Homework #3

(due Wednesday, May 1, 2024)

1. (10 pts) Consider fine structure of the n = 2 level of the hydrogen atom. Calculate energy corrections from each of the three contributions to the fine structure and then the total correction as the sum of the three. Sketch the energy level diagrams showing what each correction does to the energy level similar to how you did it in WS#6.

2. (10 pts) Consider fine structure splitting of the H_α Balmer line.

   (a) Sketch the energy level diagram and indicate transitions allowed in the electric dipole approximation. How many transitions are possible in the electric dipole approximation?
   (b) Based on (a), how many distinct frequencies can we resolve (neglect the Lamb shift)? Sketch the expected spectrum.

3. (20 pts) Here we will examine the Doppler broadening.

   (a) Use (4.188) and (4.189) to derive (4.190) of B&J. Derive the Doppler width of Eq.(4.192). Sketch the intensity distribution of (4.189) and indicate the width.

   (b) Read through the first ~three pages of Hansch's Noble Lecture and pp.840-843 of B&J (Ch. 15.2) on Doppler-free spectroscopy. Explain the principle of operation for the Doppler-free spectroscopy (use original Hansch's articles cited in the book and the paper for further context as needed). Give examples of important results obtained using this type of high-resolution spectroscopy.

4. Reading assignment: Chapters 5 and part of 15.2 of B&J; also look at the posted papers – read what sparks your interest !