AST 300B – Spring 2019

In-class/take-home Problems Due: Wednesday April 24th

38. Consider the terms for the energy levels of Carbon in the ground state $(1s^2 2s^2)2p^2$ and the terms for the energy levels of an excited state of Carbon with 1 p electron excited into a 3s orbital $(1s^2 2s^2)2p^1 3s^1$.

(a) Using Hund's Rules, order the terms of both these configurations in order of increasing energy. Sketch a rough energy level diagram (don't worry about looking up the exact energies of each level - just show which levels are higher or lower than others).

(b) What is the parity of the electronic terms in the ground electronic state and the excited electronic state.

(c) The rules for electric dipole or "resonance" transitions for atoms are given below. Using those rules, explain which resonance transitions are allowed between these energy levels (these will have the fastest Einstein A and be brightest generally).

(d) OIII is isoelectronic to CI. The famous [OIII] 5008 Angstrom green line is observable in HII regions and Planetary nebulae. Astrophotographers use a special filter to isolate this line in photographs. It is due to a transition from ${}^1D_2$ – ${}^3P_2$ in the ground electronic state. What is the strongest radiation multipole for this transition? This is called a "forbidden line" because it violates at least one of the first 4 rules below. Notation for forbidden lines is square brackets: [OIII]. See back.

Electric Dipole (Resonance) Transitions

- Only 1 e^- changes its (nl) state with $\Delta l = -1$ or $+1$
- Parity MUST change
- $\Delta L = -1, 0,$ or $+1$ ($0 \not\rightarrow 0$, no S → S term transitions)
- $\Delta J = -1, 0,$ or $+1$ ($0 \not\rightarrow 0$ NOT allowed)
- $\Delta S = 0$ (spin multiplicity does NOT change)

Multipole Transition Rules

Allowed transitions		Electric dipole (E1)	Magnetic dipole (M1)	Electric quadrupole (E2)	Magnetic quadrupole (M2)	Electric octupole (E3)	Magnetic octupole (M3)
Rigorous rules	(1)	$\Delta J = 0, \pm 1$ $(J = 0 \not\leftrightarrow 0)$		$\Delta J = 0, \pm 1, \pm 2$ $(J = 0 \not\leftrightarrow 0, 1;\ \frac{1}{2} \not\leftrightarrow \frac{1}{2})$		$\Delta J = 0, \pm 1, \pm 2, \pm 3$ $(0 \not\leftrightarrow 0, 1, 2;\ \frac{1}{2} \not\leftrightarrow \frac{1}{2}, \frac{3}{2};\ 1 \not\leftrightarrow 1)$	
	(2)	$\Delta M_J = 0, \pm 1$		$\Delta M_J = 0, \pm 1, \pm 2$		$\Delta M_J = 0, \pm 1, \pm 2, \pm 3$	
Parity	(3)	$\pi_f = -\pi_i$	$\pi_f = \pi_i$		$\pi_f = -\pi_i$		$\pi_f = \pi_i$
LS coupling	(4)	One electron jump $\Delta l = \pm 1$	No electron jump $\Delta l = 0,$ $\Delta n = 0$	None or one electron jump $\Delta l = 0, \pm 2$	One electron jump $\Delta l = \pm 1$	One electron jump $\Delta l = \pm 1, \pm 3$	One electron jump $\Delta l = 0, \pm 2$
	(5)	If $\Delta S = 0$ $\Delta L = 0, \pm 1$ $(L = 0 \not\leftrightarrow 0)$	If $\Delta S = 0$ $\Delta L = 0$	If $\Delta S = 0$ $\Delta L = 0, \pm 1, \pm 2$ $(L = 0 \not\leftrightarrow 0, 1)$		If $\Delta S = 0$ $\Delta L = 0, \pm 1, \pm 2, \pm 3$ $(L = 0 \not\leftrightarrow 0, 1, 2;\ 1 \not\leftrightarrow 1)$	
Intermediate coupling	(6)	If $\Delta S = \pm 1$ $\Delta L = 0, \pm 1, \pm 2$		If $\Delta S = \pm 1$ $\Delta L = 0, \pm 1,$ $\pm 2, \pm 3$ $(L = 0 \not\leftrightarrow 0)$	If $\Delta S = \pm 1$ $\Delta L = 0, \pm 1$ $(L = 0 \not\leftrightarrow 0)$	If $\Delta S = \pm 1$ $\Delta L = 0, \pm 1,$ $\pm 2, \pm 3, \pm 4$ $(L = 0 \not\leftrightarrow 0, 1)$	If $\Delta S = \pm 1$ $\Delta L = 0, \pm 1,$ ± 2 $(L = 0 \not\leftrightarrow 0)$