rises and sets, and estimate the maximum altitude, as the sun transits. (If you point at the Sun with the cursor, the az is part of the readout). You should also be able to calculate the Alt exactly from the Dec positions.

Name	Rise Time	Set Time	Day Length	Max Alt(approx.)
Spring or Fall Equinox				
Summer Solstice				
Summer Solstice				

In NY the changes in the daylight hours and the altitude of the Sun from the summer to winter solstices are quite striking. You will also notice that the azimuth at which the Sun rises and sets also varies remarkably during the year.

The Sun at other locations. Stranger things happen at other parts of the globe, that you should be able to work out from our previous studies of where the NCP and the CE appear in the sky at different latitudes. Two instructive cases follow. Describe what the sun does in the sky for the locations and dates specified. Then check them out with SN by resetting the location and date. Turn the daylight on, so you know whether its day or night.

The summer solstice at the North Pole. Describe what the Sun does during 24 hrs:

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The winter solstice on the arctic circle, lat = $+66.5°$. Describe what the Sun does during 24 hrs:

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5 A space view of the seasons

For later comparison with other planets it is interesting to view the changing of the seasons on Earth from space. The SN setup is more complicated than any we have done so far. So be patient! Set the date for March 21. Click the Location pulldown menu and set Radius2 and Hover As Earth Rotates. You will be carried above New York. Then click Find, and double click Earth so that it comes into the field of view. Set the time flow to see Earth spinning. Since it is the vernal equinox, you will see that for everywhere (except the exact Poles) the days and nights are 12 hrs. The sunlight just touches each Pole. You can drag the Earth around using the hand cursor to get a better look. Now speed things up by setting the time interval to 1 or a few solar days. The daily spin is not apparent, but the Earth is moving in its orbit. You will need to move about a bit to get the best view of the Poles. Note how as the days move into summer in the North, the sunlight spreads over the arctic regions. As time goes on the sunlight gradually recedes from the North, and as winter approaches, the arctic regions enter their long dark period. Check that the opposite is happening down in the southern hemisphere.

6 Appendix

If you finish early, or for later review. From the discussion in section 3, the key to finding what is in the sky at any given instant is clearly the sidereal time. We have already discussed in class one approximate way to determine this for any time and day during the year as follows.

- Determine the RA of the Sun for the day in question.
- Add/subtract the time after/before noon on the day in question.

The idea is that the RA of the sun gives you the sidereal time at noon (ignore daylight saving) so for any time on that day you just add or subtract the amount from noon. To get the RA of the Sun, we know the RA on the equinox or solstice; we add to that 2 hr for each complete month since then, and 4 min for each extra day. Example: Oct 28 at 9 pm. The RA of the sun is 12 hr (at the equinox on Sept 23) plus 2 hr (1 month to Oct 23) plus 20 min (5 days at 4 min each) = 14 hr 20 min. 9 pm is 9 hr after noon so the ST = 23:20. Check it with SN.

Your turn: Calculate the sidereal time for today at 8 pm. (Check it with SN):____________________________