

EXAM: "Atomic and Molecular Radiation Physics: Astronomy to Biomedicine"

Workshop on: SUPERSTRUCTURE, R-Matrix codes

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Aligarh Muslim University, Aligarh, March 7, 2014

Note: Number of points for each question is given within parentheses

Good luck!

1. i) What are the most abundant elements in the universe? (1)
- ii) How are elements heavier than iron formed (1)?
- iii) How do we identify an element from an astrophysical spectra? (1)
2. i) Which part of an atom is studied under Atomic Physics? (1)
- ii) What processes do elements undergo in astronomical plasmas and radiation transfer? (1)
3. i) How do we describe a black body? (1)
- ii) Why do we see the yellow sun? (1)
4. i) What is the configuration for an atomic system? (1)
- ii) Write down the ground configuration of the carbon atom. (1)
5. i) What are equivalent and non-equivalent states? (1)
- ii) Which of them have less number of LS states? (1)
- iii) Write down all the LS states of $2p3d$ and list them in energy according to Hund's rule. (2)
- iv) Write down all the LS states of $2p^3$ and list them in energy order following Hund's rule. (2)

6. i) Write down the Rydberg formula for hydrogen? (1)
- ii) What is the K_α line? (1)
- iii) Give its wavelength of Lyman α . (1)
7. i) Write down the quantum numbers that define an electronic state including fine structure. (1)
- ii) Why can we get exact wavefunction for hydrogen, but not for multi-electron systems? (1)
- iii) What equations do we need to solve for multi-electron systems? (2)
8. i) What is quantum defect? (1)
- ii) Write down the Rydberg formula with the quantum defect. (1)
- iii) When is this formula used? (1)

9. i) What approximations can we use to include relativistic effects for higher accuracy? (1)
- ii) What interaction splits the LS term energy in to fine structure levels? (1)
10. i) Name 5 types of radiative multipole transitions. (2)
- ii) How can the lifetime of an atomic state be calculated? (1)
11. Describe the most dominant atomic processes that form the plasma spectra. (2)
12. What is the difference in features between hydrogenic and multi-electron photoionization? (1)
13. i) What is the relation between photoionization and electron-ion recombination? (1)
- ii) How many ways does electronic recombination take place? (1)
- iii) Which is the method that incorporates them together? (1)
14. i) What is an autoionizing state? (1)
- ii) What does it lead to? (1)
- iii) Which approximation can generate resonances in an atomic process? (1)
15. We had demonstration of SUPERSTRUCTURE (SS) and R-Matrix codes. i) What does SS calculate? (1)
- ii) What do R-matrix codes calculate? (1)
16. What is plasma opacity (1)? What does it depend on (1)?
17. What is LTE (1)? What equations apply in LTE (1) ?
18. What are typical temperatures and densities in gaseous nebulae (1)?
19. How many kinds of spectra do molecules give rise to (1)?
20. Why are conventional medical X-rays harmful?