Study guide − AY101−2   Spring 2008

Chapter numbers are in parentheses.

Our view of the sky (2):
- The celestial sphere as a model for appearances (only!)
- Sizes and distance from naked−eye observations
- Constellations
- Daily motions from Earth's rotation
- Annual motions from Earth's orbit; seasons
- Eclipses: solar (partial/annular/total), lunar

Gravity and orbits (3,4)
- Geocentric versus heliocentric solar system schemes
- The Copernican revolution
- Galileo and early telescopic discoveries
- Kepler's laws, Newton's laws and gravity
- Gravity, orbits and tides

Light and radiation (5)
- Light and radiation: electromagnetic energy packets
- The electromagnetic spectrum, radio to gamma rays
- Manipulation: reflection, refraction, dispersion
- Examples in the open air
- Atomic structure and spectral lines
- Doppler shift and line−of−sight motions
- Special relativity and the speed of light

Telescopes (5)
- Purposes in astronomy − remember *light grasp*
- For visible light: reflectors/refractors/compound designs
- Detectors, cameras, and spectrographs with telescopes
- Atmospheric turbulence and absorption, light pollution
- Radio telescopes: single−dish, interferometric arrays
- Ultraviolet, X−ray, gamma−ray detection in space
- Infrared astronomy from the ground, aircraft, and space

Formation of the solar system (6)
- Clues: layout of orbits and rotations
  - kinds of planets at different distances from Sun
  - comet, meteorite composition
  - dusty disks around young stars
- Accretion of planets, accumulation of remaining material

The Earth (7)
- Atmosphere: troposphere, stratosphere, thermosphere (ionosphere)
- Impacts, tectonism, vulcanism, erosion on surfaces
- Greenhouse effect, ozone layer
- Magnetic field, radiation belts, aurorae
- Crust: plate tectonics, vulcanism, erosion
- Mantle, dense core known from seismic studies

The Moon (7): Tidally locked rotation; one side always faces Earth
- Size, mass; theories for lunar origin
- Features: maria, highlands, craters
- Maria = lava flows, craters dominated by meteor impacts
- Lunar exploration: probe flyby/landings, manned Apollo landings

Mercury (7): Lunar−like surface with impact craters
- High density, temperature
- Polar ice caps?

Venus (7): near−twin of Earth in size and mass
- Atmosphere: cloud layers, runaway greenhouse effect
- Radar mapping: volcanic features, features we don't yet understand

Mars (7): Features seen from Earth: light/dark markings, polar caps
- Thin atmosphere, cold surface
- Craters, huge volcanos, canyons, ancient riverbeds?
- History: strong evidence for water−rich periods
- The search for life

Giant planets (8): Jupiter,Saturn, Uranus, Neptune
- H/He composition
- Visible weather: cloud belts, winds, storms (like Great Red Spot)
- Interior inferred: no solid surface. Rocky core?
- Strong magnetic field, radiation belts
- Uranus: tipped rotation, off−center magnetic field − early impact?
- Neptune: violent winds and storms despite distance from Sun

Rings and moons (8)
- Ring locations − tidal forces, collisional flattening
- Tides and their influences, the Roche limit
- Some ring matter has been knocked off moons
- Shephard moons
- Large active moons of outer planets (some still volcanic now)
- Many small inactive ones

Small bodies (9):
- Minor planets: most in so−called asteroid belt
  - formation theories
  - potential for catastrophe from Earth impacts
- Comets: nucleus/coma/tail (always points *away from Sun*)
  - elongated orbits; spend most time far from Sun
  - Icy "primitive" makeup; fossils of early Solar System
  - Oort and Kuiper clouds; put there by Jupiter encounters
  - cometary debris can make meteor showers
- Pluto/Charon − where did they come from?
  - small and icy, unlike other outer planets
- Meteors: debris seen entering the atmosphere
  - why we sometimes see meteor showers

The Sun (10): a typical star

- Energy−producing core, transport of this energy outward
- Atmosphere: visible photosphere, chromosphere, hot corona
- Sunspots, flares, and the solar cycle: symptoms of magnetic field
- H−>He fusion in the core; solar neutrino detection

Introduction to stars (11)

- Distances: parallax, star−matching techniques
- Color and temperatures: blackbody radiation
- Hertzsprung−Russell diagram: main sequence/red giants/white dwarfs
- Masses of stars: binaries and Kepler’s laws

Interstellar matter (12):

- Dust: visible absorption, infrared emission
- Gas: cold hydrogen from 21−cm radio emission
  - mapping clouds that can’t be seen in visible light
  - molecular clouds from millimeter−wave data;
    - link to star formation
  - ionized gas (bright nebulae) around hot stars
  - hot gas (millions of degrees) filling the gaps
- Star−gas interplay

Star formation (12):

- Collapse of molecular gas clouds under gravity
- Overcoming heat, spin, magnetic fields when this happens
- Fragmentation to individual star−sized masses
- Observing young stars: disks, winds, jets

Low−mass stellar evolution (12)

- Main sequence: H−> He in core producing energy;
  - lifetime is mass−dependent
- H exhaustion in core: evolve to red giant, helium fusion
- Production of a planetary nebula, leaving a white dwarf

HIgh−mass stars (12)

- Faster lifetime, more complex red giant phase, He core reactions
- Elements up to iron, some explode as supernovae as core collapses
- Star clusters as laboratories to see these things happen

Relativity and gravity (13)

- General relativity − gravity as curvature of spacetime

Compact remnants of stars (13)

- Neutron stars, pulsars
  - neutron−degenerate matter; size 10−20 km
  - pulsar magnetic fields, spin.
- Black holes: from stars too massive for neutron stars
  - escape velocity faster than light
  - singularity, event horizon
  - detection in interacting binary systems

The Milky Way galaxy (14)

- Observed guise: band of starlight around sky
- Disk, bulge like external spiral galaxies
- Spiral structure from young stars and gas clouds
- Stars of populations I and II
- Spiral arms as wave phenomena
- Energetic events in the galactic center − massive black hole

Galaxies (15,16):

- Recognition; distances via Cepheid variable stars
- Hubble classes: elliptical, S0, ordinary/barred spirals, irregular
- Distances and the Hubble law; an expanding Universe
- Motions in galaxies: the riddle of dark matter
- Galaxy collisions and mergers; transforming galaxies in time
- Galaxy evolution: we see different kinds of galaxies at high redshift

Active galaxies (15):

- Seyfert galaxies: bright nucleus, broad emission lines
  - large central gravity to hold gas in place
- Radio galaxies: twin lobes of radio emission, jets
  - directional memory for central object
- Quasars: bright, high redshifts
  - variability implies small volume for energy source
- Standard model: accretion disk and jets around massive black hole
- Using quasars as probes of the universe: absorption lines,
  - gravitational lensing, quasar redshift evolution

Cosmology (16,17)

- Observations: Olbers’ paradox,Hubble expansion, microwave background
- Expanding universe; meaning of uniform expansion, age of Universe
- Big−bang versus concepts; cosmological principle
- Acceleration of the expansion rate
- Early Universe: inflation, nucleosynthesis

Cosmic history (17)

- Nucleosynthesis: H,He, other light elements
- Atoms form, Universe becomes transparent − microwave background
- Gravity + dark matter: structures form
- Galaxy formation, first stars and quasars
- Galaxy clusters/superclusters
  - environmental effects on galaxies (change with time)
  - hot gas in clusters, some must have come from stars

Life in the Universe (18)

- The Drake equation and unknowns in the search
- Looking for planetary systems: Doppler shifts pay off
- Communicating: signalling/using probes