

”ATOMIC SPECTROSCOPY AND OPACITY”

- 3 Weeks Lecture Course
- Textbook: ”Atomic Astrophysics and Spectroscopy” (AAS)
-A.K. Pradhan and S.N. Nahar (Cambridge, 2011)

Lecture Topics:

Week 1:

- Physics and Astronomy Connection
 - i) Elements and Spectroscopy
 - ii) Opacity and Observations
 - iii) The Sun and Evolution of Spectroscopy
 - iv) Electron and Photon Distribution Functions
 - v) The Plasma Universe
- Atomic Structure and Spectroscopy
 - i) Hydrogen - Single electron energy and wave functions
 - ii) Quantum numbers n, l, m, s , parity
 - iii) Spectral lines - Rydberg formula

Week 2:

- Atomic Structure, Computation with SUPERSTRUCTURE & Atomic Processes
 - i) Multi-electron Systems - Angular States
 - ii) Angular Couplings, Quantum Defects
 - iii) Hartree-Fock Approximation
 - iv) Central Field Approximations
 - v) Dirac Equation, Breit-Pauli Approximation, Dirac-Fock

Approximation

vi) Atomic Processes of Plasma Opacity

Week 3:

- Plasma Opacity, R-matrix Calculations for Atomic Processes

- i) Autoionization and Resonances and Opacity

- ii) Plasma Opacity

- iii) Close-Coupling Approximation and R-matrix Method

- iv) R-matrix Calculations

Good luck to everyone!

EXAM: "Atomic Spectroscopy and Opacity"

Cairo University, Giza, March 5, 2013

1. i) What are the most abundant elements in the universe?
ii) What elements are expected to be seen in stellar spectra?
2. i) What effect do the elements in an astronomical object have on the radiation?
ii) What is the problem with solar abundances?
iii) What is the Z bump?
3. i) What is the difference between photometry and spectroscopy?
ii) How can we detect a black hole?
4. i) How do we describe a black body?
ii) Why do we see the yellow sun?
5. i) What is configuration for an atomic system?
ii) Write down the configuration of carbon atom.
6. i) What are equivalent and non-equivalent states?
ii) Which of them have less number of LS states?
iii) Write down all the LS states of $2p3d$.
7. i) Write down the quantum numbers that define an electronic state.
ii) What is the notation for a LSJ symmetry?
8. i) Write down the Rydberg formula for hydrogen?
ii) What is the resonant or K_α line of hydrogen?
iii) Give its wavelength.
9. i) What is quantum defect?
ii) Write down the Rydberg formula with quantum defect.
iii) When is this formula used?
10. i) What approximations can we use to include relativistic effects for higher accuracy?

- ii) What interaction splits the LS term energy in to fine structure levels?
 - 11. i) Name types of radiative transitions.
 - ii) How do we determine them?
 - iii) How can the lifetime be calculated?
- 12. Describe the most dominant atomic processes that form the plasma spectra.
 - 13. i) Explain an autoionizing state.
- ii) What effect does it have on an atomic processes?
 - 14. Which is the quantity that can be used to calculate various parameters of radiative processes?
 - 15. What is the difference in feature between hydrogenic and multi-electron photoionization?
 - 16. i) What is the relation between photoionization and electron-ion recombination?
 - ii) How many ways do the recombination take place?
 - iii) Which is the method that incorporate them together?
- 17. Which approximation can generate resonances in an atomic process?
- 18. What are the processes that cause plasma opacity?
- 19. i) What is LTE and which equations are needed to describe its equation of state?
- ii) How did Opacity Project deal non-LTE equation of state?
- 20. What type of lines are used to calculate the abundances in nebular plasmas?
- 21. We had demonstration of SUPERSTRUCTURE (SS) and R-Matrix codes.
 - i) What does SS calculate?
 - ii) What do R-matrix codes calculate?