

hw13

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0.1 This Jupyter notebook answers HW13 questions for PHY 981 Nuclear Structure.

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0.1.1 HW13 question 3

What are the allowed J values for 19O in the d5/2 model space? What are the spectroscopic factors from the 20O ground state to each of these states in 19O?

Allowed values for 19O in d5/2 model space: $J = 3/2, 5/2, 9/2$

20O has 4 neutrons in the sd shell, and a ground state $J = 0+$. There are three possible transfers from 20O that can occur in d5/2 model space, namely the allowed values of J for 19O. The possible final J values come from the triangle condition of $0+, (3/2, 5/2, 9/2)$. The spectroscopic factor comes from the number of neutrons that can be transferred from 20O to 19O. d5/2 restricts considerations to final states of $J=5/2$. The only 19O J state that can couple with the 20O $0+$ state to reach $J=5/2$ is, of course, the 5/2 in 19O.

Therefore, the spectroscopic factors go like this:

J_i	J_f	S
0	3/2	0
0	5/2	4
0	9/2	0

0.1.2 HW13 question 4

A 21O(d,p)22O reaction is carried out. What are the possible final states and the spectroscopic factors to each of these in the 0d5/2 model space? How does the sum over all final states relate to the number of 0d5/2 neutrons in the ground state of 21O?

Possible J values of 21O in 0d5/2 model space: $J = 5/2$

Spectroscopic factor going from ground state $0+$ 22O to 21O is 6. In the d5/2 model space for 21O, the number of 0d5/2 neutrons in the ground state is 5.

0.1.3 HW13 question 5

Confirm your results from the last two problems using NuShellX.

FOR 190-200 Possible J values:

approximate time to converge 10 states with 4-core (2.6 GHz)

2J	J-dim	M-dim	t(min)	t(hour)
9	1	1	0.20	0.00
7	0	1	0.20	0.00
5	1	2	0.20	0.00
3	1	3	0.20	0.00
1	0	3	0.20	0.00

From M-dim column, J can be 9/2, 5/2, or 3/2.

```
( Ai  Tzi) ( Af  Tzf) (type n,l,2j)      Ji  Jf      ni  nf      C^2S      Ei      Ef
( 19  1.5) ( 20  2.0) ( n  1 2  5)    2.5+ 0.0+      1   1    4.0000    0.000    0.000  -14.5
                                     sum  4.0000

                                     total sum  4.0000
```

We expect a spectroscopic factor of 4 associated with the J=5/2 transition and that's what we get.

210-220 The only possible transition is 5/2 because that is the only allowed J value in 21O.

```
! model space = sd
```

```
! interaction = usdb
```

```
( Ai  Tzi) ( Af  Tzf) (type n,l,2j)      Ji  Jf      ni  nf      C^2S      Ei      Ef
( 21  2.5) ( 22  3.0) ( n  1 2  5)    2.5+ 0.0+      1   1    6.0000    0.000    0.000  -25.0
                                     sum  6.0000

                                     total sum  6.0000
```

Total spectroscopic factor is 6 as expected.

```
6      1
N      NJ      Ex  2J  P   0d3   0d5   1s1   0d3   0d5   1s1
1      1      0.000  5  1   0.00   0.00   0.00   0.00   5.00   0.00
```

5 is the occupation in 0d5/2 ground state for 21O.

0.1.4 HW13 question 6

Calculate the spectroscopic factors for the 22Ne ground state going to final states in 21Ne in the sd model space with the USDB Hamiltonian. Compare the results to experiment for states in 21Ne up to 5 MeV in excitation energy.

I get this output file:

```
! model space = sd
```

```
! interaction = usdb
```

```
( Ai  Tzi) ( Af  Tzf) (type n,l,2j)      Ji  Jf      ni  nf      C^2S      Ei      Ef
( 21  0.5) ( 22  1.0) ( n  2 0  1)    0.5+ 0.0+      1   1    0.1471    2.859    0.000  -44.5
( 21  0.5) ( 22  1.0) ( n  2 0  1)    0.5+ 0.0+      1   2    0.2538    2.859    6.259  -44.5
```

(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	3	0.7477	2.859	7.392	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	4	0.3380	2.859	8.932	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	5	0.0504	2.859	10.687	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	6	0.0478	2.859	11.176	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	7	0.0006	2.859	11.806	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	8	0.0199	2.859	13.014	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	9	0.0047	2.859	13.498	-44.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	1	10	0.0070	2.859	14.021	-44.5
							sum	1.6170		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	1	0.0044	5.962	0.000	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	2	0.1690	5.962	6.259	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	3	0.0020	5.962	7.392	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	4	0.0127	5.962	8.932	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	5	0.1109	5.962	10.687	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	6	0.1111	5.962	11.176	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	7	0.0115	5.962	11.806	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	8	0.0876	5.962	13.014	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	9	0.1515	5.962	13.498	-41.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	2	10	0.0697	5.962	14.021	-41.5
							sum	0.7304		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	1	0.0277	7.070	0.000	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	2	0.0340	7.070	6.259	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	3	0.0004	7.070	7.392	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	4	0.0230	7.070	8.932	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	5	0.3204	7.070	10.687	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	6	0.0216	7.070	11.176	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	7	0.0524	7.070	11.806	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	8	0.0245	7.070	13.014	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	9	0.1665	7.070	13.498	-40.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	3	10	0.0900	7.070	14.021	-40.5
							sum	0.7605		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	1	0.1252	9.013	0.000	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	2	0.1015	9.013	6.259	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	3	0.0869	9.013	7.392	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	4	0.0109	9.013	8.932	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	5	0.0099	9.013	10.687	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	6	0.0089	9.013	11.176	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	7	0.0004	9.013	11.806	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	8	0.0004	9.013	13.014	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	9	0.0088	9.013	13.498	-38.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	4	10	0.0002	9.013	14.021	-38.5
							sum	0.3531		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	1	0.0236	9.145	0.000	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	2	0.0056	9.145	6.259	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	3	0.0154	9.145	7.392	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	4	0.0018	9.145	8.932	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	5	0.0001	9.145	10.687	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	6	0.0001	9.145	11.176	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	7	0.0017	9.145	11.806	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	8	0.0596	9.145	13.014	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	9	0.0199	9.145	13.498	-38.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	5	10	0.0167	9.145	14.021	-38.0
							sum	0.1445		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	1	0.0112	9.834	0.000	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	2	0.1921	9.834	6.259	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	3	0.0015	9.834	7.392	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	4	0.0171	9.834	8.932	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	5	0.0000	9.834	10.687	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	6	0.0307	9.834	11.176	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	7	0.0056	9.834	11.806	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	8	0.0006	9.834	13.014	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	9	0.0000	9.834	13.498	-37.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	6	10	0.0293	9.834	14.021	-37.5
							sum	0.2881		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	1	0.0303	10.420	0.000	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	2	0.0318	10.420	6.259	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	3	0.0437	10.420	7.392	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	4	0.0180	10.420	8.932	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	5	0.0096	10.420	10.687	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	6	0.0220	10.420	11.176	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	7	0.0239	10.420	11.806	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	8	0.0450	10.420	13.014	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	9	0.0359	10.420	13.498	-36.8
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	7	10	0.0133	10.420	14.021	-36.8
							sum	0.2735		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	1	0.0062	10.589	0.000	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	2	0.0051	10.589	6.259	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	3	0.0150	10.589	7.392	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	4	0.1250	10.589	8.932	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	5	0.0148	10.589	10.687	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	6	0.0366	10.589	11.176	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	7	0.0467	10.589	11.806	-36.0

(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	8	0.0001	10.589	13.014	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	9	0.0046	10.589	13.498	-36.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	8	10	0.0427	10.589	14.021	-36.0
						sum	0.2968			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	1	0.0031	12.713	0.000	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	2	0.0033	12.713	6.259	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	3	0.0501	12.713	7.392	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	4	0.0534	12.713	8.932	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	5	0.0426	12.713	10.687	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	6	0.0041	12.713	11.176	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	7	0.0139	12.713	11.806	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	8	0.0196	12.713	13.014	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	9	0.0000	12.713	13.498	-34.5
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	9	10	0.0308	12.713	14.021	-34.5
						sum	0.2209			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	1	0.0015	13.167	0.000	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	2	0.0002	13.167	6.259	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	3	0.0139	13.167	7.392	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	4	0.0604	13.167	8.932	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	5	0.0097	13.167	10.687	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	6	0.0062	13.167	11.176	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	7	0.0204	13.167	11.806	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	8	0.0354	13.167	13.014	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	9	0.1134	13.167	13.498	-34.0
(21 0.5)	(22 1.0)	(n 2 0 1)	0.5+	0.0+	10	10	0.0011	13.167	14.021	-34.0
						sum	0.2622			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	1	0.1316	0.000	0.000	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	2	0.0541	0.000	6.259	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	3	0.0056	0.000	7.392	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	4	0.0136	0.000	8.932	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	5	0.1187	0.000	10.687	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	6	0.2116	0.000	11.176	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	7	0.4321	0.000	11.806	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	8	0.0003	0.000	13.014	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	9	0.0011	0.000	13.498	-47.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	1	10	0.0091	0.000	14.021	-47.5
						sum	0.9778			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	1	0.1246	4.913	0.000	-42.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	2	0.0007	4.913	6.259	-42.5
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	3	0.0031	4.913	7.392	-42.5

(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	4	0.0490	4.913	8.932	-42.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	5	0.0747	4.913	10.687	-42.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	6	0.3135	4.913	11.176	-42.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	7	0.0979	4.913	11.806	-42.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	8	0.2108	4.913	13.014	-42.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	9	0.2535	4.913	13.498	-42.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	2	10	0.1887	4.913	14.021	-42.3
						sum	1.3165			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	1	0.0290	5.528	0.000	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	2	0.0665	5.528	6.259	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	3	0.0103	5.528	7.392	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	4	0.0314	5.528	8.932	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	5	0.0011	5.528	10.687	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	6	0.0082	5.528	11.176	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	7	0.0123	5.528	11.806	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	8	0.1886	5.528	13.014	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	9	0.1653	5.528	13.498	-41.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	3	10	0.1408	5.528	14.021	-41.7
						sum	0.6535			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	1	0.0051	6.739	0.000	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	2	0.0003	6.739	6.259	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	3	0.1070	6.739	7.392	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	4	0.0387	6.739	8.932	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	5	0.0134	6.739	10.687	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	6	0.0126	6.739	11.176	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	7	0.0068	6.739	11.806	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	8	0.0006	6.739	13.014	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	9	0.0022	6.739	13.498	-40.4
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	4	10	0.3298	6.739	14.021	-40.4
						sum	0.5165			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	1	0.0036	7.845	0.000	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	2	0.0002	7.845	6.259	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	3	0.0031	7.845	7.392	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	4	0.0078	7.845	8.932	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	5	0.0076	7.845	10.687	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	6	0.0016	7.845	11.176	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	7	0.0003	7.845	11.806	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	8	0.0078	7.845	13.014	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	9	0.0416	7.845	13.498	-39.3
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	5	10	0.0775	7.845	14.021	-39.3
						sum	0.1511			

(Ai	Tzi)	(Af	Tzf)	(type	n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	1	0.0235	8.746	0.000	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	2	0.0218	8.746	6.259	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	3	0.0001	8.746	7.392	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	4	0.0060	8.746	8.932	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	5	0.0098	8.746	10.687	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	6	0.0127	8.746	11.176	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	7	0.0313	8.746	11.806	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	8	0.0023	8.746	13.014	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	9	0.0020	8.746	13.498	-38.4
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	6	10	0.0003	8.746	14.021	-38.4
									sum	0.1098			

(Ai	Tzi)	(Af	Tzf)	(type	n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	1	0.0036	8.942	0.000	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	2	0.0005	8.942	6.259	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	3	0.0018	8.942	7.392	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	4	0.0003	8.942	8.932	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	5	0.0043	8.942	10.687	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	6	0.0621	8.942	11.176	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	7	0.0086	8.942	11.806	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	8	0.0123	8.942	13.014	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	9	0.0616	8.942	13.498	-38.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	7	10	0.0002	8.942	14.021	-38.5
									sum	0.1553			

(Ai	Tzi)	(Af	Tzf)	(type	n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	1	0.0015	9.657	0.000	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	2	0.0091	9.657	6.259	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	3	0.0068	9.657	7.392	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	4	0.0026	9.657	8.932	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	5	0.0046	9.657	10.687	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	6	0.0036	9.657	11.176	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	7	0.0088	9.657	11.806	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	8	0.0246	9.657	13.014	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	9	0.0051	9.657	13.498	-37.5
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	8	10	0.0025	9.657	14.021	-37.5
									sum	0.0692			

(Ai	Tzi)	(Af	Tzf)	(type	n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	1	0.0000	10.365	0.000	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	2	0.0057	10.365	6.259	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	3	0.0006	10.365	7.392	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	4	0.0065	10.365	8.932	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	5	0.0001	10.365	10.687	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	6	0.0005	10.365	11.176	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	7	0.0086	10.365	11.806	-36.8
(21	0.5)	(22	1.0)	(n	1 2 3)	1.5+	0.0+	9	8	0.0137	10.365	13.014	-36.8

(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	9	9	0.0003	10.365	13.498	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	9	10	0.0120	10.365	14.021	-36.7
						sum	0.0480			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	1	0.0277	10.502	0.000	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	2	0.0038	10.502	6.259	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	3	0.0003	10.502	7.392	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	4	0.0043	10.502	8.932	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	5	0.0152	10.502	10.687	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	6	0.0107	10.502	11.176	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	7	0.0254	10.502	11.806	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	8	0.0434	10.502	13.014	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	9	0.0000	10.502	13.498	-36.7
(21 0.5)	(22 1.0)	(n 1 2 3)	1.5+	0.0+	10	10	0.0001	10.502	14.021	-36.7
						sum	0.1309			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	1	2.3831	0.266	0.000	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	2	0.0053	0.266	6.259	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	3	0.0050	0.266	7.392	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	4	0.0526	0.266	8.932	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	5	0.0033	0.266	10.687	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	6	0.0001	0.266	11.176	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	7	0.0430	0.266	11.806	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	8	0.0052	0.266	13.014	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	9	0.0001	0.266	13.498	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	10	0.0338	0.266	14.021	-46.9
						sum	2.5315			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	1	0.0050	3.718	0.000	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	2	0.6144	3.718	6.259	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	3	0.0271	3.718	7.392	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	4	0.8103	3.718	8.932	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	5	0.1387	3.718	10.687	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	6	0.0146	3.718	11.176	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	7	0.0107	3.718	11.806	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	8	0.0001	3.718	13.014	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	9	0.0016	3.718	13.498	-43.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	2	10	0.0003	3.718	14.021	-43.5
						sum	1.6228			
(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	1	0.0594	4.627	0.000	-42.6
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	2	0.2730	4.627	6.259	-42.6
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	3	0.6506	4.627	7.392	-42.6
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	4	0.0436	4.627	8.932	-42.6

(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	5	0.0333	4.627	10.687	-42.0
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	6	0.0484	4.627	11.176	-42.0
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	7	0.0575	4.627	11.806	-42.0
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	8	0.0015	4.627	13.014	-42.0
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	9	0.0446	4.627	13.498	-42.0
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	3	10	0.0009	4.627	14.021	-42.0
						sum	1.2128			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	1	0.0314	7.285	0.000	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	2	0.6246	7.285	6.259	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	3	0.6199	7.285	7.392	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	4	0.0900	7.285	8.932	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	5	0.2914	7.285	10.687	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	6	0.0543	7.285	11.176	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	7	0.0027	7.285	11.806	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	8	0.0920	7.285	13.014	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	9	0.0543	7.285	13.498	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	4	10	0.0235	7.285	14.021	-39.9
						sum	1.8841			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	1	0.0001	7.908	0.000	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	2	0.1774	7.908	6.259	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	3	0.2784	7.908	7.392	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	4	0.0752	7.908	8.932	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	5	0.0068	7.908	10.687	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	6	0.0801	7.908	11.176	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	7	0.0979	7.908	11.806	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	8	0.0023	7.908	13.014	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	9	0.0588	7.908	13.498	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	5	10	0.0937	7.908	14.021	-39.9
						sum	0.8707			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	1	0.0709	8.152	0.000	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	2	0.0158	8.152	6.259	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	3	0.1742	8.152	7.392	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	4	0.0127	8.152	8.932	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	5	0.1258	8.152	10.687	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	6	0.0578	8.152	11.176	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	7	0.0000	8.152	11.806	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	8	0.1860	8.152	13.014	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	9	0.0389	8.152	13.498	-39.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	6	10	0.0003	8.152	14.021	-39.9
						sum	0.6824			

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
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(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	1	0.4780	8.698	0.000	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	2	0.0283	8.698	6.259	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	3	0.0303	8.698	7.392	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	4	0.0133	8.698	8.932	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	5	0.0001	8.698	10.687	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	6	0.0008	8.698	11.176	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	7	0.0006	8.698	11.806	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	8	0.0129	8.698	13.014	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	9	0.0002	8.698	13.498	-38.5
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	7	10	0.0002	8.698	14.021	-38.5
							sum	0.5647		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	1	0.0151	8.790	0.000	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	2	0.0020	8.790	6.259	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	3	0.0151	8.790	7.392	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	4	0.1161	8.790	8.932	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	5	0.0455	8.790	10.687	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	6	0.4422	8.790	11.176	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	7	0.0293	8.790	11.806	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	8	0.1441	8.790	13.014	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	9	0.0040	8.790	13.498	-38.4
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	8	10	0.0299	8.790	14.021	-38.4
							sum	0.8433		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	1	0.0051	9.319	0.000	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	2	0.1755	9.319	6.259	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	3	0.0291	9.319	7.392	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	4	0.1985	9.319	8.932	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	5	0.2507	9.319	10.687	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	6	0.0627	9.319	11.176	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	7	0.0078	9.319	11.806	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	8	0.0006	9.319	13.014	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	9	0.1037	9.319	13.498	-37.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	9	10	0.0173	9.319	14.021	-37.9
							sum	0.8510		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	1	0.0063	9.888	0.000	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	2	0.0068	9.888	6.259	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	3	0.0099	9.888	7.392	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	4	0.0213	9.888	8.932	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	5	0.0616	9.888	10.687	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	6	0.0585	9.888	11.176	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	7	0.1809	9.888	11.806	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	8	0.1490	9.888	13.014	-37.3
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	10	9	0.0060	9.888	13.498	-37.3

```

( 21  0.5) ( 22  1.0) ( n  1 2  5)  2.5+  0.0+   10   10   0.0008   9.888   14.021  -37.5
                                sum  0.5011

                                total sum 20.6400

```

Below we compare the levels in the USDB Hamiltonian to experiment.

```
[7]: from IPython.display import IFrame
      IFrame("ne21b.eps.pdf", width=1280, height=720)
```

```
[7]: <IPython.lib.display.IFrame at 0x1eb720183a0>
```

0.1.5 HW13 question 7

In the previous problem, how does the sum over the lowest 10 $5/2+$ states compare to the average number of $0d_{5/2}$ neutrons calculated to be in the ground state of ^{22}Ne .

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	1	2.3831	0.266	0.000	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	2	0.0053	0.266	6.259	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	3	0.0050	0.266	7.392	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	4	0.0526	0.266	8.932	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	5	0.0033	0.266	10.687	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	6	0.0001	0.266	11.176	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	7	0.0430	0.266	11.806	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	8	0.0052	0.266	13.014	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	9	0.0001	0.266	13.498	-46.9
(21 0.5)	(22 1.0)	(n 1 2 5)	2.5+	0.0+	1	10	0.0338	0.266	14.021	-46.9
							sum	2.5315		

6	50										
N	NJ	Ex	2J	P	0d3	0d5	1s1	0d3	0d5	1s1	
1	1	0.000	0	1	0.15	1.46	0.39	0.41	3.20	0.39	

The occupation of ^{22}Ne predicts 3.20, while the sum over spectroscopic factors from the shell model calculation predicts 2.5315.

0.1.6 HW13 question 8

How do the spectroscopic factors for ^{21}O to ^{22}O change if the model space is increased to the full sd shell using the USDB Hamiltonian.

From shell:

```
! model space = sd
! interaction = usdb
```

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	1	1	0.3060	1.375	0.000	-26.0
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	2	1	0.0333	6.431	0.000	-20.9
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	3	1	0.0025	10.251	0.000	-17.9

(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	4	1	0.0006	11.013	0.000	-16.5
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	5	1	0.0008	11.823	0.000	-15.5
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	6	1	0.0000	13.899	0.000	-13.5
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	7	1	0.0022	15.495	0.000	-11.5
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	8	1	0.0000	15.673	0.000	-11.5
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	9	1	0.0000	17.224	0.000	-10.5
(21 2.5)	(22 3.0)	(n 2 0 1)	0.5+	0.0+	10	1	0.0000	19.939	0.000	-7.4
							sum	0.3454		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	1	1	0.0501	1.998	0.000	-25.4
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	2	1	0.0664	5.332	0.000	-22.0
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	3	1	0.0081	5.875	0.000	-21.5
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	4	1	0.0507	8.424	0.000	-18.9
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	5	1	0.0061	9.686	0.000	-17.7
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	6	1	0.0003	10.452	0.000	-16.9
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	7	1	0.0010	11.042	0.000	-16.3
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	8	1	0.0027	11.429	0.000	-15.9
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	9	1	0.0009	12.690	0.000	-14.7
(21 2.5)	(22 3.0)	(n 1 2 3)	1.5+	0.0+	10	1	0.0003	13.183	0.000	-14.2
							sum	0.1866		

(Ai Tzi)	(Af Tzf)	(type n,l,2j)	Ji	Jf	ni	nf	C^2S	Ei	Ef	
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	1	1	5.1457	0.000	0.000	-27.5
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	2	1	0.1865	3.063	0.000	-24.5
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	3	1	0.0287	5.161	0.000	-22.5
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	4	1	0.0216	7.154	0.000	-20.5
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	5	1	0.0013	9.198	0.000	-18.5
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	6	1	0.0078	9.544	0.000	-17.8
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	7	1	0.0616	10.582	0.000	-16.8
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	8	1	0.0009	10.912	0.000	-16.4
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	9	1	0.0044	11.154	0.000	-16.2
(21 2.5)	(22 3.0)	(n 1 2 5)	2.5+	0.0+	10	1	0.0033	12.049	0.000	-15.5
							sum	5.4618		

total sum 5.9938

The transfer process picks up spectroscopic factors from the J=1/2 and J=3/2 transitions, but the sum comes out to 6 still.

N	NJ	Ex	2J	P	0d3	0d5	1s1	0d3	0d5	1s1
1	1	0.000	5	1	0.00	0.00	0.00	0.14	4.63	0.23

Occupation in ground state 21O is 4.63, close to 5.

0.1.7 HW13 question 9

An experiment is carried out at FRIB to knock out a proton from the 7/2- ground state of 55Co going to 0+, 2+, 4+ and 6+ states in 54Fe. In the 0f7/2 model space what are the spectroscopic

factors for these. Hint: use the sum rule for adding a proton to the 54Fe states to make 55Co.

Triangle rule for $(7/2), (0,2,4,6) \rightarrow 7/2, (3/2,5/2,7/2,9/2,11/2), (1/2,3/2,5/2,7/2,9/2,11/2,13/2,15/2), (5/2,7/2,9/2,11/2,13/2,15/2,17/2,19/2)$

Sum rule is

$$\frac{2(2J_i + 1)}{2J_f + 1}?$$

From `shell` I get:

```
! model space = fp
```

```
! interaction = usdb
```

(Ai	Tzi)	(Af	Tzf)	(type	n,l,2j)	Ji	Jf	ni	nf	C ² S	Ei	Ef	
(54	1.0)	(55	0.5)	(p	1 3 7)	0.0+	3.5-	1	1	0.2500	0.000	0.000	156.1
(54	1.0)	(55	0.5)	(p	1 3 7)	2.0+	3.5-	1	1	1.2500	0.225	0.000	156.1
(54	1.0)	(55	0.5)	(p	1 3 7)	4.0+	3.5-	1	1	2.2500	0.237	0.000	156.1
(54	1.0)	(55	0.5)	(p	1 3 7)	6.0+	3.5-	1	1	3.2500	0.237	0.000	156.1
										sum	7.0000		
										total sum	7.0000		

0.1.8 HW13 question 10

For the previous problem the answer for going to the 6+ state in 54Fe is $C^2S = (13/4)$. What is the spectroscopic factor C^2S for going from the 7/2- ground state of 55Co the 6+ T=1 state of 54Co that is the isobaric analogue of the 6+ state in 54Fe.

I think it is $\frac{1}{2T+2} S_{55Co \rightarrow 54Fe} = 1/4 * 13/4 = 13/8$.

0.1.9 HW13 question 11

Use the USDB Hamiltonian to calculate the spectroscopic factors for the the second 1+ state in 20Na to the 1/2+ ground state and 5/2+ first excited states of 19F. This state is associated with the state observed experimentally at 3.001 MeV in 20Na. Calculate the proton decay width of this state using the experimental value for the proton decay Q value. Compare the obtained width to experiment.

I cannot get the spectroscopic factors from `shell`. My inputs are a 1+ 20Na wavefunction to compute the overlaps with 1/2+ and 5/2+ 19F wavefunctions. I give the “den” option initial min J, max J = 0.5,2.5 and then final min J, max J = 1.0. I have tried using the “1” for the spectroscopic factor calculation as well as “2” for the two nucleon transfer amplitude calculation, but “2” gives no .lsf output and “1” gives zero possible transitions (a file with total sum = 0.000).

[]: