Basic astrophysics

Extragalactic Astronomy and Cosmology

1. Hubble sequence and global properties of local galaxies.
2. Structural components: disk, spheroid, and dark halo. Light distributions.
3. Scaling laws and correlations along the Hubble sequence. Environmental dependence.
4. Stellar populations, gas content, and kinematics of the galaxies.
5. Luminosity and mass functions. The K-correction.
6. Active Galactic Nuclei (AGN): observational properties and physical models.
7. Star formation, chemical enrichment, stellar and AGN feedback.
8. Large scale structure of the Universe. The correlation function. Groups and clusters of galaxies. Gravitational lensing.
9. High redshift galaxies. Observational techniques. Cosmic star formation history.
10. Extragalactic distances. Hubble's law.
11. Einstein's field equations. Space-time metric. Cosmological principle.
12. Friedman equations. Equation of state and evolution of densities.
13. Thermal history of the Universe. Nucleosynthesis.
14. Recombination. Cosmic Microwave Background Radiation. Detection.
15. Observational determination of cosmological parameters.
16. Successes and limitations of the Big Bang Theory. Inflation.
17. Lineal evolution of perturbations: baryonic and non-baryonic matter.
18. Anisotropies in the Cosmic Microwave Background Radiation.
19. Galaxy formation.

Interstellar Medium

1. Atoms, semi-classical and quantic theories.
2. Radiative transitions: spontaneous, stimulated by photons and collisional.
3. Line broadening mechanisms.
4. Photoionization and radiative recombination.
5. Free-free emission.
6. Interstellar medium components: physical conditions (density, temperature and pressure).
7. Heating and cooling processes.
8. Emission and absorption lines.
9. 21cm HI line.
10. Extinction.
11. Interstellar dust.
12. Photoionized regions: Strömgren sphere, ionization equilibrium.

13. Virial theorem: application to interstellar medium, equilibrium.
14. Jeans criterion.
15. Shock waves: jump conditions, adiabatic shocks.
16. Molecular clouds and stellar formation.
17. Stellar formation models.

Galactic Structure and Stellar Dynamics

1. Two- and three-body problem.
2. Spherical potentials.
3. Axisymmetric potentials (with and without rotation).
4. The collisionless Boltzmann equation.
5. Jeans equations.
6. A dynamical description of our Galaxy: bulge, disk and halo.
7. Rotation of the Galactic disk.
8. Spiral arms and bars.
9. Dynamical friction.
10. Tidal forces (static case): Truncation.
11. Star counts (including Hipparcos results).
12. Stellar density and luminosity functions. Initial mass function (IMF).
13. Motion of the Local Standard of Rest (LSR). Proper motion of Sag A*.
14. Velocity ellipsoid.
15. Galactic rotation. Rotation curves and Oort constants.
16. Gas distribution. Star formation distribution.
17. Theories of Galaxy formation and evolution.

Stellar Astrophysics

1. Basic concept of radiative transfer: Emission, absorption, specific intensity and their moments
2. Local thermodynamically equilibrium
3. Stellar atmosphere: Basic terminology, spectral classification in the HR diagram
4. Opacity
5. Observed profiles and equivalent width
6. Stellar winds
7. Basic concept of stellar interiors : Hydrostatic equilibrium, state equation, perfect gas, generated gas, Virial theorem
8. Transport of energy by radiation
9. Transport of energy by convection
10. Nuclear reactions

11. Simple stellar structure models
12. Pre-main-sequence phase
13. Main sequence theory
14. Post-main-sequence phase