

Conclusion of the course:  
The Periodic Table

# First: Summary of 3 external B fields

$B' > 0$

1. Stern-Gerlach exp.
2. Force acting on a neutral atom. Number of discrete force projections on z, depends on the value of  $\mu_z$ .

$B = \text{Constant}$

1. Zeeman effect
2. Energy splitting  
Number of discrete energy levels depends on the number of projections on z, i.e. different values of  $\mu_z$ .
3. No force.

$B = 0$

1. Fine structure  
Splitting caused by Spin-orbit coupling.
2. No force on the atom.

The total magnetic moment of the atom is:

$$\mu_z = [e/(2m) l_z + e/(m) s_z + e/(2M) i_z] = [e\hbar/(2m) m_l + e\hbar/(m) m_s + e\hbar/(2M) m_i] =$$

$$\mu_B [m_l + 2m_s] + \mu_N [m_i]$$

In this course we ignore the last term which is caused by the Nuclear spin and which gives rise to the Hyperfine structure (i.e. final state splitting for  $B=0$  case).


To conclude:

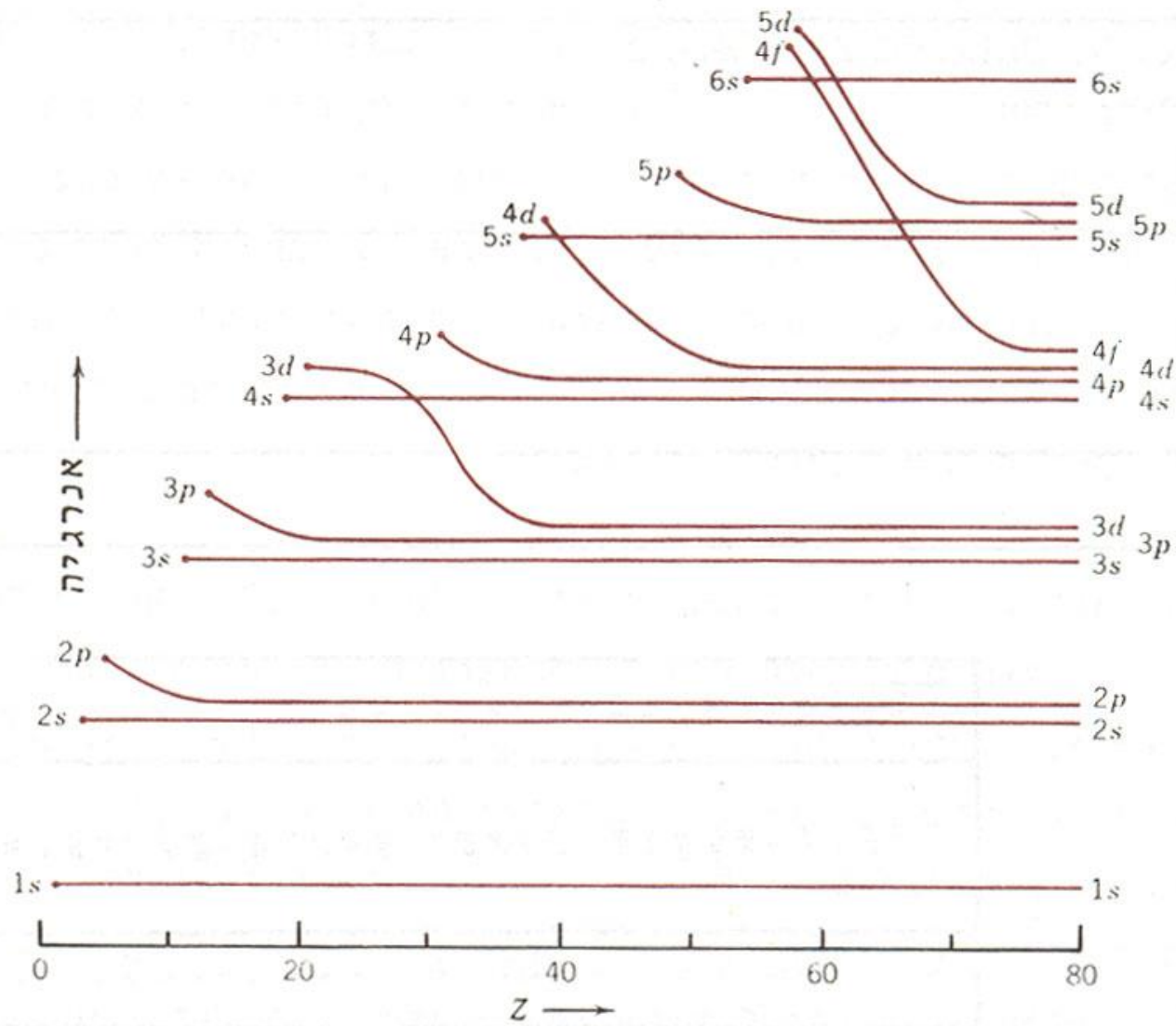
1. We have three sources of angular momentum in the atom: nucleus, angular orbital momentum, and electron spin. The nucleus couples very weakly because of the magnitude of  $\mu_N$

2. We have said that for each  $n$  level,  $l=0,1,\dots,n-1$  ( $l$  is the orbital angular momentum). This means  $2l+1$  projections on the  $z$  axis (noted by  $m_l$ ).

3. As the Pauli exclusion principle states that two fermions (spin half particles) cannot be at the exact same quantum state if they are at the same position, each quantum level of the atom (denoted by  $n, l, m$ ) can only hold 2 electrons (as they have two possibilities for their spin).

4. Therefore, the total number of electrons each shell ( $n,l$  level) can hold is  $2(2l+1)$ .

קיבול התת-קליפה $2(2l+1)$	סימון התת-קליפה	מספרים קוואנטיים $n, l$	
2	1s	1,0	$E_{n,l}$ עולה 
2	2s	2,0	
6	2p	2,1	
2	3s	3,0	
6	3p	3,1	
2	4s	4,0	
10	3d	3,2	
6	4p	4,1	
2	5s	5,0	
10	4d	4,2	
6	5p	5,1	
2	6s	6,0	
14	4f	4,3	
10	5d	5,2	
6	6p	6,1	
2	7s	7,0	
14	5f	5,3	
10	6d	6,2	



3.2 אָרְבִּיב

Z	היסוד	1	2	3	4	5	6	7
		s	s p	s p d	s p d	s p d f	s d p f	s
1	H	1						
2	He	2						
3	Li	2	1					
4	Be	2	2					
5	B	2	2 1					
6	C	2	2 2					
7	N	2	2 3					
8	O	2	2 4					
9	F	2	2 5					
10	Ne	2	2 6					
11	Na	2	2 6	1				
12	Mg	2	2 6	2				
13	Al	2	2 6	2 1				
14	Si	2	2 6	2 2				
15	P	2	2 6	2 3				
16	S	2	2 6	2 4				
17	Cl	2	2 6	2 5				
18	Ar	2	2 6	2 6				
19	K	2	2 6	2 6	1			
20	Ca	2	2 6	2 6	2			
21	Sc	2	2 6	2 6 1	2			
22	Ti	2	2 6	2 6 2	2			
23	V	2	2 6	2 6 3	2			
24	Cr	2	2 6	2 6 5	1			
25	Mn	2	2 6	2 6 5	2			
26	Fe	2	2 6	2 6 6	2			
27	Co	2	2 6	2 6 7	2			
28	Ni	2	2 6	2 6 8	2			
29	Cu	2	2 6	2 6 10	1			
30	Zn	2	2 6	2 6 10	2			
31	Ga	2	2 6	2 6 10	2 1			
32	Ge	2	2 6	2 6 10	2 2			
33	As	2	2 6	2 6 10	2 3			
34	Se	2	2 6	2 6 10	2 4			
35	Br	2	2 6	2 6 10	2 5			
36	Kr	2	2 6	2 6 10	2 6			
37	Rb	2	2 6	2 6 10	2 6	1		
38	Sr	2	2 6	2 6 10	2 6	2		
39	Y	2	2 6	2 6 10	2 6 1	2		
40	Zr	2	2 6	2 6 10	2 6 2	2		
41	Nb	2	2 6	2 6 10	2 6 4	1		
42	Mo	2	2 6	2 6 10	2 6 5	1?		
43	Tc	2	2 6	2 6 10	2 6 6	1?		
44	Ru	2	2 6	2 6 10	2 6 7	1		
45	Rh	2	2 6	2 6 10	2 6 8	1		
46	Pd	2	2 6	2 6 10	2 6 10			
47	Ag	2	2 6	2 6 10	2 6 10	1		
48	Cd	2	2 6	2 6 10	2 6 10	2		
49	In	2	2 6	2 6 10	2 6 10	2 1		
50	Sn	2	2 6	2 6 10	2 6 10	2 2		
51	Sb	2	2 6	2 6 10	2 6 10	2 3		
52	Te	2	2 6	2 6 10	2 6 10	2 4		
53	I	2	2 6	2 6 10	2 6 10	2 5		
54	Xe	2	2 6	2 6 10	2 6 10	2 6		

Z	היסוד	1	2	3	4	5	6	7
		s	s f	s p d	s p d f	s p d f	s p d f	s
55	Cs	2	2 6	2 6 10	2 6 10	2 6	1	
56	Ba	2	2 6	2 6 10	2 6 10	2 6	2	
57	La	2	2 6	2 6 10	2 6 10	2 6 1	2	
58	Ce	2	2 6	2 6 10	2 6 10 2	2 6	2?	
59	Pr	2	2 6	2 6 10	2 6 10 3	2 6	2?	
60	Nd	2	2 6	2 6 10	2 6 10 4	2 6	2	
61	Pm	2	2 6	2 6 10	2 6 10 5	2 6	2?	
62	Sm	2	2 6	2 6 10	2 6 10 6	2 6	2	
63	Eu	2	2 6	2 6 10	2 6 10 7	2 6	2	
64	Gd	2	2 6	2 6 10	2 6 10 7	2 6 1	2	
65	Tb	2	2 6	2 6 10	2 6 10 9	2 6	2?	
66	Dy	2	2 6	2 6 10	2 6 10 10	2 6	2?	
67	Ho	2	2 6	2 6 10	2 6 10 11	2 6	2?	
68	Er	2	2 6	2 6 10	2 6 10 12	2 6	2?	
69	Tm	2	2 6	2 6 10	2 6 10 13	2 6	2	
70	Yb	2	2 6	2 6 10	2 6 10 14	2 6	2	
71	Lu	2	2 6	2 6 10	2 6 10 14	2 6 1	2	
72	Hf	2	2 6	2 6 10	2 6 10 14	2 6 2	2	
73	Ta	2	2 6	2 6 10	2 6 10 14	2 6 3	2	
74	W	2	2 6	2 6 10	2 6 10 14	2 6 4	2	
75	Re	2	2 6	2 6 10	2 6 10 14	2 6 5	2	
76	Os	2	2 6	2 6 10	2 6 10 14	2 6 6	2	
77	Ir	2	2 6	2 6 10	2 6 10 14	2 6 7	2	
78	Pt	2	2 6	2 6 10	2 6 10 14	2 6 9	1	
79	Au	2	2 6	2 6 10	2 6 10 14	2 6 10	1	
80	Hg	2	2 6	2 6 10	2 6 10 14	2 6 10	2	
81	Tl	2	2 6	2 6 10	2 6 10 14	2 6 10	2 1	
82	Pb	2	2 6	2 6 10	2 6 10 14	2 6 10	2 2	
83	Bi	2	2 6	2 6 10	2 6 10 14	2 6 10	2 3	
84	Po	2	2 6	2 6 10	2 6 10 14	2 6 10	2 4?	
85	At	2	2 6	2 6 10	2 6 10 14	2 6 10	2 5?	
86	Rn	2	2 6	2 6 10	2 6 10 14	2 6 10	2 6	
87	Fr	2	2 6	2 6 10	2 6 10 14	2 6 10	2 6	1?
88	Ra	2	2 6	2 6 10	2 6 10 14	2 6 10	2 6	2
89	Ac	2	2 6	2 6 10	2 6 10 14	2 6 10	2 6 1	2?
90	Th	2	2 6	2 6 10	2 6 10 14	2 6 10	2 6 2	2
91	Pa	2	2 6	2 6 10	2 6 10 14	2 6 10 2	2 6 1	2?
92	U	2	2 6	2 6 10	2 6 10 14	2 6 10 3	2 6 1	2
93	Np	2	2 6	2 6 10	2 6 10 14	2 6 10 4	2 6 1	2?
94	Pu	2	2 6	2 6 10	2 6 10 14	2 6 10 6	2 6	2?
95	Am	2	2 6	2 6 10	2 6 10 14	2 6 10 7	2 6	2?
96	Cm	2	2 6	2 6 10	2 6 10 14	2 6 10 7	2 6 1	2?
97	Bk	2	2 6	2 6 10	2 6 10 14	2 6 10 8	2 6 1	2?
98	Cf	2	2 6	2 6 10	2 6 10 14	2 6 10 10	2 6	2?
99	Es	2	2 6	2 6 10	2 6 10 14	2 6 10 11	2 6	2?
100	Fm	2	2 6	2 6 10	2 6 10 14	2 6 10 12	2 6	2?
101	Md	2	2 6	2 6 10	2 6 10 14	2 6 10 13	2 6	2?
102	No	2	2 6	2 6 10	2 6 10 14	2 6 10 14	2 6	2?
103	Lw	2	2 6	2 6 10	2 6 10 14	2 6 10 14	2 6 1	2?

טבלה 3.2: קונפיגורציות אלקטרוניות