Motions in the Sky
The Celestial Sphere

Zenith = Point on the celestial sphere directly overhead

Nadir = Point on the c.s. directly underneath (not visible!)

Celestial equator = projection of Earth’s equator onto the c.s.

South celestial pole = projection of Earth’s south pole onto the c.s.
Distances on the Celestial Sphere

The distance between two stars on the celestial sphere can only be given as the difference between the directions in which we see the stars. Therefore, distances on the celestial sphere are measured as angles, i.e., in:

- degrees ($^\circ$):
  - Full circle = $360^\circ$

- arc minutes (‘):
  - $1^\circ = 60'$

- arc seconds ("):
  - $1' = 60''$
The Celestial Sphere (2)

• From geographic latitude $\ell$ (northern hemisphere), you see the celestial north pole $\ell$ degrees above the northern horizon;
• From geographic latitude $-\ell$ (southern hemisphere), you see the celestial south pole $\ell$ degrees above the southern horizon.

• Celestial equator at maximum altitude ($90^\circ - \ell$) above the horizon.
The Celestial Sphere (Example)

Sydney: $\ell \approx -33.9^\circ$

The Celestial North Pole is not visible from the southern hemisphere.
The Celestial Sphere (3)
Apparent Motion of The Celestial Sphere

In the Northern Hemisphere: Looking north, you will see stars apparently circling counterclockwise around the Celestial North Pole.
Some constellations around the Celestial North Pole never set. These are called "circumpolar".

The circle on the celestial sphere containing the circumpolar constellations is called the "circumpolar circle".
**Apparent Motion of The Celestial Sphere (3)**

In the Northern Hemispher[e: Looking east, you see stars rising and moving to the upper right (south)

In the Northern Hemisphere: Looking south, you see stars moving to the right (west)
Apparent Motion of The Celestial Sphere (4)
The Celestial Sphere in the South

- Long exposure from Siding Spring Observatory, Coonabarabran, NSW (Anglo-Australian Telescope in foreground)
- Note absence of a bright star near the South Celestial Pole (compare with Polaris in the North)
Precession (1)

At left, gravity is pulling on a slanted top. =>
Wobbling around the vertical.

The Sun’s gravity is doing the same to Earth.
The resulting “wobbling” of Earth’s axis of rotation around the vertical
w.r.t. the Ecliptic takes about 26,000 years and is called **precession**.
Precession (2)

As a result of precession, the north celestial pole (NCP) follows a circular pattern on the sky, once every 26,000 years.

The NCP will be closest to Polaris ~ A.D. 2100.

Polaris not “special” – NCP closest to Thuban in ancient times (5000 years ago)

~12,000 years from now, the north celestial pole will be close to Vega.
Earth’s rotation causes the day/night cycle.
The Sun and Its Motions (2)

Due to Earth’s revolution around the Sun, the Sun appears to move through the zodiacal constellations.

The Sun’s apparent path on the sky is called the Ecliptic.

Equivalent statement: The Ecliptic is the projection of Earth’s orbit onto the celestial sphere.
The Seasons

Earth’s axis of rotation is inclined vs. the normal to its orbital plane by $23.5^\circ$ -- this causes the seasons.
The Seasons (2)

The seasons are caused only by a varying angle of incidence of the Sun’s rays.

We receive more energy from the sun when it is shining onto the Earth’s surface at a steeper angle of incidence (= when the Sun is higher in the sky)
The seasons are not related to Earth’s distance from the Sun (e.g., Earth is slightly closer to the sun in Northern winter than in Northern summer).
The Seasons (4)

Northern summer = Southern winter

Northern winter = Southern summer
Earth’s distance from the Sun has only a very minor influence on seasonal temperature variations.
The Motion of the Planets

The planets are orbiting the Sun almost exactly in the plane of the Ecliptic.

The Moon is orbiting Earth in almost the same plane (Ecliptic).
The Motion of the Planets (2)

All **outer planets** (Mars, Jupiter, Saturn, Uranus, Neptune and Pluto) *generally* appear to move eastward along the Ecliptic (vs. retrograde motion).

The **inner planets** Mercury and Venus can never be seen at large angular distance from the sun and appear only as **morning or evening stars**.
The Motion of the Planets (2)

Retrograde Motion:

- Earth “catches up” to outer planet (e.g., Mars) and “passes” it
- Outer planet appears to move with retrograde (= backwards, i.e., westward) motion, then resume its prograde ( = forward, i.e., eastward motion)
The Motion of the Planets (4)

Mercury appears at most ~28° from the sun.

It can occasionally be seen shortly after sunset in the west or before sunrise in the east.

Venus appears at most ~46° from the sun.

It can occasionally be seen for at most a few hours after sunset in the west ("evening star") or before sunrise in the east ("morning star").
Class Announcements

• Assignment #1 due this Friday, 12 March
• Lecture PDFs and other materials available from: web.science.mq.edu.au/~zucker/Astronomy_170.html
• Labs today (immediately after lecture, E7B 213/217, 11:00 – 2:00)
• Sign up sheet for Observatory practical available now and at labs, and on my door (E7A 317)
• Observatory weather updates by 5 PM on the day at www.astronomy.mq.edu.au/observatory/public/ or call (02) 9850 8914 for a recorded message
• Physics/Astronomy & Astrophysics/Photonics BBQ on Thursday (11 March, tomorrow) 12:30 – 2:00
This practical experience may be your first time at our observatory. You should come warmly dressed and perhaps bring some insect repellent. If driving, park in the N3 car-park. Make sure you purchase a parking ticket if you don’t have a sticker, or park outside the university grounds in Culloden Road. Car entry is via the Waterloo Road gate; take the left turn into the car-park. The observatory is beyond the car-park.

There will be a number of staff and higher year astronomy students to assist you with the program at the observatory. Please assist with setting up and packing up telescopes if requested by staff.

Make sure to note down all your observations and the answers to the questions. A staff member will initialize them at the end of the evening. Your notes should be handed in the following week at the lab class.

**Things to do at the observatory.**

1. Find South using the Southern Cross.
2. Find the plane of the solar system in the sky.
3. Find the celestial equator.
4. Identify the brightest stars visible and locate any planets that are up.
5. Note the colours of various stars. What does colour tell you about stars?
6. Locate the plane of the galaxy. What features can you see along it?

**Now you can use the telescopes...**

7. Observe a double star. Comment on the separation compared to the apparent size of the images of the stars. Does it appear different in different telescopes?
8. Observe an open cluster and comment on the different colours of the stars.
9. Observe a globular cluster. How is it different from the open cluster?
10. Observe a nebula. Describe what you can see. How does it differ from pictures in books? Why?
11. Describe the images of any planets you are able to observe with a telescope.
12. If the moon is visible locate and observe the terminator, craters, maria and rays. Comment on any atmospheric effects you can see while observing the moon.
13. If the sky is dark enough observe one of the Magellanic Clouds and some other galaxy. Describe what you can see in each case.
Sky Calendar – March 2010

3  Moon near Spica (morning sky) at 18h UT.
7  Moon near Antares (morning sky) at 1h UT.
7  Last Quarter Moon at 15:42 UT.
11 Mars stationary at 9h UT. The red planet ends its retrograde motion and resumes direct (eastward) motion towards a mid-April encounter with M44. Mag. ~0.3.
12  Moon at apogee (farthest from Earth) at 10h UT (distance 406,008 km; angular size 29.4º).
15  New Moon at 21:01 UT. Start of lunation 1079.
17  Moon near Venus (evening sky, 16º from Sun) at 5h UT. Mag. ~-4.9. Best view from northern hemisphere.
20  Vernal equinox at 17:33 UT. The time when the Sun reaches the point along the ecliptic where it crosses into the northern celestial hemisphere marking the start of spring in the Northern Hemisphere and autumn in the Southern Hemisphere.
21  Moon very near the Pleiades (evening sky) at 0h UT. Occultation visible from Mexico, Central America, and South America.
22  Saturn at opposition (opposite the Sun) at 0h UT. Visible all night long, the ringed planet is at its brightest (mag. ~0.5) and closest all year (disk diameter 19.9º). Saturn’s rings are near edge-on but still appear magnificent even in a small telescope.
23  First Quarter Moon at 11:00 UT.
24  Moon near Pollux (evening sky) at 22h UT.
25  Moon near Mars (evening sky) at 11h UT. Mag. ~+0.0.
25  Moon near Beehive cluster (M44) (evening sky) at 22h UT.
27  Moon near Regulus (evening sky) at 10h UT.
28  Moon at perigee (closest to Earth) at 5h UT (361,876 km; 33.0º).
29  Moon near Saturn (midnight sky) at 12h UT. Mag. ~+0.6.
30  Full Moon at 2:25 UT.
31  Moon near Spica (morning sky) at 2h UT.

More sky events and links at http://Skymaps.com/skycalendar/
All times in Universal Time (UT). (Australian Eastern Summer Time = UT + 11 hours.)
PHYSICS, ASTRONOMY & ASTROPHYSICS AND PHOTONICS

BBQ

Who: ALL Physics, Astronomy & Astrophysics and Optical Technology students, postgrads and staff.

When: Thursday 11th March (Week 3), 12.30 pm – 2pm

Where: Adjacent to the North balcony of E7B, near the First Year Physics Labs

Why: An opportunity for students of these degrees to meet informally with each other & staff, and to ask questions, pass on views and experience etc.

Did we mention that:

FOOD AND BEVERAGES ARE BEING PROVIDED