Physics 531, Problem Set #7

Due: Tuesday, April 5, 2005

Problem 1: The discovery of Argon

In the paper announcing the discovery of the element argon (Z=18), extracted from atmospheric nitrogen (Lord Rayleigh and W. Ramsay, Phil. Trans. **186A**, 187 (1895)), the authors state that spectroscopic observations on discharge tubes containing samples of the gas showed previously unknown prominent red lines and one intense violet line (at low pressure where excitation dominates over ionization) and several strong blue lines (at atmospheric pressure where ionization is more prominent). In 1895 the presence of both red and blue light suggested to some people that there was more than one element present; Rayleigh and Ramsay were skeptical of this idea and they were right.

Below is a table of the wavelengths (in Angstroms) of the of the characteristic lines, taken from the CRC Handbook (including some infrared lines, not seen in 1895).

Low pressure lines	Atmospheric pressure lines
4200.7	4348.1
6965.4	4726.9
7067.2	4735.9
7384.0	4764.9
8115.3	4806.0
9123.0	4879.9

(a) Using the NIST online data base of energy levels for neutral argon to identify the transitions responsible for the lines at low pressure. List the Russell-Sunders initial and final states, the total angular momentum change, and the parity change. Are there changes in the spin states? Are all these transitions consistent with electric dipole radiation? List also the single particle orbital transition in each case.

(b) Repeat for the lines listed for the atmospheric discharge by studying the levels of singly ionized argon.

Problem2: The Zeeman effect

A transition from a $^2P_{3/2}$ to $^2S_{1/2}$ state (the sodium D2 line, for example) is split into six components by a weak magnetic field (not resolving the hyperfine structure). At right angles to the direction of the magnetic field, all six components are observed with a photon detector that is polarization insensitive. If the same detector is placed along the field direction, only four components are detected. If a polarizer is placed in front of the detector at right angle to the filed, some of the components have polarization along the field (π components) and some have polarization perpendicular to the field (σ components).

(a) Determine the *g*-factors for the initial and final states and so infer the arrangement of the six components in frequency with respect to the single line in the absence of the magnetic field. Why are there not $(2J+1)(2J'+1)=8$ components?

(b) What are the relative intensities of the components for the polarization-insensitive detector parallel and perpendicular to the field. Make a bar chart showing the lines and there relative intensities.

(c) For the detector perpendicular to the field, including the polarizer, repeat part (b). Label the lines that are π and those that are σ.