Chapter 1

Angular Measure At a Glance

One circle contains 360 degrees

One degree equals 60 minutes of arc

One minute equals 60 seconds of arc

Motions of Stars At a Glance

Daily: east to west, with respect to the horizon

Yearly: east to west, with respect to the sun.

Lifelong: no visible motions relative to each other

Motions of the Sun At a Glance

Daily: westward with respect to the horizon

Annually: eastward through the zodiac

Seasonally: At noon, highest (summer) and lowest (winter) with respect to the horizon.

Motions of the Moon At a Glance

Daily: westward with respect to the horizon

Monthly: eastward with respect to the stars

Rate: covers 360° in about 27 days around zodiac

Motions of the Planets At a Glance

Daily: westward with respect to the horizon.

General: eastward near the ecliptic

Occasional: westward in retrograde loops

Chapter 2

Scientific Models At a Glance

Explain: current and past observations

Predict: future observations

Verifiable: by a variety of observations

Changeable: to match observations better

Greek Cosmology At a Glance

Geocentric, earth spherical

Forced and natural motions

Symmetry: Celestial spheres (rotating)

Celestial motions: uniform around circles

Ptolemy's Model At a Glance

Geocentric

Finite in size, stars near compared to earth–sun distance

No forces for heavenly motions

Variations in eastward motions: eccentrics

Retrograde motions: deferents and epicycles

Variations in retrograde motions: equants

Chapter 3

The Copernican Model At a Glance

Heliocentric

No forces for heavenly motions

Finite in size: stars farther from earth than the sun is

Variations in eastward motions: Earth's orbit eccentric

Retrograde motions: Illusion from the passing of planets

Variations in retrograde motions: Small epicycles

The Keplerian Model At a Glance

Heliocentric

Magnetic forces for heavenly motions

Finite in size: stars farther from earth than the sun is

Variations in eastward motions: Earth's orbit is elliptical

Retrograde motions: Illusion from the passing of planets

Variations in retrograde motions: Elliptical orbits

Chapter 4

Gravitation At a Glance

Force between all masses of any material

Acts over large distances

Proportional to: Product of masses

Inversely proportional to: Distance between masses squared

The Newtonian Model At a Glance

Heliocentric

Gravitational forces for heavenly motions

Infinite in size, nearby stars farther from earth than the sun is

Variations in eastward motions: Earth's orbit around sun elliptical

Retrograde motions: Illusion from the passing of planets

Variations in retrograde motions: Elliptical orbits

Chapter 5

Atoms At a Glance

Nucleus: Protons and neutrons, positive charge

Elements: Determined by number of protons

Isotopes: Determined by number of neutrons

Electrons: Orbiting nucleus, equal to number of protons for neutral atom

Energy At a Glance

Energy: Changes the condition of matter

Examples: Kinetic, potential, and radiative

Heat: Microscopic kinetic energy

Conservation: Energy mutates, but the total remains the same

Atoms and Light At a Glance

Photons: Produced and absorbed by electron transitions

Transitions: Electrons move between discrete energy levels

Energy levels: Stable values of energies for electrons

Excitation: By collisions, absorption of photons

Chapter 6

Telescopes At a Glance

Primary function: To gather light

Primary designs: Reflectors and refractors

Primary ground-based types: Optical, radio, and infrared

Primary space-based types: Ultraviolet, x-ray, gamma-ray, infrared

Primary choice for amateur: Small (10- or 20-cm) reflector

Spectral Bands At a Glance

Ranges of Electromagnetic Spectrum (cm)

Radio: 10^{8} to 10^{-1}

Infrared: 10^{-1} to 10^{-4}

Visible: 8×10^{-5} to 4×10^{-5}

Ultraviolet: 4×10^{-5} to 10^{-6}

X-ray: 10^{-6} to 3×10^{-10}

Gamma ray: 10^{-10} to 10^{-13}

Chapter 7

General Relativity At a Glance

Deals with: Accelerated observers

Natural motion: Weightlessness

Gravitation: Result of curved spacetime

Spacetime curved by: Matter and energy

Einstein's Model At a Glance

Space and time: Integrated into four dimensions

Geometry: Non-Euclidean (curved) possible

Universe: Finite or infinite; expanding

Natural motions: Straight lines in curved spacetime

Chapter 8

The Earth At a Glance

Equatorial radius: 6378 km

Mass: 5.97×10^{24} kg

Bulk density: 5520 kg/m^3

Escape speed: 11.2 km/s

Atmosphere: Nitrogen, oxygen

The Earth's Magnetic Field At a Glance

Type: Two poles, north and south

Strength: About 0.4×10^{-4} T at surface

Source: Dynamo in conducting, fluid core

Effects: Magnetosphere, auroras

The Solid Earth's Evolution At a Glance

Cause: Energy flow to surface

Process: Convection in mantle

Effects: Volcanism, motions of crustal plates

Duration: Billions of years

Evolutionary Processes At a Glance

External: Impacts of bodies from space

Internal: Volcanism and tectonics

Surface: Wind and water erosion

Driven by: Internal energy, sunlight

Chapter 9

The Moon At a Glance

Equatorial radius: 1738 km

Mass: 7.35 x 10^{22}kg

Bulk density: 3340 kg/m^3

Escape speed: 2.4 km/s

Atmosphere: Neon, helium (thin!)

Mercury At a Glance

Equatorial radius: 2430 km

Mass: 3.30 x 10^{23} kg

Bulk density: 5430 kg/m^3

Escape speed: 4.3 km/s

Atmosphere: Sodium, potassium (thin!)

Mars At a Glance

Equatorial radius: 3397 km

Mass: 6.42 x 10^{23} kg

Bulk density: 3940 kg/m^3

Escape speed: 5.0 km/s

Atmosphere: Carbon dioxide, nitrogen

Venus At a Glance

Equatorial radius: 6052 km

Mass: 4.87 x 10^{24} kg

Bulk density: 5240 kg/m^3

Escape speed: 10.4 km/s

Atmosphere: Carbon dioxide, nitrogen

Chapter 10

Jupiter At a Glance

Equatorial radius: 71,492 km

Mass: 18.99 x 10^{27} kg

Bulk density: 1330 kg/m^3

Escape speed: 59.6 km/s

Atmosphere: Hydrogen, helium

Saturn At a Glance

Radius: 60,268 km

Mass: 5.68 _ 10^{26} kg

Bulk density: 690 kg/m^3

Escape speed: 35.6 km/s

Atmosphere: Hydrogen, helium

Uranus At a Glance

Equatorial radius: 25,559 km

Mass: 8.66 x 10^{25} kg

Bulk density: 1270 kg/m^3

Escape speed: 21.3 km/s

Atmosphere: Hydrogen, helium, methane

Neptune At a Glance

Equatorial radius: 25,269 km

Mass: 1.03 x 10^{26} kg

Bulk density: 1640 kg/m^3

Escape speed: 23.8 km/s

Atmosphere: Hydrogen, helium, methane

Chapter 11

Asteroids At a Glance

Orbits: Most in asteroid belt

Sizes: Small, less than 1000-km diameter

Shapes: Irregular

Surfaces: Cratered and cracked

Composition: Rocks and metals

Comets At a Glance

Orbits: Elliptical for periodic ones

Size of nucleus: Very small, less than tens of kilometers

Shapes: Irregular

Surfaces: Craters and vents; small hills

Composition: Rocky with carbon, embedded ices (water)

Meteorites At a Glance

Sizes: Centimeters to meters

Shapes: Irregular

Composition: Rocks (some with high carbon content) and metals

Sources: Comets and asteroids

Nebular Models At a Glance

Origin: Interstellar cloud of gas and dust

Processes: Gravitational contraction, conservation of angular momentum

Sun: Forms at center of nebula, reflects original composition

Planets: Form in disk of nebula, reflect temperature locally

Formation processes: Condensation, accretion

Chapter 12

The Sun At a Glance

Distance from the earth: 1 AU = 1.496×10^8 km

Radius: 6.966×10^8 m

Mass: 1.991×10^{30} kg

Luminosity: 3.86×10^{26} W

Surface temperature (photosphere): 5780 K

Age: 4.5 to 5 billion years

Composition (surface) by mass: Hydrogen, 74%; helium, 25%; other elements, 1%

Chapter 13

Stars At a Glance

Composition: Hydrogen, helium

Energy sources: Fusion reactions, gravitational contraction

Core: Site of fusion reactions, temperatures 10^7 K and higher

Luminosity: Total amount of energy produced each second

Photosphere: Source of stellar spectra

Chapter 14

The Interstellar Medium At a Glance

Contents: Gas and dust

Dust: Small grains of silicates and ices

Gas: Atomic, molecular, and ionized

Structure: Clumpy, with a thin gas between clouds

Source of: Stars and planets

Interstellar Gas At a Glance

Found in: Clouds, space between clouds

Detected by: Optical, radio, infrared, x-rays

Made of: Atoms, ions, molecules

Composition: Mostly hydrogen, some helium

Interstellar Dust At a Glance

Found in: Interstellar gas clouds

Detected by: Extinction, reddening

Structure: Small core with larger mantle

Radius: 0.1 to 1.0 μm

Composition: Silicate core with icy mantle; tarry crust

Formation site: Stellar winds of cool stars

Starbirth At a Glance

Where: Molecular clouds, large and small

When: Now, about ten stars per year in Milky Way

How: Gravitational contraction, fragmentation

What: Protostellar sources, visible in the infrared

Chapter 15

Stellar Lives At a Glance

Mass: Mainly determines the lifetime of a star

Chemical composition: Secondary effect on star lives

Energy sources: Gravitational contraction and fusion

Lifetimes: From tens of millions to tens of billions of years

Evolution: Changes in radius, luminosity, surface temperature, and chemical composition

Stellar Models At a Glance

Based on: Initial mass, chemical composition

Balance: Gravity and internal pressure

Energy flow: Convection and radiation

Results: Evolutionary track on H - R diagram

Star Clusters At a Glance

Main types: Open, globular

Star types: Population I (open), Population II (globular)

General ages: Globulars older, open younger

Ages found by: Turnoff point of main sequence

Chapter 16

White Dwarfs At a Glance

Mass: Averages 0.6 solar mass

Size: 7000 km radius (≈ earth's radius)

Density: ≈ 10^9 kg/m^3

Internal pressure: Degenerate electron gas

Energy: Stored internal energy; no fusion reactions

Neutron Stars At a Glance

Mass: Up to 3 solar masses

Size: ≈ 10 km in radius

Density: Averages 10^{17} kg/m^3

Internal pressure: Degenerate neutron gas

Energy source: Stored internal energy; rapid rotation

Chapter 17

The Galaxy At a Glance

Diameter of disk: 120,000 ly

Diameter of halo: 300,000 ly

Sun's distance from center: 30,000 ly

Total mass: About 10^{12} solar masses

Age: About 15×10^{9} years

Spiral Tracers At a Glance

Optical: OB stars, H II regions, cepheid variables

Radio: 21-cm emissions from H I regions, millimeter from CO

Results: Four main spiral arms

Caution: Limited areas mapped so far

The Galactic Center At a Glance

Size: Inner 1000 ly

Luminosity: 10^{9} solar luminosities

Mass in gas: 7×10^{7} solar masses

Mass in stars: 7×10^{9} solar masses

Chapter 18

Galaxies At a Glance

Types: Disks (spirals), irregular, and elliptical (supergiant to dwarf)

Relative numbers: Irregulars most common now; then spiral and ellipticals

Found in: Clusters, numbering up to a few thousand galaxies

Visible content: Stars, gas, and dust

Clusters of Galaxies At a Glance

Number of galaxies: Few to a few thousand

Total mass: 10^{14} to 10^{15} solar masses

Extent: Few million light years

Distance to next cluster: Few tens of millions of light years

Superclusters of Galaxies At a Glance

Number of clusters: A few tens to a few hundred

Total mass: 10^{16} to 10^{18} solar masses

Extent: Few hundred million light years

Shape: Filamentary, pancake

Contain: Voids (millions of cubic light years); roughly spherical

Chapter 19

Active Galaxies At a Glance

High luminosity, greater than a billion solar luminosities

Nonthermal emission (usually)

Rapid variability and/or small size of nucleus (a few light years at most)

Very bright nucleus with jetlike projections

Broad emission lines (sometimes); narrow emission lines (less often)

Chapter 20

The Big Bang Model At a Glance

Origin: In Big Bang some 15 billion years ago

Evidence: Expansion (redshifts), 2.7 K background radiation

Nucleosynthesis: During first few minutes

Future: Expansion forever (the Big Bore) or collapse (the Big Crunch)