Chapter 2

Knowing the Heavens

No absolute reference frame.

Must define the frame in which we make our observations and conclusions.

Constellations

Ancient astronomers grouped the stars seen in the sky into constellations (many names we still use are associated with Greek mythology).

Stars which make up constellations are generally unrelated.

Different cultures created different groupings

Celestial Sphere

To visualize the motions of the stars, planets, etc we consider that they reside on a huge spherical dome. This dome completely surrounds the Earth, which is at its center.

The locations of stars in the sky (on the Celestial sphere) are specified in terms of their celestial coordinates (RA and Dec).

Right Ascension (RA)

Equivalent to Longitude on Earth

Measured in Hours, minutes and seconds

Declination (Dec)

Equivalent to Latitude on Earth

Measured in Degrees, arcmins, arcsecs

Local sidereal time

A time keeping system used by astronomers which is based on the apparent motion of the stars. It tells you when a star of a particular right ascension will be at its highest point in the sky (i.e. on the meridian).

An observer of the sky will find qualitative differences between the motions of:

Sun

Moon

any one of the planets

stars

The observed motions of these celestial bodies are primarily governed by 4 types of movement in the Solar System.

1. Daily or Diurnal Motion

The Earth rotates (spins) about its axis approximately once each day. This causes celestial bodies to appear to rise and set approximately once each day when observed from moderate latitudes.

It is this motion that gives rise to the concept of the Celestial sphere. Two points, the South and North Celestial poles, are seen not to move. These poles lie directly above the South and North poles of the Earth.

2. Annual Motion

The Earth revolves around the Sun approximately once each year (365 days). Since a circle has 360 degrees, this means that each day the Sun moves about 1 degree east with respect to the background stars.

This motion means that different stars are seen at different times of the year.

Means of distinguishing the seasons.

Ecliptic

The path of the sun on the celestial sphere. Defined by the plane of the earths orbital motion about the sun

Sequence of 12 constellations through which Sun passes is called the zodiac.

The Moon and planets lie near the ecliptic.

The ecliptic is inclined to the celestial equator by 23.5^{o}. This causes the seasons. When it is Summer in the northern hemisphere, it is Winter in the southern hemisphere.

Sun crosses the celestial equator twice each year. Referred to as

Vernal (Spring) Equinox (approx. Mar 21)

Autumnal Equinox (approx. Sep 22)

The Vernal Equinox is used to define the zero point for the Astronomical coordinate Right Ascension (i.e. Zero hours) (equivalent to Longitude).

Summer Solstice

Sun reaches most northerly point above the celestial equator.

At a latitude of 23.5 deg N the sun is at the zenith at noon (local time). This defines the Tropic of Cancer.

Winter Solstice

Sun reaches most southerly point below celestial equator.

3. Planetary Motion (Ch 4).

The positions of the planets on the celestial sphere change from night to night. Their motion on the celestial sphere is determined by their own orbital motion, and that of the Earths about the sun. Their positions with respect to the background stars change by less than a few degrees from night-to-night --- usually the change is much less.

Planets are confined to a narrow band of sky, centered on the ecliptic, called the ZODIAC.

The planets generally move east with respect ot the stars. Occasionally the star moves west showing RETROGRADE motion.

4. Lunar Motion (Ch 3)

Seasons

Caused by the tilt of the earths axis, and the orbital motion of the Earth about the Sun.

The Earths rotation axis is inclined at 23.5º away from the perpendicular to the plane of the Earth orbit. This axis ‘‘always ‘‘ points in the same direction.

In Summer the northern hemisphere is pointed *towards* the sun.

In Winter the northern hemisphere is pointed *away* the sun.

Summer months are warmer since the Sun spends longer above the horizon, and because the Suns rays strike the ground at a more nearly perpendicular angle to the ground.

Precession

Over a period of 26000 years, the gravitational force of the Sun and Moon cause the direction of the Earth’s rotation axis to change.

Caused by the slightly unequal gravitational force on the Earth caused by the Earth’s bulge. ***If the Earth was spherical, precession would not occur.***

North Pole currently points at Polaris.

In 12000 years North pole will point at the Bright star Vega.

Precession is important for Astronomers, and must be allowed for when Observing --- the RA and DEC of an object changes with time.

Keeping Time

Number of Daylight Hours

Varies with the seasons

Changes caused by the tilt of the Earth's axis with respect to the Earth's orbital plane about the Sun.

In Summer we (Pittsburgh) get about 15 hrs of daylight, and 9 hours darkness. Reverse is true in Winter.

Daylight and night are of equal length at the equinoxes.

Solar Day

Defined by the motion of the Sun.

A solar day is the time between successive apparent noons, with apparent noon defined as when the Sun is highest in the sky (i.e. on the meridian).

Length of the solar day varies with the time of the year, because the speed of the Earth in its orbit about the sun varies.

Because solar day varies, too complicated for general time keeping.

Mean Solar Day

The average length of the Solar day.

Used for practical time keeping.

Defined to have exactly 24 hours of clock time.

Sidereal Day

Length of day defined with respect to the stars.

A Sidereal Day is about 4 minutes shorter than the Mean Solar Day.

The Sidereal Day is shorter than the Mean Solar Day because of the Earth's orbit about the Sun.

The stars are so far away that on successive days their position does not change. The Sun, being much closer, is in a different direction. The Earth must therefore rotate a little more to put the Sun overhead.

Sidereal time is based on the Sidereal Day.

Sidereal time is used by Astronomers to locate the stars in the sky

--- A star always rises at the same sidereal time.

--- When the Sidereal time equals the object RA, the object is on the meridian.

Time Zones

Earth is defined to have approximately 24 time zones.

Time differs by one hour from one time zone to the next.

Defined so that apparent noon occurs at about 12pm in each time zone.

Time in each zone is called Standard Time

e.g. Eastern standard time

Central Standard time.

International Date Line

Consider a traveller moving around the Earth, who continually sets their watch as they cross into each time zone. If they travel fast enough (westward), they could arrive back with their watch set to 24hrs before they left.

To avoid this contradiction, a traveller adjusts the day when they cross the INTERNATIONAL DATE LINE.

A day is added when you are travelling west

A day is subtracted when travelling east.

The international date line follows (approximately) 180° longitude.

Universal Time (UT)

Time kept in the time zone covering Longitude 0, which passes through Greenwich, England.

24 hour system (ie no am or pm).

By using UT you can co-ordinate with someone else (eg, in another country) without worrying about what time zone you are in.

Daylight Saving Time

Creates more daylight time when people are awake.

Originally used to save energy, but now used to allow more recreational hours in the evening.

Month

Based on the time between full moons which is 29.5 days

Rounded to 30 so that integer number of days in Month.

Length of Months adjusted slightly so that 12 months cover the 365 days in a year.

Sidereal Year

Time taken for Sun to return to same position as defined by the stars = 365.2564days.

Tropical Year

Time taken for the Sun to return to the Vernal Equinox = 365.2422days.

Shorter than Sidereal year due to the precession of the Equinoxes.

Calendar and Leap Years

Julian Calendar --- 12 months and 365 days in each year.

The time it takes for the Earth to orbit the Sun is not 365 days exactly, but approximately 365 and 1/4 days. Therefore every 4th year an extra day is added to the calendar. The year in which this is done is called a Leap Year.

Because the true year is slightly smaller than 365 and 1/4 days, centuries that are not divisible by 400 are not treated as Leap Years:

2000 is a leap year.

1700, 1800, and 1900 were not leap years.

Important to have Leap Years so that the seasons occur at the same time:

After 360 years the seasons would be out by a full 3 months if leap years were ignored.

The omission of 3 leap years every 400 years was not part of the Julian Calendar. Calendar used today is known as the **Gregorian Calendar**.