Using_PyCloudy_3

August 21, 2018

In [1]:
```
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
import pyCloudy as pc
print(pc.__version__)
```

```
0.9.7
```

In [2]:
```
pc.config.cloudy_exe = '/usr/local/Cloudy/c17.01/source/cloudy.exe'
```

In [3]:
```
dir_ = '/tmp'
pc.print_make_file(dir_)
```

In [4]:
```
def set_models(dir_, model_name):
    emis_tab = ['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'
                ]
    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',
                    'O  1 63.17m',
                    'O  1 145.5m',
                    'C  2 157.6m',
                    'H  1 4.051m']
```

```
        a = 2.
        b = 1.0
        thetas = np.linspace(0., 90., 6)
        thetas_rad = np.pi / 180. * thetas
        fact_elli = a * b / np.sqrt((b * np.sin(thetas_rad))**2 + (a * np.cos(thetas_rad))**
        rs_in = 16.5 + np.log10(fact_elli)
        densities = 4 - np.log10(fact_elli) * 2

        model = pc.CloudyInput()
        model.set_BB(80000., 'q(H)', 47.3)
        model.set_grains()
        model.set_emis_tab(emis_tab)

        for theta, r_in, density in zip(thetas, rs_in, densities):
            model.model_name = '{0}/{1}_{2:.0f}'.format(dir_, model_name,theta)
            model.set_cste_density(density)
            model.set_radius(r_in)
            model.set_theta_phi(theta)
            model.print_input(to_file = True, verbose = False)
```

In [5]:
```
def def_profiles(m3d):
    """
    This uses the default velocity law (polynome) and default profile (gaussian)
    """
    m3d.set_velocity(params = [20.,60.])
    m3d.config_profile(size_spectrum = 51, vel_max = 50, v_turb = 0.01)
```

In [6]:
```
def def_profiles_user(m3d):
    """
    Use this to define your own expansion velocity
    """
    def velo_polynome(params):
        """
        USer defined expansion velocity
        """
        # params is a 2 elements table, the first element is a table of parameters, the
        # which is needed to know r, x, y and z to define the velocity.
        coeffs = params[0]
        cub_coord = params[1]
        tmp = 0.
        for i, coeff in enumerate(coeffs):
            # for each parameter we add the corresponding coeff * R**power
            tmp = tmp + coeff * cub_coord.r**i
        tmp = tmp / cub_coord.r
        # to avoid the singularity:
        tt = (cub_coord.r == 0.)
        tmp[tt] = 0
        # Projecting on each one of the 3 axes to obtain the velocity components
```

```
        vel_x = tmp * cub_coord.x / np.max(cub_coord.x)
        vel_y = tmp * cub_coord.y / np.max(cub_coord.y)
        vel_z = tmp * cub_coord.z / np.max(cub_coord.z)
        return vel_x, vel_y, vel_z

    def Hb_prof(x, zeta_0):
        """
        The Hbeta profile is sum of 2 blocks of lines (actually 3 + 4 lines)
        """
        res1 = .41 /zeta_0 / np.sqrt(np.pi) * np.exp(-(((x-2.7)/zeta_0)**2))
        res2 = .59 /zeta_0 / np.sqrt(np.pi) * np.exp(-(((x+2.0)/zeta_0)**2))
        return res1 + res2

    m3d.set_velocity(velocity_law='user', params = [[20.,60.], m3d.cub_coord], user_func
    m3d.config_profile(size_spectrum = 41, vel_max = 25, profile_function = Hb_prof, v_t
```

In [7]:
```
def plot_profiles(m3d, x_pos, y_pos):
    plt.plot(m3d.vel_tab,m3d.get_profile('H__1_486133A', axis='x')[:,x_pos,y_pos] * 5, l
    plt.plot(m3d.vel_tab,m3d.get_profile('N__2_658345A', axis='x')[:,x_pos,y_pos] * 5, l
    plt.plot(m3d.vel_tab,m3d.get_profile('O__3_500684A', axis='x')[:,x_pos,y_pos], label
    plt.legend()
```

In [8]:
```
def other_plots(m3d, proj_axis):
    plt.subplot(331)
    plt.imshow(m3d.get_emis('H__1_486133A').sum(axis = proj_axis)*m3d.cub_coord.cell_siz
    plt.title('Hb')
    plt.colorbar()

    plt.subplot(332)
    plt.imshow(m3d.get_emis('N__2_658345A').sum(axis = proj_axis)*m3d.cub_coord.cell_siz
    plt.title('[NII]')
    plt.colorbar()

    plt.subplot(333)
    plt.imshow(m3d.get_emis('O__3_500684A').sum(axis = proj_axis)*m3d.cub_coord.cell_siz
    plt.title('[OIII]')
    plt.colorbar()

    plt.subplot(334)
    plt.imshow(m3d.get_emis('N__2_658345A').sum(axis = proj_axis)/m3d.get_emis('H__1_486
    plt.title('[NII]/Hb')
    plt.colorbar()

    plt.subplot(335)
    plt.imshow(m3d.get_emis('O__3_500684A').sum(axis = proj_axis)/m3d.get_emis('H__1_486
    plt.title('[OIII]/Hb')
    plt.colorbar()
```

```
            plt.subplot(336)
            plt.imshow(m3d.get_ionic('O',1)[n_cut,:,:])
            plt.title('O+ cut')
            plt.colorbar()

            plt.subplot(337)
            plt.scatter(m3d.get_ionic('O',1).ravel(),m3d.get_ionic('N',1).ravel()/m3d.get_ionic(
                        c=np.abs(m3d.cub_coord.theta.ravel()), edgecolors = 'none')
            plt.title('Colored by |Theta|')
            plt.xlabel('O+ / O')
            plt.ylabel('N+/O+ / N/O')
            plt.colorbar()

            plt.subplot(338)
            plt.scatter(m3d.get_ionic('O',1).ravel(),m3d.get_ionic('N',1).ravel()/m3d.get_ionic(
                        c=m3d.relative_depth.ravel(),vmin = 0, vmax = 1, edgecolors = 'none')
            plt.title('Colored by position in the nebula')
            plt.xlabel('O+ / O')
            plt.ylabel('N+/O+ / N/O')
            plt.colorbar()

            plt.subplot(339)
            C1 = (m3d.get_ionic('N',1)/m3d.get_ionic('O',1)*m3d.get_ionic('N',2))
            C2 = (m3d.get_ionic('N',2))
            tt = (m3d.get_ionic('O',1) == 0)
            C1[tt] = 0
            C2[tt] = 0
            V = C1.sum(axis = proj_axis) / C2.sum(axis = proj_axis)
            plt.imshow(V)
            plt.colorbar()
            plt.title('N+/O+ / N/O weighted by NII')
            plt.contour(V,levels=[1.0])
```

In [9]:
```
model_name = "M3D_1"
pc.log_.calling = 'Model3D : ' + model_name
pc.log_.level = 3
```

In [10]:
```
dim = 101
n_cut = int((dim-1) /2)
proj_axis = 0
```

In [11]:
```
set_models(dir_, model_name)
```

```
CloudyInput: Input writen in /tmp/M3D_1_0.in
CloudyInput: Input writen in /tmp/M3D_1_18.in
CloudyInput: Input writen in /tmp/M3D_1_36.in
CloudyInput: Input writen in /tmp/M3D_1_54.in
CloudyInput: Input writen in /tmp/M3D_1_72.in
```

```
    CloudyInput: Input writen in /tmp/M3D_1_90.in
```

```
In [12]: pc.print_make_file(dir_ = dir_)
         pc.run_cloudy(dir_ = dir_, n_proc = 6, model_name = model_name, use_make = True)
```

```
    run_cloudy: running: cd /tmp ; make -j 6 name="M3D_1"
    run_cloudy: ending: cd /tmp ; make -j 6 name="M3D_1"
```

```
In [13]: liste_of_models = pc.load_models('{0}/{1}'.format(dir_, model_name), list_elem=['H', 'H
                                                  read_cont = False, read_grains = False)
```

```
    CloudyModel /tmp/M3D_1_18: Creating CloudyModel for /tmp/M3D_1_18
    CloudyModel /tmp/M3D_1_18: Be abundance not defined
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.rad read
    CloudyModel /tmp/M3D_1_18: Number of zones: 181
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.phy read
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_H read
    CloudyModel /tmp/M3D_1_18: filling H with 3 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_He read
    CloudyModel /tmp/M3D_1_18: filling He with 3 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_C read
    CloudyModel /tmp/M3D_1_18: filling C with 13 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_N read
    CloudyModel /tmp/M3D_1_18: filling N with 8 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_O read
    CloudyModel /tmp/M3D_1_18: filling O with 12 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_Ar read
    CloudyModel /tmp/M3D_1_18: filling Ar with 19 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.ele_Ne read
    CloudyModel /tmp/M3D_1_18: filling Ne with 11 columns
    CloudyModel /tmp/M3D_1_18: /tmp/M3D_1_18.emis read
    CloudyModel /tmp/M3D_1_18: Number of emissivities: 9
    CloudyModel /tmp/M3D_1_72: Creating CloudyModel for /tmp/M3D_1_72
    CloudyModel /tmp/M3D_1_72: Be abundance not defined
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.rad read
    CloudyModel /tmp/M3D_1_72: Number of zones: 177
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.phy read
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_H read
    CloudyModel /tmp/M3D_1_72: filling H with 3 columns
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_He read
    CloudyModel /tmp/M3D_1_72: filling He with 3 columns
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_C read
    CloudyModel /tmp/M3D_1_72: filling C with 13 columns
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_N read
    CloudyModel /tmp/M3D_1_72: filling N with 8 columns
    CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_O read
    CloudyModel /tmp/M3D_1_72: filling O with 12 columns
```

```
CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_Ar read
CloudyModel /tmp/M3D_1_72: filling Ar with 19 columns
CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.ele_Ne read
CloudyModel /tmp/M3D_1_72: filling Ne with 11 columns
CloudyModel /tmp/M3D_1_72: /tmp/M3D_1_72.emis read
CloudyModel /tmp/M3D_1_72: Number of emissivities: 9
CloudyModel /tmp/M3D_1_0: Creating CloudyModel for /tmp/M3D_1_0
CloudyModel /tmp/M3D_1_0: Be abundance not defined
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.rad read
CloudyModel /tmp/M3D_1_0: Number of zones: 181
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.phy read
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_H read
CloudyModel /tmp/M3D_1_0: filling H with 3 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_He read
CloudyModel /tmp/M3D_1_0: filling He with 3 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_C read
CloudyModel /tmp/M3D_1_0: filling C with 13 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_N read
CloudyModel /tmp/M3D_1_0: filling N with 8 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_O read
CloudyModel /tmp/M3D_1_0: filling O with 12 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_Ar read
CloudyModel /tmp/M3D_1_0: filling Ar with 19 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.ele_Ne read
CloudyModel /tmp/M3D_1_0: filling Ne with 11 columns
CloudyModel /tmp/M3D_1_0: /tmp/M3D_1_0.emis read
CloudyModel /tmp/M3D_1_0: Number of emissivities: 9
CloudyModel /tmp/M3D_1_36: Creating CloudyModel for /tmp/M3D_1_36
CloudyModel /tmp/M3D_1_36: Be abundance not defined
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.rad read
CloudyModel /tmp/M3D_1_36: Number of zones: 180
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.phy read
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_H read
CloudyModel /tmp/M3D_1_36: filling H with 3 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_He read
CloudyModel /tmp/M3D_1_36: filling He with 3 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_C read
CloudyModel /tmp/M3D_1_36: filling C with 13 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_N read
CloudyModel /tmp/M3D_1_36: filling N with 8 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_O read
CloudyModel /tmp/M3D_1_36: filling O with 12 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_Ar read
CloudyModel /tmp/M3D_1_36: filling Ar with 19 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.ele_Ne read
CloudyModel /tmp/M3D_1_36: filling Ne with 11 columns
CloudyModel /tmp/M3D_1_36: /tmp/M3D_1_36.emis read
CloudyModel /tmp/M3D_1_36: Number of emissivities: 9
```

```
CloudyModel /tmp/M3D_1_54: Creating CloudyModel for /tmp/M3D_1_54
CloudyModel /tmp/M3D_1_54: Be abundance not defined
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.rad read
CloudyModel /tmp/M3D_1_54: Number of zones: 179
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.phy read
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_H read
CloudyModel /tmp/M3D_1_54: filling H with 3 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_He read
CloudyModel /tmp/M3D_1_54: filling He with 3 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_C read
CloudyModel /tmp/M3D_1_54: filling C with 13 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_N read
CloudyModel /tmp/M3D_1_54: filling N with 8 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_O read
CloudyModel /tmp/M3D_1_54: filling O with 12 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_Ar read
CloudyModel /tmp/M3D_1_54: filling Ar with 19 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.ele_Ne read
CloudyModel /tmp/M3D_1_54: filling Ne with 11 columns
CloudyModel /tmp/M3D_1_54: /tmp/M3D_1_54.emis read
CloudyModel /tmp/M3D_1_54: Number of emissivities: 9
CloudyModel /tmp/M3D_1_90: Creating CloudyModel for /tmp/M3D_1_90
CloudyModel /tmp/M3D_1_90: Be abundance not defined
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.rad read
CloudyModel /tmp/M3D_1_90: Number of zones: 176
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.phy read
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_H read
CloudyModel /tmp/M3D_1_90: filling H with 3 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_He read
CloudyModel /tmp/M3D_1_90: filling He with 3 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_C read
CloudyModel /tmp/M3D_1_90: filling C with 13 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_N read
CloudyModel /tmp/M3D_1_90: filling N with 8 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_O read
CloudyModel /tmp/M3D_1_90: filling O with 12 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_Ar read
CloudyModel /tmp/M3D_1_90: filling Ar with 19 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.ele_Ne read
CloudyModel /tmp/M3D_1_90: filling Ne with 11 columns
CloudyModel /tmp/M3D_1_90: /tmp/M3D_1_90.emis read
CloudyModel /tmp/M3D_1_90: Number of emissivities: 9
load_models: 6 models read
```

```
In [14]: m3d = pc.C3D(liste_of_models, dims = [dim, dim, dim], angles = [45,45,0], plan_sym = Tr
```

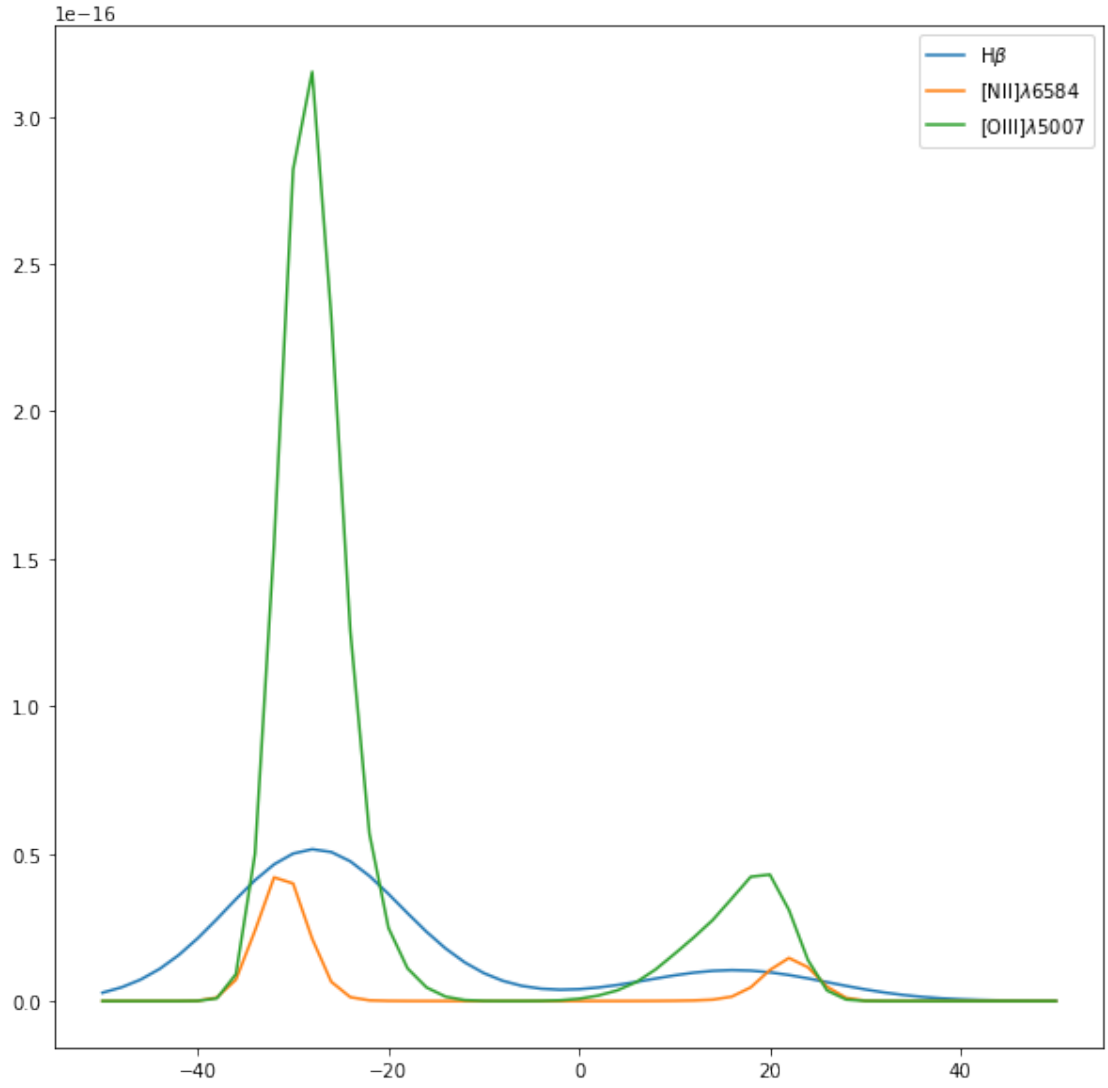
```
C3D: Entering C3D
CubCoord: building a cube of 101x101x101
```

```
CubCoord: Rotation matrix by 45.0, 45.0, 0.0 degrees.
C3D: CubCoord done.
C3D: interp_bi done.
C3D: Interpolation mesh done
C3D: All 3D values reset
```

```
In [15]: def_profiles(m3d)
```

```
In [16]: plt.figure(figsize=(10,10))
         plot_profiles(m3d, 55, 55)
```

```
C3D: get_emis(0) interpolated using numpy-method
C3D: te interpolated using numpy-method
C3D: line H__1_486133A : profile computed on axis x
C3D: get_emis(3) interpolated using numpy-method
C3D: line N__2_658345A : profile computed on axis x
C3D: get_emis(7) interpolated using numpy-method
C3D: line O__3_500684A : profile computed on axis x
```



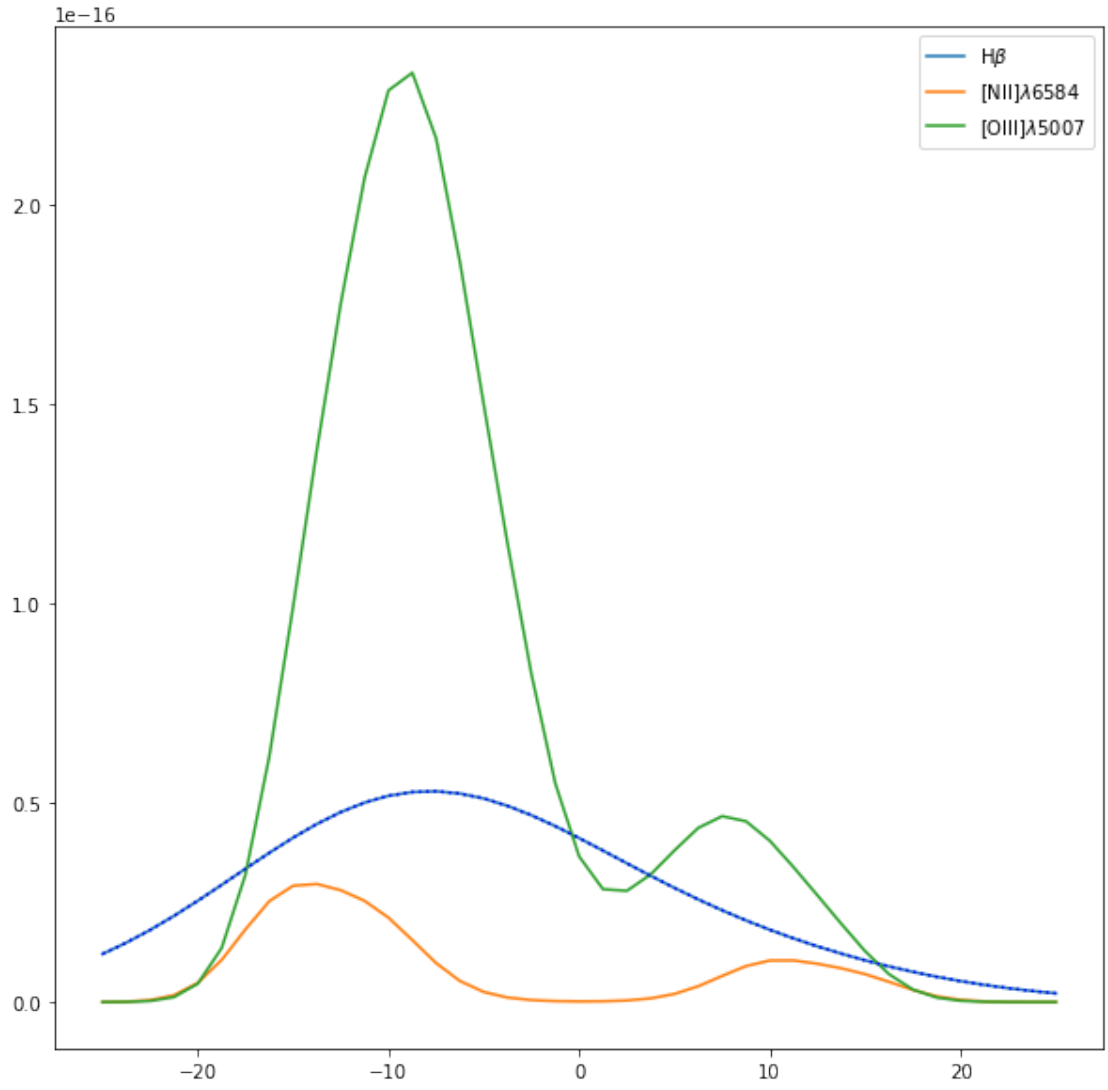

```
In [19]: plt.figure(figsize=(10,10))
         plot_profiles(m3d, 55, 55)
         def_profiles_user(m3d)
         plt.plot(m3d.vel_tab,m3d.get_profile('H__1_486133A', axis='x')[:,55,55] * 5, ':b', labe
```

```
    C3D: line N__2_658345A : profile computed on axis x
    C3D: line O__3_500684A : profile computed on axis x
```

```
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:17: RuntimeWarning: d
```

```
    C3D: line H__1_486133A : profile computed on axis x
```

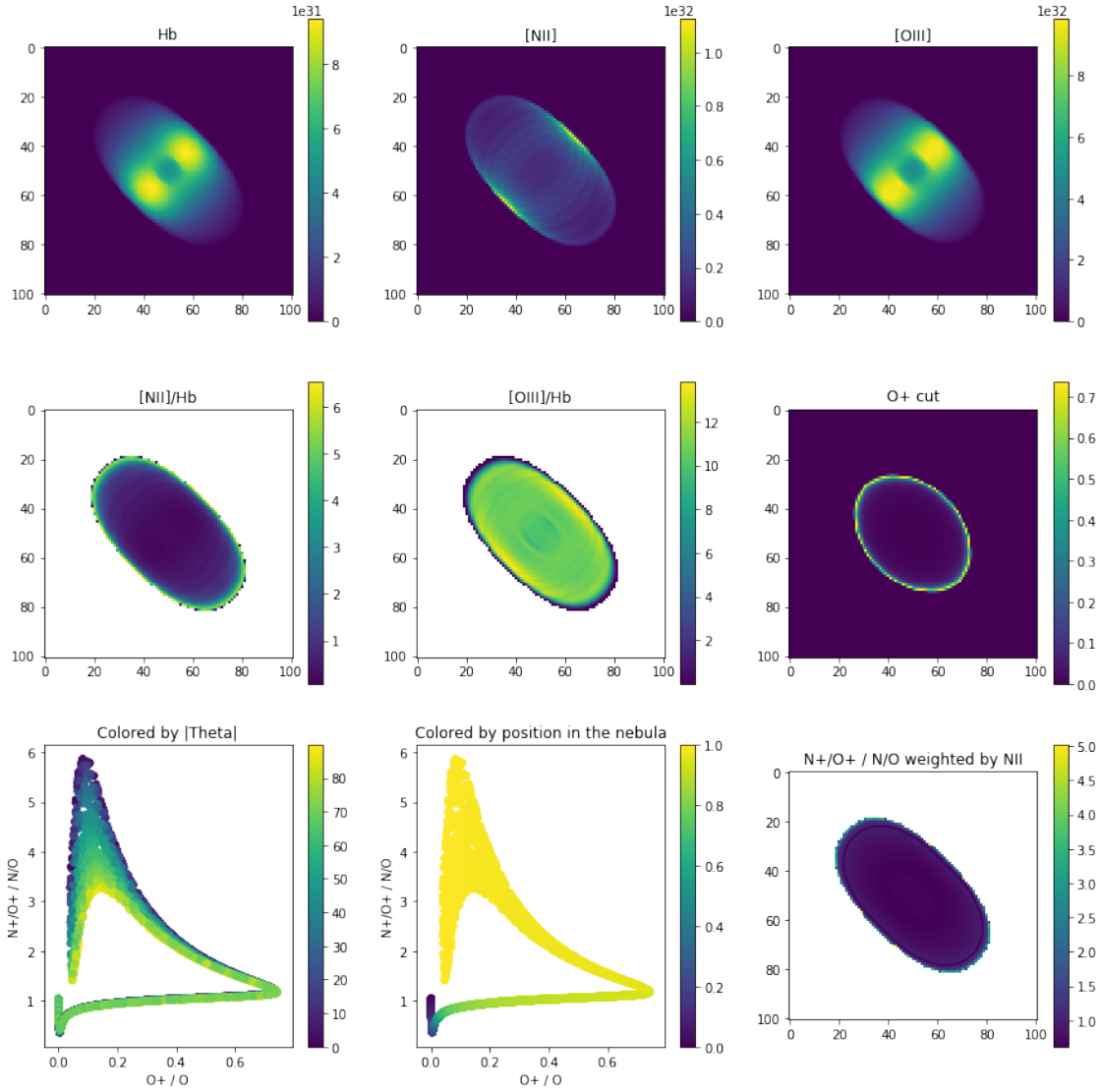
Out[19]: [<matplotlib.lines.Line2D at 0x7f3fd25c2048>]



In [20]:
```
plt.figure(figsize=(15,15))
other_plots(m3d, proj_axis)
```

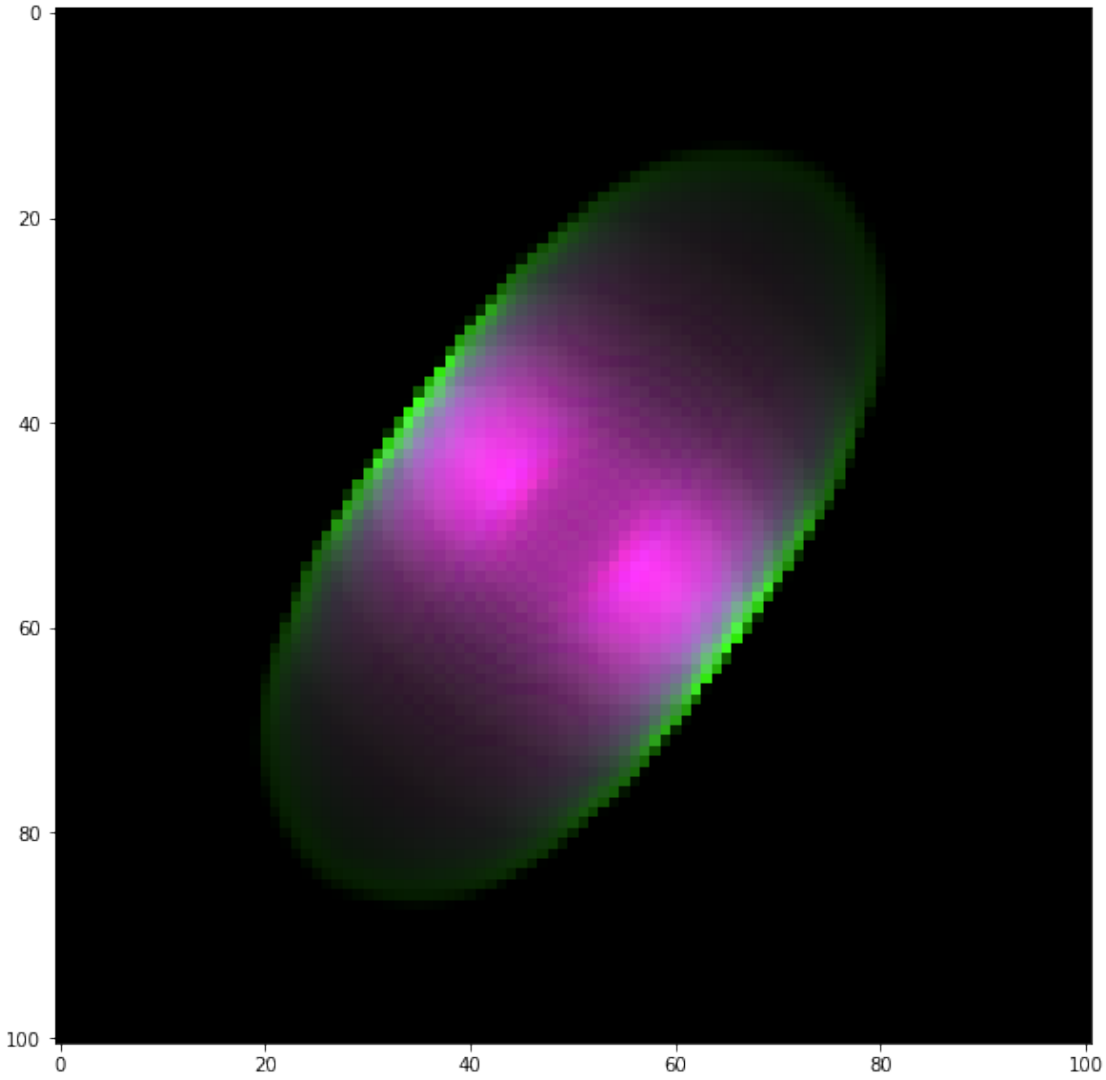
```
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:18: RuntimeWarning: d
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:18: RuntimeWarning: i
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:23: RuntimeWarning: d
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:23: RuntimeWarning: i
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:33: RuntimeWarning: d
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:33: RuntimeWarning: i
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:41: RuntimeWarning: d
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:41: RuntimeWarning: i
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:49: RuntimeWarning: d
```

```
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:49: RuntimeWarning: i
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:54: RuntimeWarning: d
/home/morisset/anaconda3/lib/python3.6/site-packages/ipykernel_launcher.py:54: RuntimeWarning: i
```



In [21]:
```
im = m3d.get_RGB(list_emis = [0, 3, 7])
plt.figure(1, figsize=(10,10))
plt.imshow(im)
```

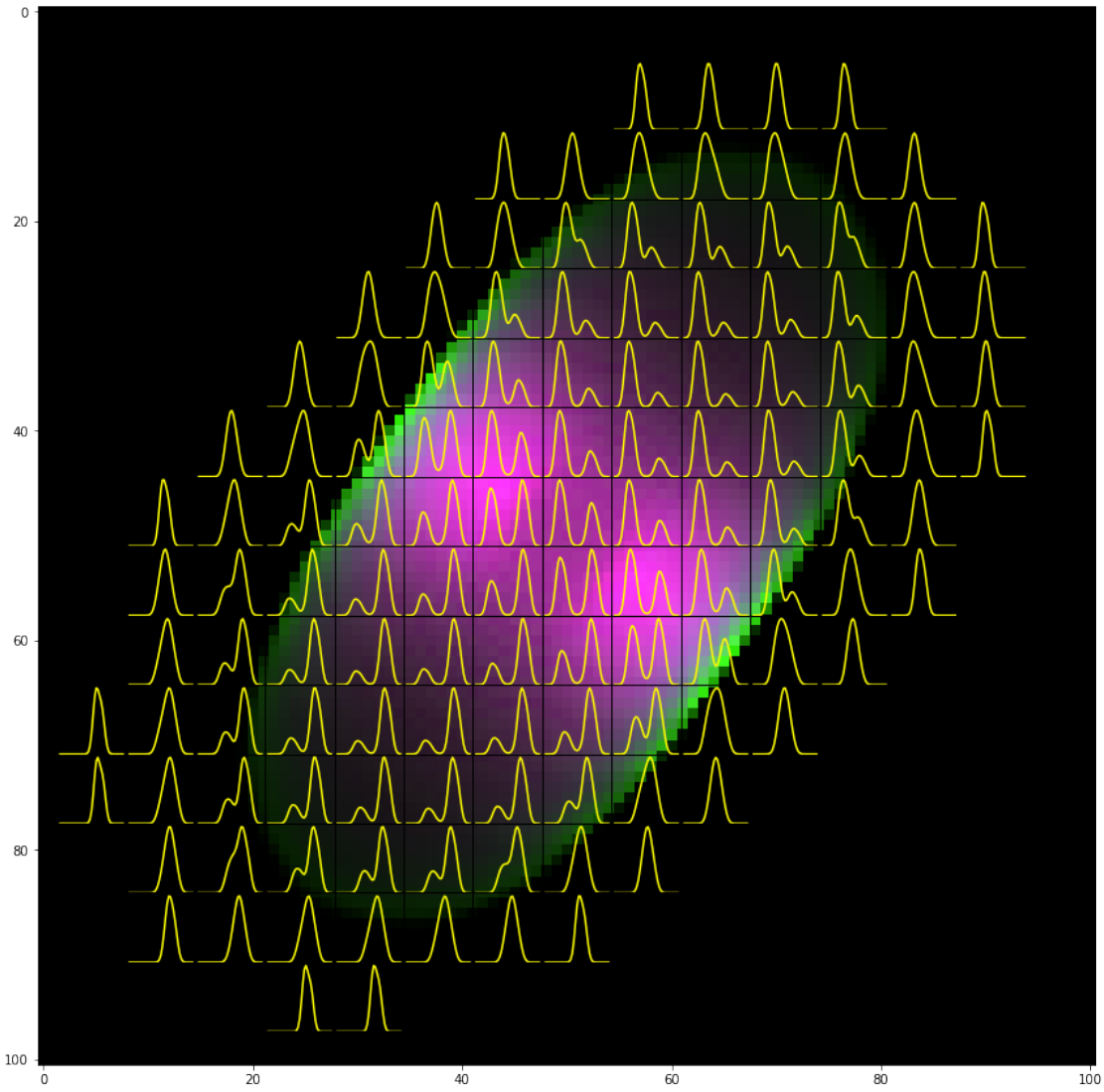
Out[21]: <matplotlib.image.AxesImage at 0x7f3fd29fdba8>




```
In [22]: im = m3d.get_RGB(list_emis = [0, 3, 7])
         plt.figure(1, figsize=(15,15))
         plt.imshow(im)
         m3d.plot_profiles(ref = 3, i_fig = 1, Nx=20, Ny=20)
```

```
     C3D: line N__2_658345A : profile computed on axis x
```

```
/home/morisset/Dropbox/Python/pyCloudy/pyCloudy/c3d/model_3d.py:943: RuntimeWarning: invalid val
  prof /= np.max(prof)
/home/morisset/Dropbox/Python/pyCloudy/pyCloudy/c3d/model_3d.py:957: MatplotlibDeprecationWarnin
  ax.axesPatch.set_alpha(0.0)
```


0
20
40
60
80
100
0
20
40
60
80
100