CGMCloudyRun

March 17, 2021

[1]:

```
import pandas as pd
import numpy as np
import pyCloudy as pc
import os
pc.log_.level = 3;
```

```
warng pyCloudy config: pyCloudy works better with PyNeb
```

[2]:

```
from __future__ import print_function
from ipywidgets import interact, interactive, fixed, interact_manual
import ipywidgets as widgets
from ipywidgets import Button, Layout
from IPython.display import display
```

This will be the style for the button font

[3]:

```
%%html
<style>.myclass { color:white ; font-size:150%}
```

```
<IPython.core.display.HTML object>
```

# Create Input Script

[4]:

```
# Define path to executable
dir_ = './'
make='ASTR302' #will also be punch prefix
pathtorun='{0}{1}'.format(dir_, make) #path to input script
pathtoexec='/Users/danielpiacitelli/nublado/c17.02/source/cloudy.exe' #path to␣
 ↪Cloudy executable
```

Temperature command

[5]:

```
Topt='CONSTANT TEMPERATURE' #can also be SET TEMP
```

Choose of which lines emisitivity is needed

[6]:

```
emis = ['H  1  4861.33A',
        'H  1  6562.81A',
        'O 6  1031.00A',
        'O  6 1037.62A']
```

[ ]:

```
```

[7]:

```
opti = ['CMB redshift 0.2000000',
         'no molecules',
         'table HM96',
         'Print column densities on'] #mostly miscellaneous manipulations
```

[8]:

```
def createinput(Temperature, HDensity, Metallicity):
    T=Temperature #K Linear
    H=HDensity #Log /cm^3
    M=Metallicity #Log
    distance= 300000.0 # Linear kpc and mostly meaningless for CGM purposes
    manip= ['{0} {1}'.format('metals', str(M))] + ['{0} {1} {2}'.format(Topt, '1e0'+str(T), 'K linear')] + opti
    stop= ['proton column density 15.500000','temperature = 10000K [linear]'] #stopping criteria
    run = pc.CloudyInput(pathtorun);
    run.set_cste_density(H, ff = None );run.set_distance(dist=distance, unit='kpc', linear=True);
    run.set_abund(nograins = True);
    run.set_iterate() # (0) = no iteration, () = 1 iteration, (N) = N iterations
    run.set_emis_tab(emis); #insert list of desired lines
    run.set_other(manip);
    run.set_stop(stop); #will insert our stopping criteria
    run.print_input(to_file = True, verbose = False)
    return run
print("Temperature is in Kelvin and Linear, HDensity is in /cm^3 and Log, Metallicity is Log")
T=widgets.IntSlider(value=5,min=0,step=1,max=8); H=widgets.FloatSlider(value=-2.5,min=-6,max=1,step=0.25); M=widgets.IntSlider(value=-1,min=-5,max=1,step=1);
ui = widgets.HBox([T, H, M])
T.style.handle_color = '#738678';H.style.handle_color = '#738678';M.style.handle_color = '#738678';
interact(createinput,Temperature=T,HDensity=H,Metallicity=M);
```

```
Temperature is in Kelvin and Linear, HDensity is in /cm^3 and Log, Metallicity
is Log
```

```
interactive(children=(IntSlider(value=5, description='Temperature', max=8, style=SliderStyle(ha
```

[9]:

```
b = Button(description='Run Cloudy with last run file',layout=Layout(width='50%', height='80px'))
b.style.button_color = '#738678';b.add_class('myclass')
```

```
output = widgets.Output()
def runCloudy(b):
    run = pc.CloudyInput(pathtorun);
    pc.config.cloudy_exe = pathtoexec;
    pc.log_.timer('Starting Cloudy', quiet = True)
    run.run_cloudy()
    with output:
        pc.log_.message('Ran {0}'.format(make))
        pc.log_.timer('Cloudy ended after seconds:')
display(b, output)
b.on_click(runCloudy)
```

```
Button(description='Run Cloudy with last run file', layout=Layout(height='80px', width='50%'),
```

```
Output()
```

[ ]:

```

```

0.1 Pandas Tables

Returns ovr table with Temperature, Htot, hydrogen density, e density, and OVI density

[11]:

```
vari='.ovr'
table=pd.read_csv('../nublado/runs/ASTR302.ovr',delimiter='        ')
ovr=table.loc[:,['#depth','Te','Htot','hden','eden','O5']]
Temp=np.log10(ovr.loc[1,"Te"])
ovr
```

[11]:

```
          #depth           Te          Htot      hden      eden            O5
0   2.500000e+16  100000000.0  1.501000e-34  0.003162  0.003798  5.350200e-16
1   9.750000e+16  100000000.0  1.501000e-34  0.003162  0.003798  5.350200e-16
2   1.877500e+17  100000000.0  1.501000e-34  0.003162  0.003798  5.350200e-16
3   2.689750e+17  100000000.0  1.501000e-34  0.003162  0.003798  5.350200e-16
4   3.420780e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
5   4.078700e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
6   4.670830e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
7   5.203750e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
8   5.683370e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
9   6.115040e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
10  6.503530e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
11  6.853180e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
12  7.167860e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
13  7.451080e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
14  7.705970e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
15  7.935370e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
16  8.141830e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
```

```
17  8.327650e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
18  8.494890e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
19  8.645400e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
20  8.780860e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
21  8.902770e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
22  9.012500e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
23  9.114470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
24  9.214470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
25  9.314470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
26  9.414470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
27  9.514470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
28  9.614470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
29  9.714470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
30  9.814470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
31  9.914470e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
32  9.982240e+17  100000000.0  1.501000e-34  0.003162  0.003798  1.175500e-36
```

Returns emis table with Emissivity of H 1 4861.33A, H 1 6562.81A, O 6 1031.00A, O 6 1037.62A

[213]:

```
vari='.emis'
emis=pd.read_csv('{0}{1}'.format(make, vari),delimiter='        ')
emis.columns=['#depth','H1-4861.33A', 'H1-6562.81A', 'O6-1031.91A','O6-1037.
 ↪62A']

#isolates the 1031 and 1037 lines as independent tables
tenthirtyone= emis.loc[:,'O6-1031.91A']
tenthirtyseven= emis.loc[:,'O6-1037.62A']

#tenthirtyone
#tenthirtyseven
emis
```

[213]:

```
          #depth   H1-4861.33A   H1-6562.81A   O6-1031.91A   O6-1037.62A
0   2.500000e+16  1.537200e-35  4.178600e-35  2.162700e-39  1.075700e-39
1   9.750000e+16  1.537200e-35  4.178700e-35  2.162700e-39  1.075700e-39
2   1.877500e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
3   2.689750e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
4   3.420780e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
5   4.078700e+17  1.537300e-35  4.178700e-35  0.000000e+00  0.000000e+00
6   4.670830e+17  1.537300e-35  4.178700e-35  2.163600e-39  1.076200e-39
7   5.203750e+17  1.537300e-35  4.178700e-35  0.000000e+00  0.000000e+00
8   5.683370e+17  1.537300e-35  4.178700e-35  2.163600e-39  1.076200e-39
9   6.115040e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
10  6.503530e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
11  6.853180e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
12  7.167860e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
```

```
13  7.451080e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
14  7.705970e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
15  7.935370e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
16  8.141830e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
17  8.327650e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
18  8.494890e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
19  8.645400e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
20  8.780860e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
21  8.902770e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
22  9.012500e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
23  9.114470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
24  9.214470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
25  9.314470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
26  9.414470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
27  9.514470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
28  9.614470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
29  9.714470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
30  9.814470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
31  9.914470e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
32  9.982240e+17  1.537300e-35  4.178700e-35  2.162700e-39  1.075700e-39
```

Returns eleH table with H H+ H2 probabilites for each zone

[214]:
```
#returns eleH table with H        H+        H2 probabilites for each zone

vari='.ele_H'
eleH=pd.read_csv('{0}{1}'.format(make, vari),delimiter='        ')
#print(eleH)
#returns eleO table with␣
 ↪O        O+        O+2        O+3        O+4        O+5        O+6        O+7        O+8
 ↪probabilities for each zone
vari='.ele_O'
eleO=pd.read_csv('{0}{1}'.format(make,vari),delimiter='        ')
eleO
```

[214]:
```
          #depth    O           O+           O+2           O+3           O+4  \
0   2.500000e+16  0.0  4.970000e-34  2.570000e-27  1.960000e-21  5.350000e-16
1   9.750000e+16  0.0  0.000000e+00  2.570000e-27  1.960000e-21  5.350000e-16
2   1.877500e+17  0.0  0.000000e+00  0.000000e+00  1.960000e-21  5.350000e-16
3   2.689750e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  5.350000e-16
4   3.420780e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
5   4.078700e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
6   4.670830e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
7   5.203750e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
8   5.683370e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
9   6.115040e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
10  6.503530e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
```

```
11  6.853180e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
12  7.167860e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
13  7.451080e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
14  7.705970e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
15  7.935370e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
16  8.141830e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
17  8.327650e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
18  8.494890e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
19  8.645400e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
20  8.780860e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
21  8.902770e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
22  9.012500e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
23  9.114470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
24  9.214470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
25  9.314470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
26  9.414470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
27  9.514470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
28  9.614470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
29  9.714470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
30  9.814470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
31  9.914470e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
32  9.982240e+17  0.0  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00

             O+5           O+6       O+7    O+8  O[1]  O[2]  O[3]
0   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
1   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
2   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
3   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
4   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
5   0.000000e+00  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
6   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
7   0.000000e+00  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
8   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
9   3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
10  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
11  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
12  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
13  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
14  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
15  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
16  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
17  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
18  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
19  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
20  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
21  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
22  3.770000e-11  2.220000e-07  0.000561  0.999   0.0   0.0   0.0
```

```
23   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
24   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
25   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
26   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
27   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
28   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
29   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
30   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
31   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
32   3.770000e-11   2.220000e-07   0.000561   0.999   0.0   0.0   0.0
```

Returns table OVI_prob with OVI probabilites for each zone

```
[215]: OVI_prob = eleO.loc[:,['#depth', 'O+5']]
       OVI_prob
```

```
[215]:          #depth           O+5
       0    2.500000e+16   3.770000e-11
       1    9.750000e+16   3.770000e-11
       2    1.877500e+17   3.770000e-11
       3    2.689750e+17   3.770000e-11
       4    3.420780e+17   3.770000e-11
       5    4.078700e+17   0.000000e+00
       6    4.670830e+17   3.770000e-11
       7    5.203750e+17   0.000000e+00
       8    5.683370e+17   3.770000e-11
       9    6.115040e+17   3.770000e-11
       10   6.503530e+17   3.770000e-11
       11   6.853180e+17   3.770000e-11
       12   7.167860e+17   3.770000e-11
       13   7.451080e+17   3.770000e-11
       14   7.705970e+17   3.770000e-11
       15   7.935370e+17   3.770000e-11
       16   8.141830e+17   3.770000e-11
       17   8.327650e+17   3.770000e-11
       18   8.494890e+17   3.770000e-11
       19   8.645400e+17   3.770000e-11
       20   8.780860e+17   3.770000e-11
       21   8.902770e+17   3.770000e-11
       22   9.012500e+17   3.770000e-11
       23   9.114470e+17   3.770000e-11
       24   9.214470e+17   3.770000e-11
       25   9.314470e+17   3.770000e-11
       26   9.414470e+17   3.770000e-11
       27   9.514470e+17   3.770000e-11
       28   9.614470e+17   3.770000e-11
       29   9.714470e+17   3.770000e-11
```

```
30  9.814470e+17  3.770000e-11
31  9.914470e+17  3.770000e-11
32  9.982240e+17  3.770000e-11
```

0.2 Calculations

Returns single float of OVI fraction, electron density, emissivity of OVI1031/OVI1037, and total emissivity of OVI

[216]:
```
O6frac=np.average(OVI_prob.loc[:,'O+5'].values)
#O6total=np.average(ovr.loc[:,'eden'].values)
eden=np.average(ovr.loc[:,'eden'].values)
emis1031=np.average(tenthirtyone.values)
emis1037=np.average(tenthirtyseven.values)
hden=np.average(ovr.loc[:,'hden'].values)

print('The OVI fraction is',O6frac)
#print('OVI total is',O6total)
print('The electron density is',eden)
print('The emissivity of OVI1031 is',emis1031)
print('The emissivity of OVI1037 is',emis1037)
print('The total emissivity of OVI is',emis1037+emis1037)
```

```
The OVI fraction is 3.5415151515151514e-11
The electron density is 0.0037975969696969697
The emissivity of OVI1031 is 2.031681818181818e-39
The emissivity of OVI1037 is 1.0105363636363635e-39
The total emissivity of OVI is 2.021072727272727e-39
```

Gives number of oxygnVI and Column Densities

[217]:
```
Noxy_Sol=10**-3.309
Zsol=10**-1
nOVI=O6frac*Zsol*Noxy_Sol
print('nOVI is',nOVI)
length=ovr.loc[:,"#depth"].max() -  ovr.loc[:,"#depth"].min()
N_OVI=nOVI*length
print('Column density of OVI is',N_OVI)
```

```
nOVI is 1.7385576813925667e-15
Column density of OVI is 1692.0060609155994
```

0.3 This will give you the list of classes for th cloudy output

[10]:
```
Mod = pc.CloudyModel(pathtorun);
# dir(Mod) #remove # at beginning to print list
```

```
     CloudyModel ./ASTR302: Creating CloudyModel for ./ASTR302
     CloudyModel ./ASTR302: ./ASTR302.rad read
```

```
    CloudyModel ./ASTR302: Number of zones: 33
    CloudyModel ./ASTR302: ./ASTR302.phy read
    CloudyModel ./ASTR302: ./ASTR302.ele_H read
    CloudyModel ./ASTR302: filling H with 3 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_He read
    CloudyModel ./ASTR302: filling He with 3 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_C read
    CloudyModel ./ASTR302: filling C with 13 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_N read
    CloudyModel ./ASTR302: filling N with 8 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_O read
    CloudyModel ./ASTR302: filling O with 12 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_Ne read
    CloudyModel ./ASTR302: filling Ne with 11 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_Ar read
    CloudyModel ./ASTR302: filling Ar with 19 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_S read
    CloudyModel ./ASTR302: filling S with 17 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_Cl read
    CloudyModel ./ASTR302: filling Cl with 18 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_Fe read
    CloudyModel ./ASTR302: filling Fe with 27 columns
    CloudyModel ./ASTR302: ./ASTR302.ele_Si read
    CloudyModel ./ASTR302: filling Si with 15 columns
    CloudyModel ./ASTR302: ./ASTR302.emis read
    CloudyModel ./ASTR302: Number of emissivities: 4
    CloudyModel ./ASTR302: ./ASTR302.cont read
```

[11]:

```
Mod.print_lines()
Mod.print_stats()
```

```
H__1_486133A 1.931812e+44
H__1_656281A 5.251109e+44
O__6_103100A 2.411241e+40
O__6_103762A 1.199328e+40
 Name of the model: ./ASTR302
 R_in (cut) = 1.000e+30 (1.000e+30), R_out (cut) = 1.000e+30 (1.000e+30)
 H+ mass = 3.34e+19, H mass = 3.34e+19 N zones: 33
 <H+/H> = 1.00, <He++/He> = 1.00, <He+/He> = 0.00
 <O+++/O> = 0.00, <O++/O> = 0.00, <O+/O> = 0.00
 <N+++/N> = 0.00, <N++/N> = 0.00, <N+/N> = 0.00
 T(O+++) = 100000000, T(O++) = 100000000, T(O+) = 100000000
 <ne> = 0,  <nH> = 0, T0 = 100000000, t2=0.0000
 <log U> = -2.11
```

0.4 Save Simulation data for future use

[170]:
```
# run this once
location=0
```

[171]:
```
# run this once
SimuDatKeyset=['H Density Log /cm^3','e Density Log /cm^3','OVI␣
↪Probability','OVI 1031+1037 Emis']
SimnDat=[hden, eden,O6frac,emis1031+emis1037]
matrix={SimuDatKeyset[0]:[SimnDat[0]],SimuDatKeyset[1]:
↪[SimnDat[1]],SimuDatKeyset[2]:[SimnDat[2]],SimuDatKeyset[3]:[SimnDat[3]]}
PastSimulationData=pd.DataFrame(data=matrix,index={f"Temp:1e{Temp:1.1f} K ,␣
↪hden: {np.log10(hden):1.1f}"}).transpose()
PastSimulationData
```

[171]:
```
                     Temp:1e7.0 K , hden: -2.5
H Density Log /cm^3                3.162300e-03
e Density Log /cm^3                3.797497e-03
OVI Probability                    3.160000e-07
OVI 1031+1037 Emis                 5.741494e-35
```

[198]:
```
SimnDat=[hden, eden,O6frac,emis1031+emis1037]
```

This will add new sim data to table

[221]:
```
location=location+1
PastSimulationData.insert(location,f"Temp:1e{Temp:1.1f} K , hden: {np.
↪log10(hden):1.1f}",SimnDat)
```

[222]:
```
PastSimulationData
```

[222]:
```
                     Temp:1e7.0 K , hden: -2.5  Temp:1e7.0 K , hden: -2.0  \
H Density Log /cm^3                3.162300e-03               1.000000e-02
e Density Log /cm^3                3.797497e-03               1.200900e-02
OVI Probability                    3.160000e-07               3.170000e-07
OVI 1031+1037 Emis                 5.741494e-35               5.555100e-34

                     Temp:1e8.0 K , hden: -2.5
H Density Log /cm^3                1.000000e-02
e Density Log /cm^3                1.200900e-02
OVI Probability                    3.170000e-07
OVI 1031+1037 Emis                 5.555100e-34
```

0.4.1 Save PastSimulationData as csv file

[ ]:
```
PastSimulationData.to_csv('./CloudyDataTables/SimulationData.csv',index=True)
```

[220]:

```
```

[ ]:

```
```