hw07

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0.1 This Jupyter notebook answers HW07 questions for PHY 981 Nuclear Structure.

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0.1.1 HW07 question 5

The first bound state for (0,2,5/2) does not appear until `VN=1.24`. The first bound state for (1,0,1/2) does not appear until `VN=1.25`. Below, we tabulate the results for each neutron orbit per change in VN.

Neutron orbit (1,0,1/2)

VN	s-p energy (MeV)	rms radius (fm)
1.25	-0.479	7.344
1.26	-0.544	7.044
1.28	-0.684	6.546
1.29	-0.760	6.338
1.30	-0.838	6.150
1.31	-0.919	5.980
1.32	-1.004	5.825
1.33	-1.092	5.684
1.34	-1.182	5.555
1.35	-1.275	5.436
1.36	-1.371	5.326
1.37	-1.470	5.223
1.38	-1.572	5.128
1.39	-1.676	5.039
1.40	-1.782	4.956
1.41	-1.891	4.878
1.42	-2.003	4.805

Neutron orbit (0,2,5/2)

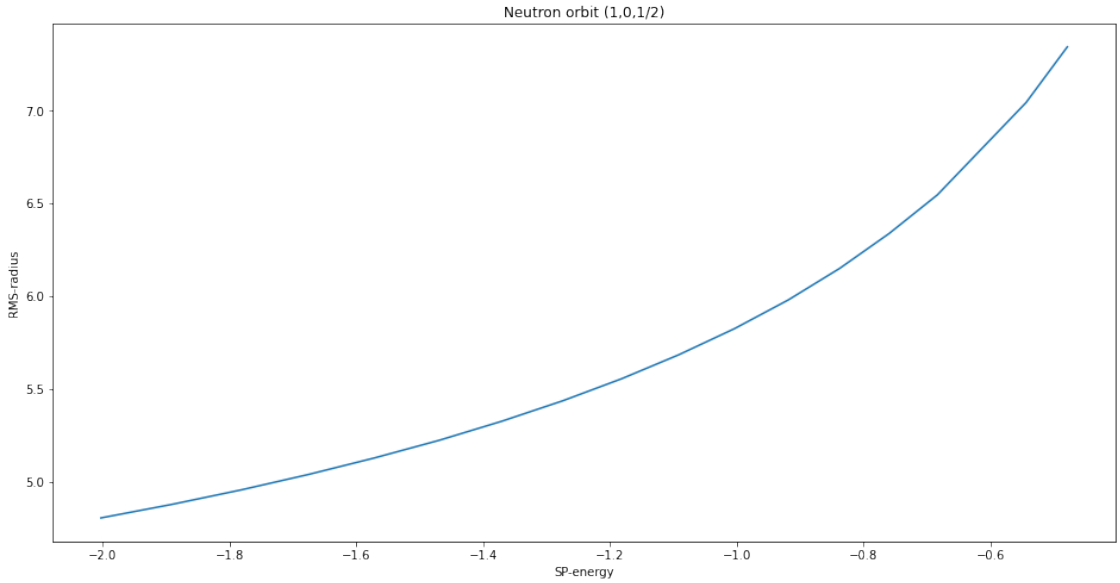
VN	s-p energy (MeV)	rms radius (fm)
1.24	-0.255	4.230
1.25	-0.400	4.118

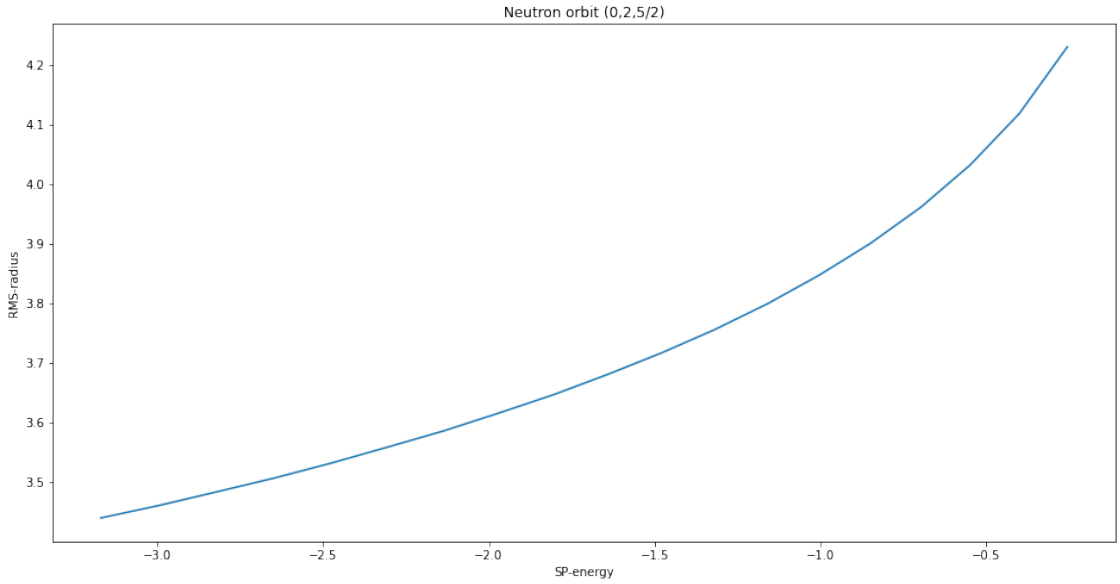
VN	s-p energy (MeV)	rms radius (fm)
1.26	-0.548	4.032
1.27	-0.697	3.961
1.28	-0.850	3.900
1.29	-1.004	3.847
1.30	-1.160	3.799
1.31	-1.318	3.756
1.32	-1.478	3.717
1.33	-1.640	3.681
1.34	-1.803	3.647
1.35	-1.969	3.616
1.36	-2.136	3.586
1.37	-2.304	3.559
1.38	-2.475	3.532
1.39	-2.646	3.507
1.40	-2.819	3.484
1.41	-2.994	3.461
1.42	-3.170	3.440

Maximum single particle energy for the (1,0,1/2) orbit to be a halo state is around -1.676 MeV, at which point the RMS radius is 5.039 fm. This is computed at a `VN=1.39`. At single particle energies below this point (closer to zero) the bound states are considered halo states; above this point, the bound states are not halo states.

[8]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

data1 = pd.read_csv('1-0-1.txt', sep=' ')
data2 = pd.read_csv('0-2-5.txt', sep=' ')

fig = plt.figure(figsize=(16,8))
sns.lineplot(x='SP-energy', y='RMS-radius', data=data1)
plt.title('Neutron orbit (1,0,1/2)')

fig = plt.figure(figsize=(16,8))
sns.lineplot(x='SP-energy', y='RMS-radius', data=data2)
plt.title('Neutron orbit (0,2,5/2)')
```

[8]:
```
Text(0.5, 1.0, 'Neutron orbit (0,2,5/2)')
```





Change VN to make deeper well to get bound states

proton decay width will not depend on potential depth (change e.g. diff,radius instead)

0.1.2 HW07 question 6

One neutron separation energy for 25O is -0.757 MeV

Here is the output I get from `wspot` for 25O in the 0d3 state, fixing the energy at 0.757 and varying VN to find a resonance.

```
ws paramters, v0,v1,r0,a0,vs,rc:

-51.000 -33.000   1.270   0.670  22.000   1.200
input: iat,izt,iap,izp =  25  8  1  0

input: emin,emax,vnmin,vnmax =      0.757     0.757     0.500     2.000
defaults:  vn,adif,rr0,vnls,r0c =   1.0000  0.6700  1.2700  1.0000  1.2000
input:     vn,adif,rr0,vnls,r0c =   0.0000  0.0000  0.0000  0.0000  0.0000

resonance at vn =   1.062
resonance at vn =   1.063
resonance at vn =   1.063
resonance at ei =   0.757 with  G =    0.08516 MeV    half-life (ps) =
0.5354E-08
resonance at ei =   0.755 with  G =    0.07835 MeV    half-life (ps) =
0.5820E-08
resonance at ei =   0.755 with  G =    0.07835 MeV    half-life (ps) =
0.5820E-08
```

The decay width is 78.35 keV. I can't find the experimental data to compare with because I don't have access to this paper (behind APS paywall).

0.1.3 HW07 question 7

I think that the Γ I should be looking for is 101 keV, but I can't seem to find it. The closest I come is with `VN=1.910`, `adiff=4.5`, and `rr0=0.85`, which gives me a `G=62.76 keV`.

```
ws paramters, v0,v1,r0,a0,vs,rc:
-51.000 -33.000   1.270   0.670  22.000   1.200
input: iat,izt,iap,izp =  19 11  1  1

input: emin,emax,vnmin,vnmax =      0.745     0.745     0.500     2.000
defaults:  vn,adif,rr0,vnls,r0c =   1.0000  0.6700  1.2700  1.0000  1.2000
input:     vn,adif,rr0,vnls,r0c =   0.0000  4.5000  0.8500  0.0000  0.0000

resonance at vn =   1.910
resonance at vn =   1.910
resonance at vn =   1.910
resonance at ei =   0.745 with  G =    0.08381 MeV    half-life (ps) =
0.5441E-08
resonance at ei =   0.743 with  G =    0.06035 MeV    half-life (ps) =
0.7557E-08
resonance at ei =   0.745 with  G =    0.06276 MeV    half-life (ps) =
0.7266E-08
resonance at ei =   0.745 with  G =    0.06276 MeV    half-life (ps) =
0.7266E-08
```

[ ]: