Using_pyCloudy_1

August 6, 2025

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
import os
home_dir = os.environ['HOME'] + '/'
```

[2]:
```
import pyCloudy as pc
```

```
warng pyCloudy config: pyCloudy works better with matplotlib Triangulation
```

[3]:
```
# Define verbosity to high level (will print errors, warnings and messages)
pc.log_.level = 3
```

[4]:
```
# The directory in which we will have the model
# You may want to change this to a different place so that the current directory
# will not receive all the Cloudy files.
dir_ = '/tmp/models/'
```

[5]:
```
# Define some parameters of the model:
model_name = 'model_1'
full_model_name = '{0}{1}'.format(dir_, model_name)
dens = 2. #log cm-3
Teff = 45000. #K
qH = 47. #s-1
r_min = 5e17 #cm
dist = 1.26 #kpc
```

[6]:
```
# these are the commands common to all the models (here only one ...)
options = ('no molecules',
           'no level2 lines',
           'no fine opacities',
           'atom h-like levels small',
           'atom he-like levels small',
           'COSMIC RAY BACKGROUND',
           'element limit off -8',
           'print line optical depth',
           )
```

[7]:
```
emis_tab_c13 = ['H  1  4861',
            'H  1  6563',
            'He 1  5876',
            'N  2  6584',
            'O  1  6300',
            'O II  3726',
            'O II  3729',
            'O  3  5007',
            'TOTL  4363',
            'S II  6716',
            'S II 6731',
            'Cl 3 5518',
            'Cl 3 5538',
            'O  1 63.17m',
            'O  1 145.5m',
            'C  2 157.6m']
```

[ ]:
```
emis_tab_17 = ['H  1  4861.33A',
            'H  1  6562.81A',
            'Ca B  5875.64A',
            'N  2  6583.45A',
            'O  1  6300.30A',
            'O  2  3726.03A',
            'O  2  3728.81A',
            'O  3  5006.84A',
            'BLND  4363.00A',
            'S  2  6716.44A',
            'S  2  6730.82A',
            'Cl 3  5517.71A',
            'Cl 3  5537.87A',
            'O  1  63.1679m',
            'O  1  145.495m',
            'C  2  157.636m']
```

[24]:
```
emis_tab = ['H  1  4861.32A',
            'H  1  6562.80A',
            'Ca B  5875.64A',
            'N  2  6583.45A',
            'O  1  6300.30A',
            'O  2  3726.03A',
            'O  2  3728.81A',
            'O  3  5006.84A',
            'O  3  4363.21A',
            'O 3R  4363.00A',
            'O 3C  4363.00A',
            'S  2  6716.44A',
            'S  2  6730.82A',
```

```
            'Cl 3  5517.71A',
            'Cl 3  5537.87A',
            'O  1  63.1679m',
            'O  1  145.495m',
            'C  2  157.636m']
```

[25]:
```
abund = {'He' : -0.92, 'C' : 6.85 - 12, 'N' : -4.0, 'O' : -3.40, 'Ne' : -4.00,
         'S' : -5.35, 'Ar' : -5.80, 'Fe' : -7.4, 'Cl' : -7.00}
```

[26]:
```
# Defining the object that will manage the input file for Cloudy
c_input = pc.CloudyInput(full_model_name)
```

[27]:
```
# Filling the object with the parameters
# Defining the ionizing SED: Effective temperature and luminosity.
# The lumi_unit is one of the Cloudy options, like "luminosity solar", "q(H)",␣
 ↪"ionization parameter", etc...
c_input.set_BB(Teff = Teff, lumi_unit = 'q(H)', lumi_value = qH)
```

[28]:
```
# Defining the density. You may also use set_dlaw(parameters) if you have a␣
 ↪density law defined in dense_fabden.cpp.
c_input.set_cste_density(dens)
```

[29]:
```
# Defining the inner radius. A second parameter would be the outer radius␣
 ↪(matter-bounded nebula).
c_input.set_radius(r_in=np.log10(r_min))
c_input.set_abund(ab_dict = abund, nograins = True)
c_input.set_other(options)
c_input.set_iterate() # (0) for no iteration, () for one iteration, (N) for N␣
 ↪iterations.
c_input.set_sphere() # () or (True) : sphere, or (False): open geometry.
c_input.set_emis_tab(emis_tab) # better use read_emis_file(file) for long list␣
 ↪of lines, where file is an external file.
c_input.set_distance(dist=dist, unit='kpc', linear=True) # unit can be 'kpc',␣
 ↪'Mpc', 'parsecs', 'cm'. If linear=False, the distance is in log.
```

[30]:
```
# Writing the Cloudy inputs. to_file for writing to a file (named by␣
 ↪full_model_name). verbose to print on the screen.
c_input.print_input(to_file = True, verbose = False)
```

```
    CloudyInput: Input writen in /tmp/models/model_1.in
```

[31]:
```
# Printing some message to the screen
pc.log_.message('Running {0}'.format(model_name), calling = 'test1')
```

```
    test1: Running model_1
```

[32]:
```
# Tell pyCloudy where your cloudy executable is:
pc.config.cloudy_exe = '/usr/local/Cloudy/c25.00_rc2/source/cloudy.exe'
```

```
    _Config: cloudy_exe set to /usr/local/Cloudy/c25.00_rc2/source/cloudy.exe
```

[33]:
```
# Running Cloudy with a timer. Here we reset it to 0.
pc.log_.timer('Starting Cloudy', quiet = True, calling = 'test1')
c_input.run_cloudy()
pc.log_.timer('Cloudy ended after seconds:', calling = 'test1')
```

```
    run_cloudy: running:  /usr/local/Cloudy/c25.00_rc2/source/cloudy.exe -p
model_1
    run_cloudy: ending:  /usr/local/Cloudy/c25.00_rc2/source/cloudy.exe -p
model_1
   test1: Cloudy ended after seconds: in 33.35822319984436
```

[34]:
```
# Reading the Cloudy outputs in the Mod CloudyModel object
Mod = pc.CloudyModel(full_model_name)
```

```
    CloudyModel /tmp/models/model_1: Creating CloudyModel for
/tmp/models/model_1
    CloudyModel /tmp/models/model_1: Li abundance not defined
    CloudyModel /tmp/models/model_1: Be abundance not defined
    CloudyModel /tmp/models/model_1: B abundance not defined
    CloudyModel /tmp/models/model_1: Sc abundance not defined
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.rad read
    CloudyModel /tmp/models/model_1: Number of zones: 118
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.phy read
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_H read
    CloudyModel /tmp/models/model_1: filling H with 3 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_He read
    CloudyModel /tmp/models/model_1: filling He with 3 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_C read
    CloudyModel /tmp/models/model_1: filling C with 13 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_N read
    CloudyModel /tmp/models/model_1: filling N with 8 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_O read
    CloudyModel /tmp/models/model_1: filling O with 12 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_Ne read
    CloudyModel /tmp/models/model_1: filling Ne with 11 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_Ar read
    CloudyModel /tmp/models/model_1: filling Ar with 19 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_S read
    CloudyModel /tmp/models/model_1: filling S with 17 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_Cl read
    CloudyModel /tmp/models/model_1: filling Cl with 18 columns
    CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_Fe read
    CloudyModel /tmp/models/model_1: filling Fe with 27 columns
```

```
CloudyModel /tmp/models/model_1: /tmp/models/model_1.ele_Si read
CloudyModel /tmp/models/model_1: filling Si with 15 columns
CloudyModel /tmp/models/model_1: /tmp/models/model_1.emis read
CloudyModel /tmp/models/model_1: Number of emissivities: 18
CloudyModel /tmp/models/model_1: /tmp/models/model_1.cont read
```

[35]:
```
# Use TAB to know all the methods and variables for CloudyModel class
# Mod.TAB
dir(Mod) # This is the online answering way
# Description of this class is available here: http://pythonhosted.org//
 ↪pyCloudy/classpy_cloudy_1_1c1d_1_1cloudy__model_1_1_cloudy_model.html
```

[35]:
```
['C3D_comments',
 'ColDens',
 'ColDens_cut',
 'H0_mass',
 'H_mass',
 'H_mass_cut',
 'H_mass_full',
 'Hbeta',
 'Hbeta_cut',
 'Hbeta_full',
 'Hbeta_label',
 'Hp_mass',
 'Phi',
 'Phi0',
 'Q',
 'Q0',
 'T0',
 'Teff',
 '_CloudyModel__H_mass_cut',
 '_CloudyModel__Hbeta_cut',
 '_CloudyModel__depth_in_cut',
 '_CloudyModel__depth_out_cut',
 '_CloudyModel__r_in_cut',
 '_CloudyModel__r_out_cut',
 '_CloudyModel__r_range',
 '__class__',
 '__delattr__',
 '__dict__',
 '__dir__',
 '__doc__',
 '__eq__',
 '__format__',
 '__ge__',
 '__getattribute__',
 '__getstate__',
```

```
'__gt__',
'__hash__',
'__init__',
'__init_subclass__',
'__le__',
'__lt__',
'__module__',
'__ne__',
'__new__',
'__reduce__',
'__reduce_ex__',
'__repr__',
'__setattr__',
'__sizeof__',
'__str__',
'__subclasshook__',
'__weakref__',
'_depth_out_cut_doc',
'_get_ColDens_cut',
'_get_H_mass_cut',
'_get_Hbeta_cut',
'_get_depth_in_cut',
'_get_depth_out_cut',
'_get_over_range',
'_get_r_in_cut',
'_get_r_out_cut',
'_i_emis',
'_i_line',
'_init_abunds',
'_init_all2zero',
'_init_cont',
'_init_emis',
'_init_grains',
'_init_heatcool',
'_init_ionic',
'_init_lin',
'_init_opd',
'_init_ovr',
'_init_phy',
'_init_pressure',
'_init_rad',
'_l_emis',
'_quiet_div',
'_r_out_cut_doc',
'_read_stout',
'_res',
'_set_ColDens_cut',
```

```
'_set_H_mass_cut',
'_set_Hbeta_cut',
'_set_depth_in_cut',
'_set_depth_out_cut',
'_set_r_in_cut',
'_set_r_out_cut',
'aborted',
'abund',
'abunds',
'abunds_full',
'add_emis_from_pyneb',
'calling',
'cautions',
'cloudy_version',
'cloudy_version_major',
'comments',
'cool',
'cool_full',
'date_model',
'depth',
'depth_full',
'depth_in',
'depth_in_cut',
'depth_out',
'depth_out_cut',
'distance',
'dr',
'dr_full',
'drff',
'dv',
'dv_full',
'dvff',
'emis_from_pyneb',
'emis_full',
'emis_is_log',
'emis_labels',
'emis_labels_13',
'emis_labels_17',
'empty_model',
'ff',
'ff_full',
'gabund',
'gabund_full',
'gabund_labels',
'gas_mass_per_H',
'gasize',
'gdgrat',
```

```
'gdgrat_full',
'gdgrat_labels',
'gdsize',
'get_EW',
'get_EW2',
'get_G0',
'get_Ha_EW',
'get_Hb_EW',
'get_Hb_SB',
'get_T0_emis',
'get_T0_emis_rad',
'get_T0_ion_rad',
'get_T0_ion_rad_ne',
'get_T0_ion_vol',
'get_T0_ion_vol_ne',
'get_ab_ion_rad',
'get_ab_ion_rad_ne',
'get_ab_ion_vol',
'get_ab_ion_vol_ne',
'get_cont_x',
'get_cont_y',
'get_emis',
'get_emis_rad',
'get_emis_vol',
'get_integ_spec',
'get_interp_cont',
'get_ionic',
'get_line',
'get_ne_emis',
'get_ne_ion_rad_ne',
'get_ne_ion_vol_ne',
'get_t2_emis',
'get_t2_ion_rad_ne',
'get_t2_ion_vol_ne',
'gmass',
'gsize',
'gtemp',
'gtemp_full',
'gtemp_labels',
'heat',
'heat_full',
'info',
'intens',
'ionic_full',
'ionic_names',
'is_valid_ion',
'line_is_log',
```

```
'lines',
'liste_elem',
'log_',
'log_U',
'log_U_mean',
'log_U_mean_ne',
'model_name',
'model_name_s',
'nH',
'nH_full',
'nH_mean',
'nHff_full',
'n_elements',
'n_emis',
'n_gabund',
'n_gdgrat',
'n_gtemp',
'n_ions',
'n_lines',
'n_zones',
'n_zones_full',
'ne',
'ne_full',
'nenH',
'nenH_full',
'nenHff2_full',
'opd_absorp',
'opd_energy',
'opd_scat',
'opd_total',
'out',
'out_exists',
'phi',
'plan_par',
'plot_spectrum',
'pressure_full',
'print_lines',
'print_stats',
'r_in',
'r_in_cut',
'r_out',
'r_out_cut',
'r_range',
'rad_integ',
'rad_mean',
'radius',
'radius_full',
```

```
 'read_outputs',
 'rlines',
 'slines',
 't2',
 'te',
 'te_full',
 'tenenH',
 'tenenH_full',
 'theta',
 'thickness',
 'thickness_full',
 'vol_integ',
 'vol_mean',
 'warnings',
 'zones',
 'zones_full']
```

[36]:
```
Mod.print_stats()
```

```
 Name of the model: /tmp/models/model_1
 R_in (cut) = 5.000e+17 (5.001e+17), R_out (cut) = 1.963e+18 (1.963e+18)
 Depth_in (cut) = 0.000e+00 (4.094e+13), depth_out (cut) = 1.463e+18 (1.463e+18)
 H+ mass = 2.47e+00, H mass = 2.62e+00 N zones: 118
 <H+/H> = 0.97, <He++/He> = 0.00, <He+/He> = 0.83
 <O+++/O> = 0.00, <O++/O> = 0.28, <O+/O> = 0.68
 <N+++/N> = 0.00, <N++/N> = 0.38, <N+/N> = 0.59
 T(O+++) = 7870, T(O++) = 7706, T(O+) = 8010
 <ne> = 104,  <nH> = 100, T0 = 7919, t2=0.0016
 <log U> = -2.81
```

[37]:
```
Mod.print_lines()
```

```
H__1_486132A 4.731489e+34
H__1_656280A 1.292871e+35
CA_B_587564A 7.039804e+33
N__2_658345A 7.422383e+34
O__1_630030A 1.429729e+33
O__2_372603A 5.364218e+34
O__2_372881A 7.225001e+34
O__3_500684A 5.841670e+34
O__3_436321A 1.440794e+32
O_3R_436300A 2.498971e+28
O_3C_436300A 5.030977e+27
S__2_671644A 9.510303e+33
S__2_673082A 7.307401e+33
CL_3_551771A 1.092508e+32
CL_3_553787A 7.805376e+31
O__1_631679M 9.118685e+32
```

```
O__1_145495M 8.892037e+31
C__2_157636M 1.834483e+32
```

[38]:
```
Mod.get_ab_ion_vol_ne('O',2)
```

[38]:
```
0.2830849460329957
```

[39]:
```
Mod.get_T0_ion_vol_ne('O', 2)
```

[39]:
```
7705.599436691873
```

[40]:
```
Mod.log_U_mean
```

[40]:
```
-2.8052821899672953
```

[41]:
```
Mod.log_U_mean_ne
```

[41]:
```
-2.787562990864106
```

[42]:
```
print('T0 = {0:7.1f}K, t2 = {1:6.4f}'.format(Mod.T0, Mod.t2))
```

```
T0 =  7919.2K, t2 = 0.0016
```

[43]:
```
print('Hbeta Equivalent width = {0:6.1f}, Hbeta Surface Brightness = {1:4.2e}'.
 ↪format(Mod.get_Hb_EW(), Mod.get_Hb_SB()))
```

```
Hbeta Equivalent width = -721.1, Hbeta Surface Brightness = 9.19e-14
```

[44]:
```
Mod.emis_labels
```

[44]:
```
array(['H__1_486132A', 'H__1_656280A', 'CA_B_587564A', 'N__2_658345A',
       'O__1_630030A', 'O__2_372603A', 'O__2_372881A', 'O__3_500684A',
       'O__3_436321A', 'O_3R_436300A', 'O_3C_436300A', 'S__2_671644A',
       'S__2_673082A', 'CL_3_551771A', 'CL_3_553787A', 'O__1_631679M',
       'O__1_145495M', 'C__2_157636M'], dtype='<U12')
```

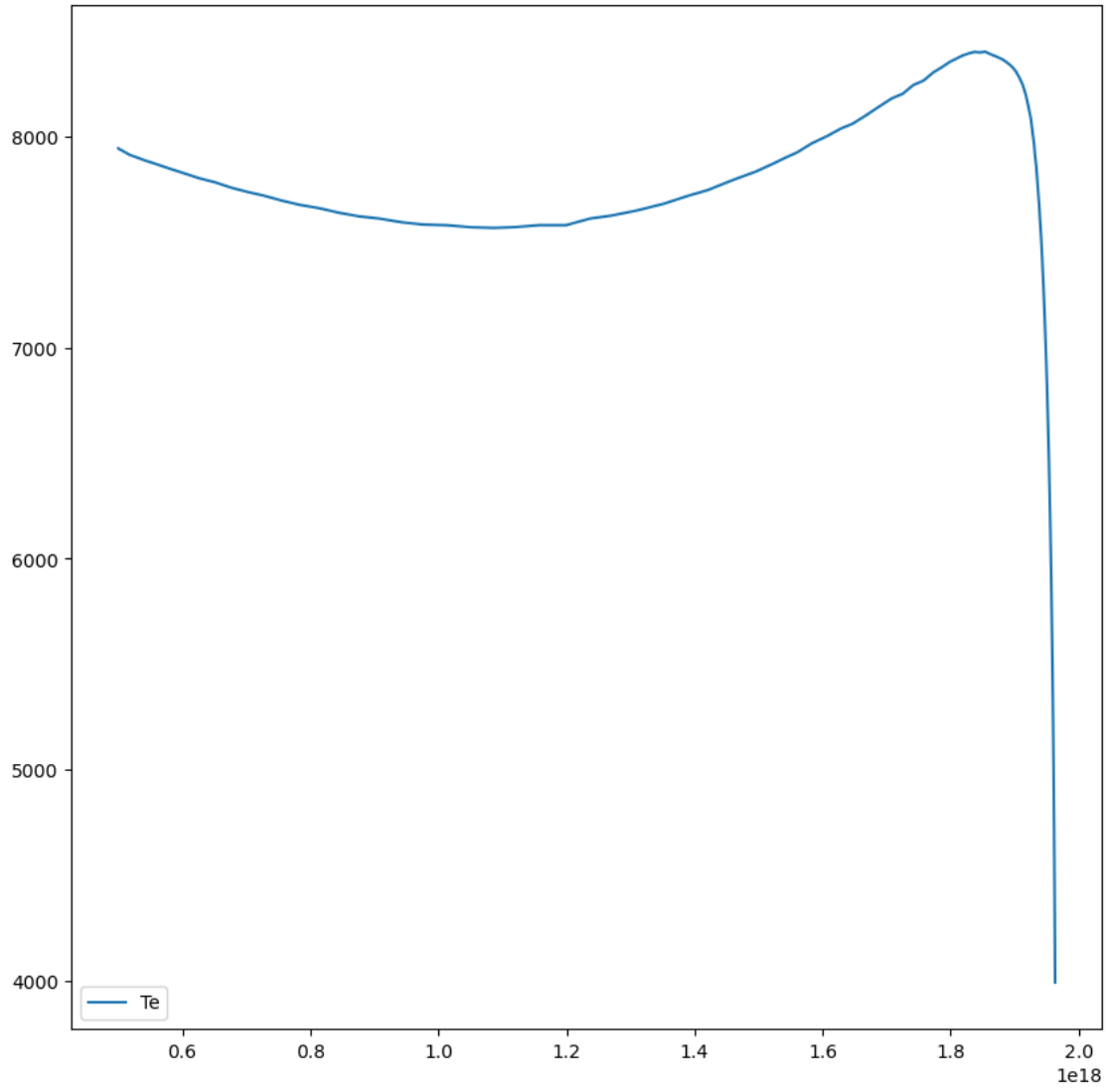
[45]:
```
# printing line intensities
for line in Mod.emis_labels:
    print('{0} {1:10.3e} {2:7.2f}'.format(line, Mod.get_emis_vol(line), Mod.
 ↪get_emis_vol(line) / Mod.get_emis_vol('H__1_486133A') * 100.))
```

```
warng CloudyModel /tmp/models/model_1: H__1_486133A is not a correct line
reference - 1
```

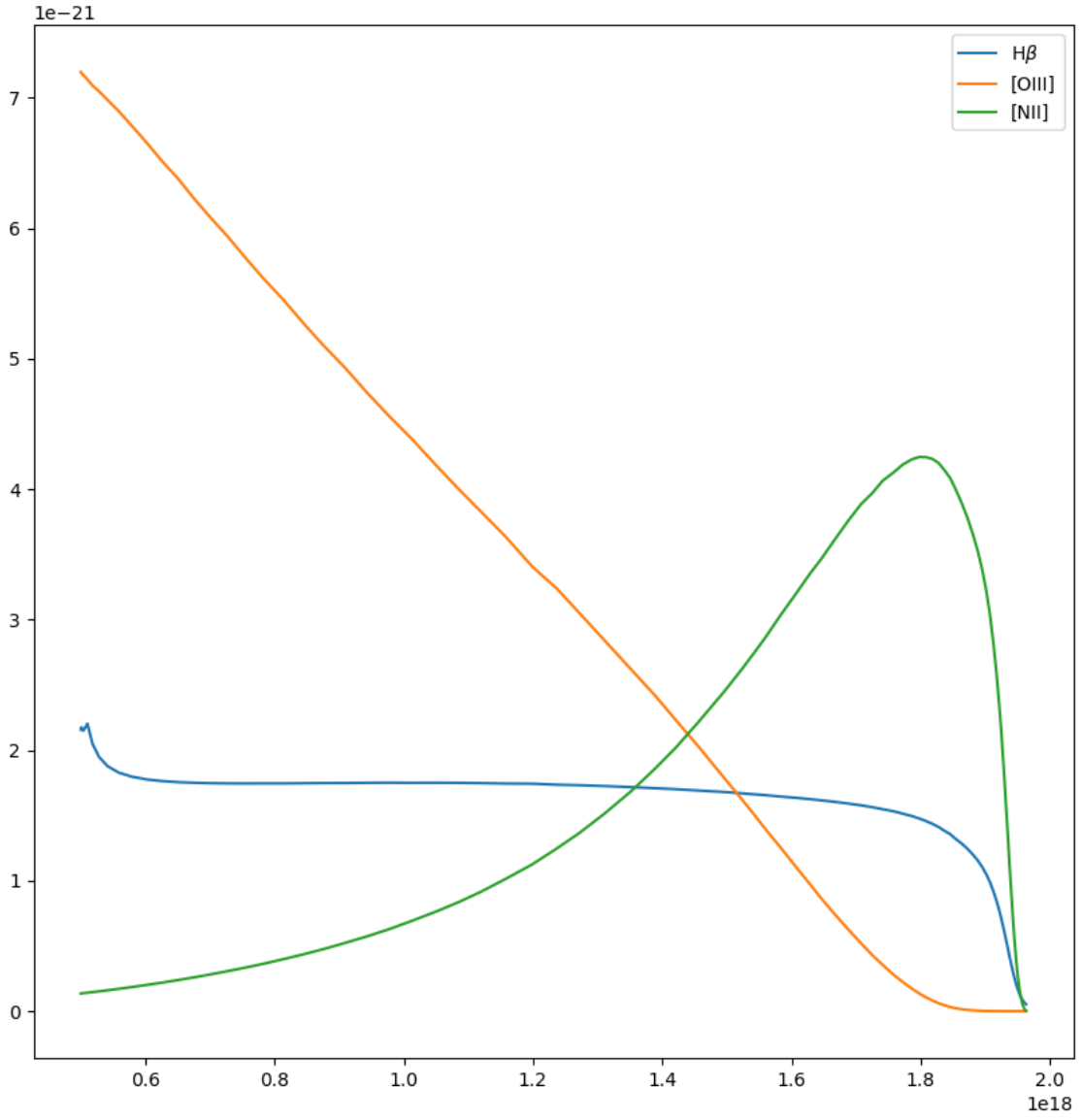
```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[45], line 3
      1 # printing line intensities
```

```
      2 for line in Mod.emis_labels:
----> 3     print('{0} {1:10.3e} {2:7.2f}'.format(line, Mod.get_emis_vol(line),
 ↪Mod.get_emis_vol(line) / Mod.get_emis_vol('H__1_486133A') * 100.))

File ~/Google Drive/Pro/pyCloudy/pyCloudy/c1d/cloudy_model.py:1298, in␣
 ↪CloudyModel.get_emis_vol(self, ref, at_earth)
   1296 else:
   1297     coeff = 1.
-> 1298 return self.vol_integ(self.get_emis(ref)) / coeff

TypeError: unsupported operand type(s) for /: 'NoneType' and 'float'
```

[46]:
```
plt.figure(figsize=(10,10))
plt.plot(Mod.radius, Mod.te, label = 'Te')
plt.legend(loc=3);
```

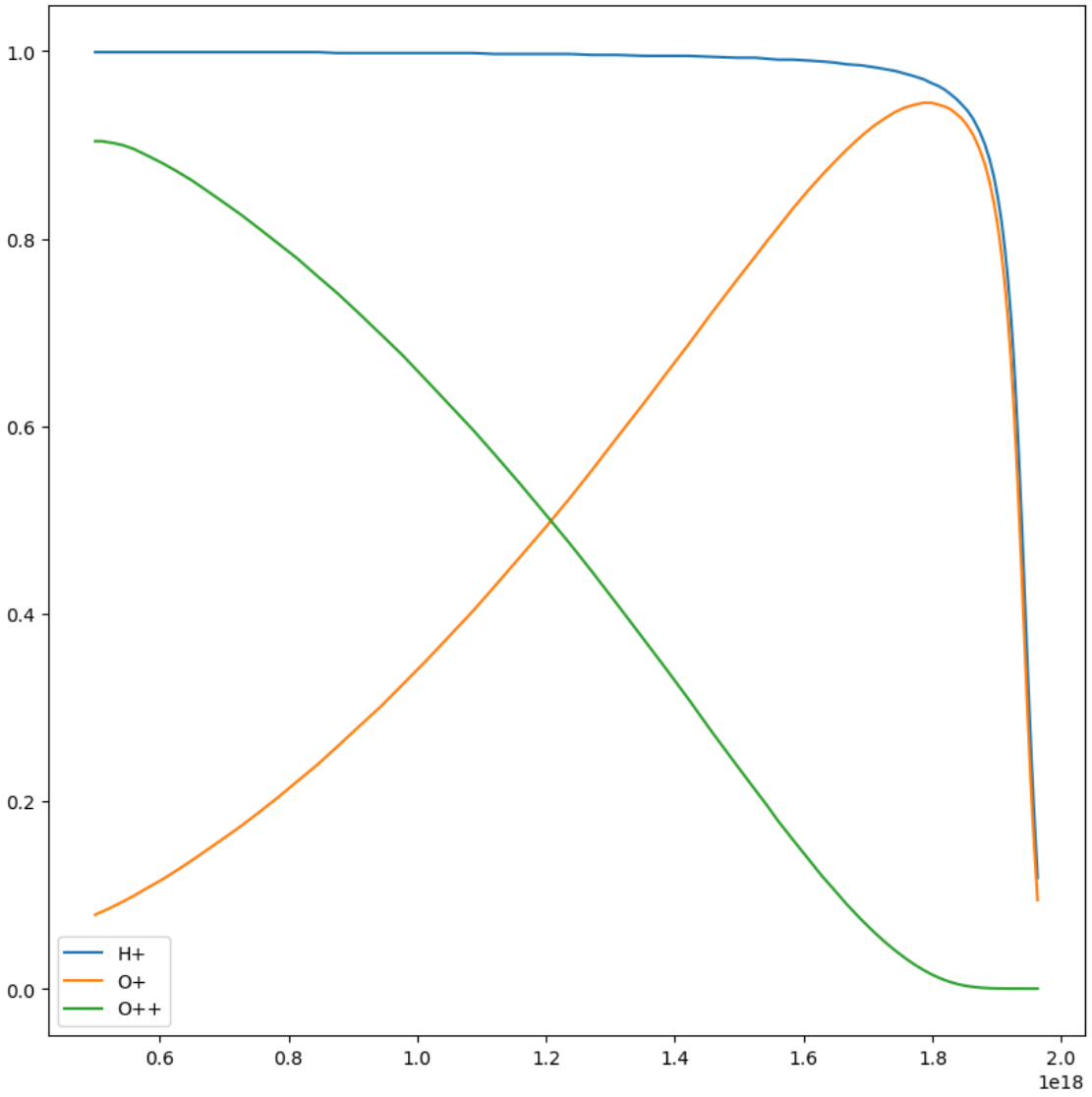


[50]:
```
plt.figure(figsize=(10,10))
plt.plot(Mod.radius, Mod.get_emis('H__1_486132A'), label = r'H$\beta$')
plt.plot(Mod.radius, Mod.get_emis('O__3_500684A'), label = '[OIII]')
plt.plot(Mod.radius, Mod.get_emis('N__2_658345A'), label = '[NII]')
plt.legend();
```

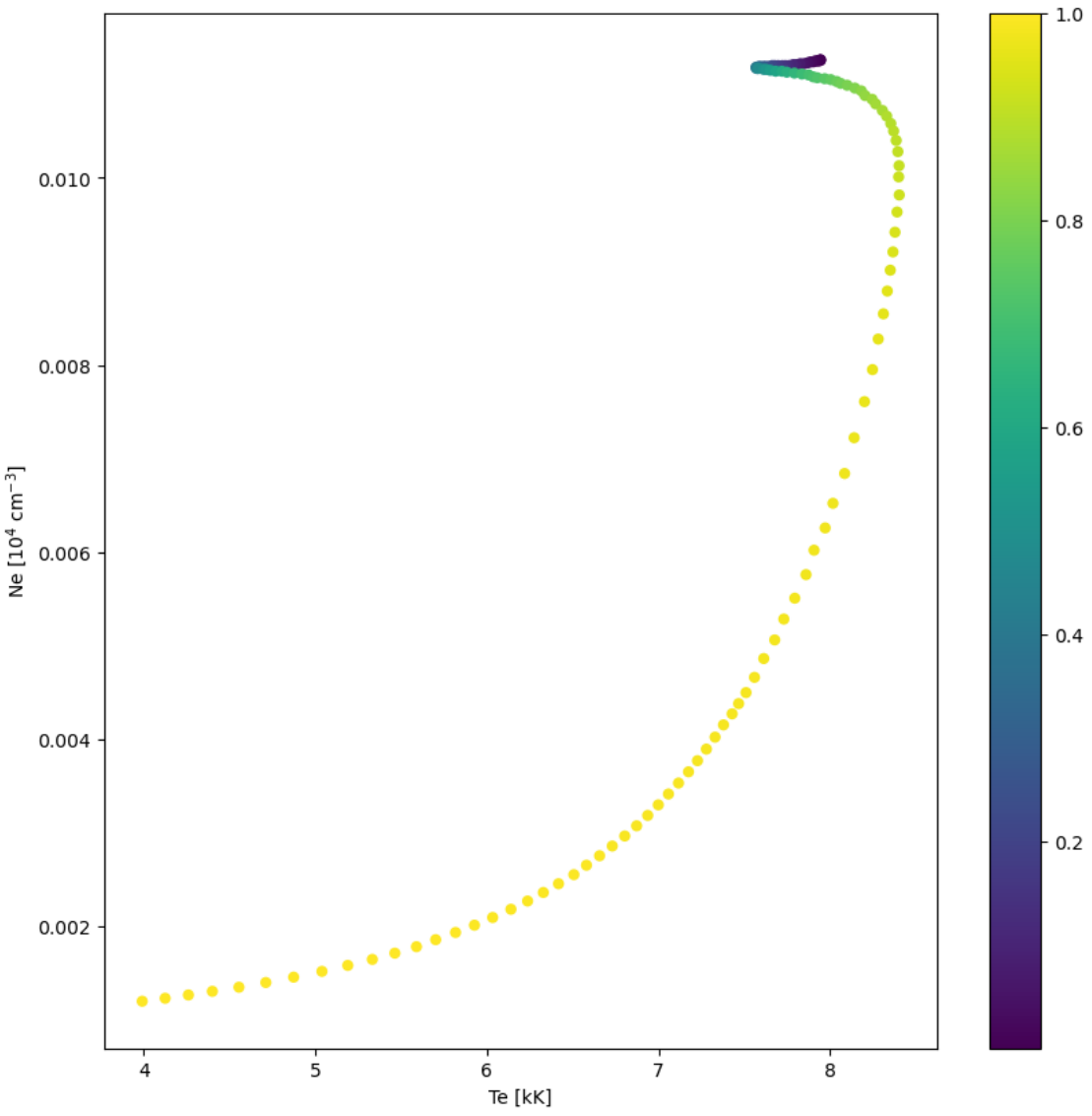


[51]:
```
plt.figure(figsize=(10,10))
plt.plot(Mod.radius, Mod.get_ionic('H', 1), label = 'H+')
plt.plot(Mod.radius, Mod.get_ionic('O', 1), label = 'O+')
```

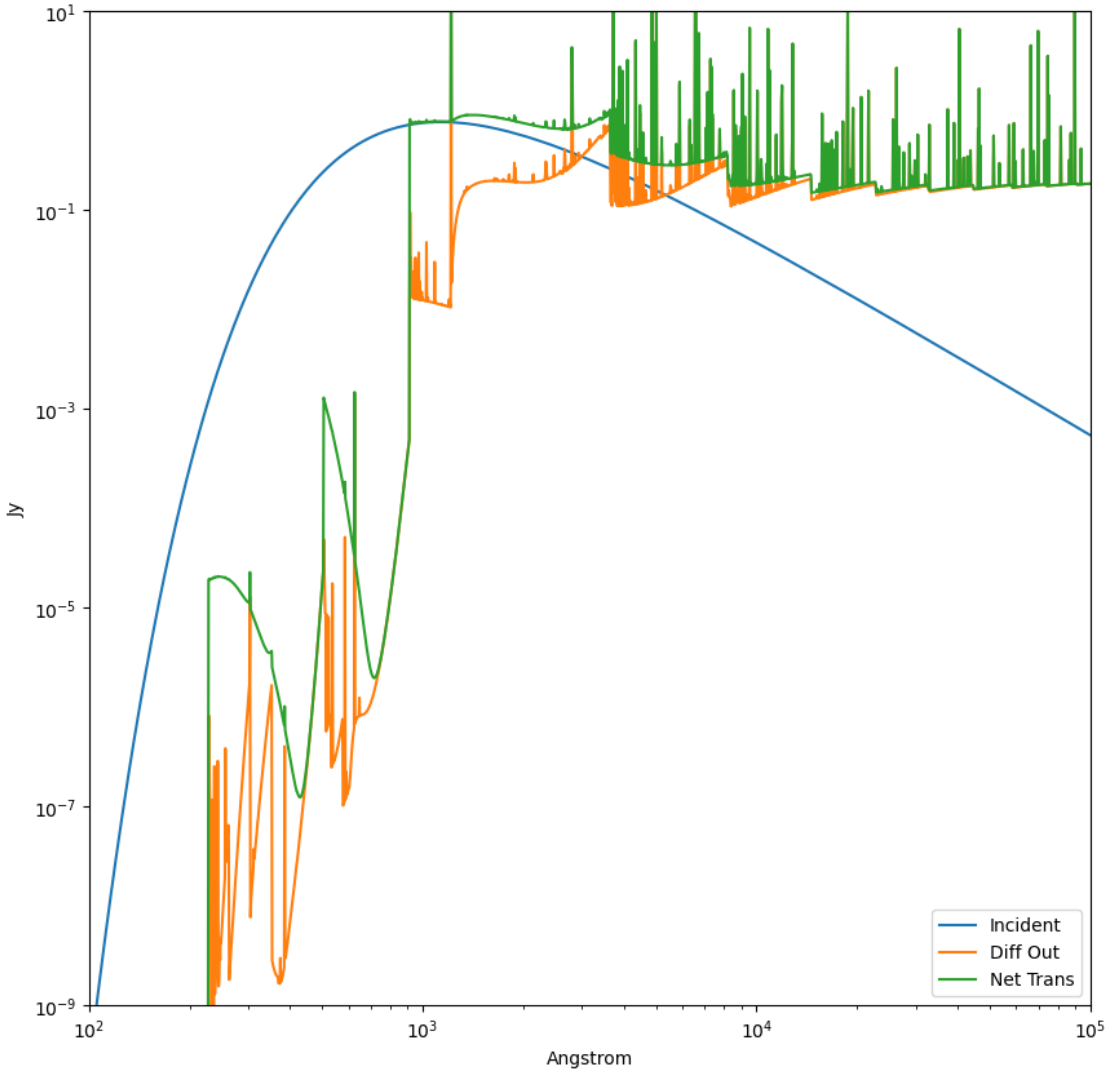
```
plt.plot(Mod.radius, Mod.get_ionic('O', 2), label = 'O++')
plt.legend(loc=3);
```



[52]:
```
plt.figure(figsize=(10,10))
plt.scatter(Mod.te/1e3, Mod.ne/1e4, c = Mod.depth/np.max(Mod.depth), edgecolors␣
↪= 'none')
plt.colorbar()
plt.xlabel('Te [kK]')
plt.ylabel(r'Ne [$10^4$ cm$^{-3}$]');
```



[53]:
```
plt.figure(figsize=(10,10))
plt.loglog(Mod.get_cont_x(unit='Ang'), Mod.get_cont_y(cont = 'incid', unit =␣
 ↪'Jy'), label = 'Incident')
plt.loglog(Mod.get_cont_x(unit='Ang'), Mod.get_cont_y(cont = 'diffout', unit =␣
 ↪'Jy'), label = 'Diff Out')
plt.loglog(Mod.get_cont_x(unit='Ang'), Mod.get_cont_y(cont = 'ntrans', unit =␣
 ↪'Jy'), label = 'Net Trans')
plt.xlim((100, 100000))
plt.ylim((1e-9, 1e1))
plt.xlabel('Angstrom')
plt.ylabel('Jy')
plt.legend(loc=4);
```


Jy
Angstrom
Incident
Diff Out
Net Trans