Instruction Guide For Astrophysicists

A one-semester course on **Astrophysical Spectroscopy** of approximately 40 lectures may be designed with the material in the book (AAS).

The outline assumes that astronomy students have basic knowledge of astrophysical objects and physical processes. This would include, for example, the stellar classification scheme, nebulae and ionized H II regions, the black hole paradigm underlying active galactic nuclei, and fundamentals of cosmology. Introductory material in the corresponding chapters — Chs. 10, 12, 13 and 14 — may therefore be skipped or assigned for self-study. **We plan to post an elementary description of selected topics on our website under "Popular Articles"**.

The instruction guide for astrophysicists also recognizes that some of the advanced material in the early chapters on the theory of atomic processes (such as relativistic fine structure and the R-matrix method), may be delegated for later study, unless specifically required in research on astrophysical models.

With these criteria, we recommend the following topics from AAS.

Ch.1 **Introduction** — All sections.

Ch.2 **Atomic Structure**

2.1 The hydrogen atom
2.2 Quantum numbers and parity
2.3 Spectrals lines and the Rydberg Formula
2.4 Spectroscopic designation
2.5 The ground state of multi-electron systems
2.6 Empirical rules for electronic configurations
2.7 Intermediate coupling and jj coupling
2.9 Rydberg formula with quantum defect

Partial overview of Hartree Fock approximation and Central-field approximation (2.11 and 2.12)

Ch. 3 **Atomic Processes**

3.1 Bound, continuum and resonance states
3.2 Collisional and radiative processes
3.3 Theoretical approximations (partial)

Partial overview of the Close Coupling approximation (3.4)

Ch. 4 **Radiative transitions**

4.1 Einstein A and B coefficients
4.2 Electron motion in an electromagnetic field
4.3 Transition matrix elements
4.4 Multipole expansion
4.5 Electric dipole approximation
4.8 Oscillator strengths for hydrogen
4.12 Higher order multipole transitions
4.14 Dipole and non-dipole transitions in He-like ions

Ch. 5 **Electron-ion collisions**

5.1 Electron impact excitaiton

5.2 Theoretical approximations
5.3 Excitation rate coefficients
5.4 Atomic effects
5.8 Electron impact ionization
5.9 Auger effect

Ch. 6 **Photoionization**

6.1 Hydrogen and helium
6.2 Photoionization cross section
6.4 Central potential
6.6 Channel coupling and resonance
6.7 Experimental measurements

Ch. 7 **Electron-ion recombination**

7.1 Detailed balance
7.2 Total electron-ion recombination rate
7.3 Independent treatmetns of RR and DR
7.4 The unified treatment
7.7 Recombination to H and He-like ions
7.8 Ionization equilibrium

Ch. 8 **Multi-wavelength emission spectra** — All sections

Ch. 9 **Absorption lines and radiative transfer** — All sections

Selected sections from

Ch. 10 **Stellar properties and spectra**
Ch. 11 **Opacity and radiative forces**
Ch. 12 **Gaseous nebulae and H II regions**
Ch. 13 **Active galactic nuclei and quasars**
Ch. 14 **Cosmology**