OOP

January 10, 2021

[1]:
```
# The following is to know when this notebook has been run and with which␣
 ↪python version.
import time, sys
print(time.ctime())
print(sys.version.split('|')[0])
```

```
Tue Dec  1 12:24:58 2020
3.7.9 (default, Aug 31 2020, 07:22:35)
[Clang 10.0.0 ]
```

1 G Object Oriented Programation. Objects, classes, etc...

This is part of the Python lecture given by Christophe Morisset at IA-UNAM. More informations at: https://github.com/Morisset/Python-lectures-Notebooks

[2]:
```
%matplotlib inline
import numpy as np
import matplotlib.pyplot as plt
import os # We will need this latter
from scipy.integrate import simps
from urllib.request import urlopen
# In python 2, it was:
# from urllib2 import urlopen
```

We want here to make some plots of atmosphere models that will be downloaded from internet. We need:

- Download the file
- read it
- plot it

This can all be done in functions, and also in object.

1.0.1 Functions

Let's first see the way we can do it with functions:

The files are located there: http://astro.uni-tuebingen.de/~rauch/TMAF/flux_He+C+N+O.html

For exemple, a file is: http://astro.uni-tuebingen.de/~rauch/TMAF/NLTE/He+C+N+O/0050000_7.00_33_50_(
We can download it using urllib2, putting this into a function:

[3]:
```
def dlfile(filename):
    stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/NLTE/
↪He+C+N+O/' + filename)
    output = open(filename,'wb') #the file where we will put the data. b stands␣
↪for binary, as it is a gzip file
    output.write(stel_file.read()) # the reading of the distant file is␣
↪redirected to the writting of the local one
    output.close()
```

[4]:
```
filename = '0050000_7.00_33_50_02_15.bin_0.1.gz'
dlfile(filename)
```

[5]:
```
! ls -lh *gz
```

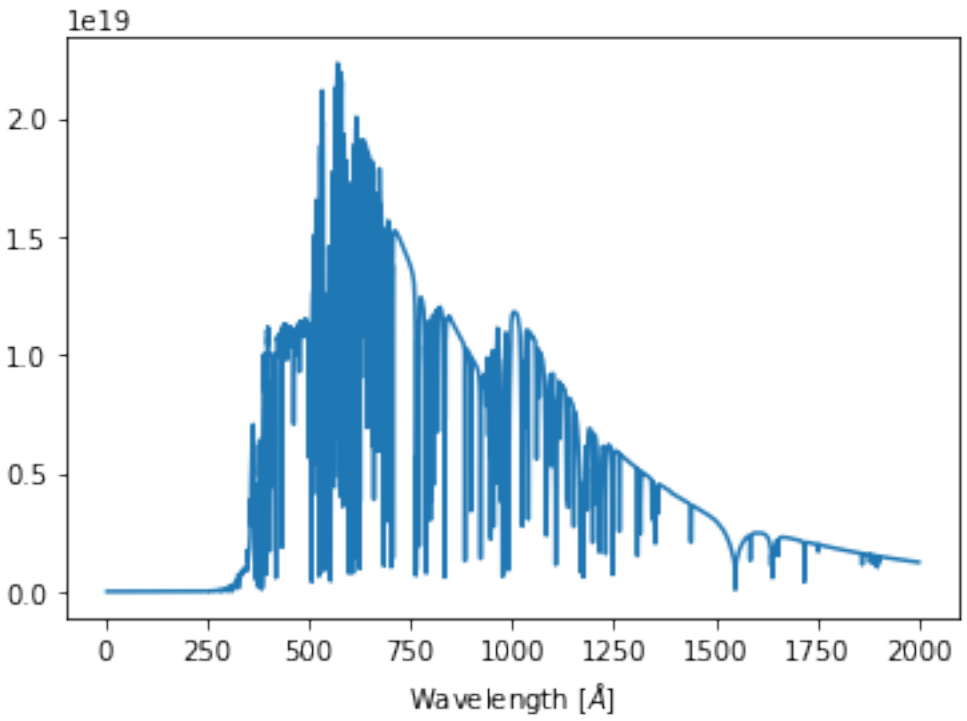
```
-rw-r--r--  1 christophemorisset  staff    84K Dec  1 12:25
0050000_7.00_33_50_02_15.bin_0.1.gz
-rw-------  1 christophemorisset  staff   4.0M May 31  2016 CALIFA_ah7.dat.gz
-rw-r--r--  1 christophemorisset  staff    46K Oct 22 10:18 HII.dat.gz
-rw-------  1 christophemorisset  staff   1.2M May 31  2016 MySQL.pdf.gz
```

[6]:
```
data = np.genfromtxt(filename, comments='*', names='wl, fl') # genfromtxt can␣
↪read gzip files
```

[7]:
```
data
```

[7]:
```
array([(   5. , 4.596e-20), (   5.1, 3.524e-19), (   5.2, 2.475e-18), …,
       (1999.8, 1.242e+18), (1999.9, 1.242e+18), (2000. , 1.241e+18)],
      dtype=[('wl', '<f8'), ('fl', '<f8')])
```

[8]:
```
plt.plot(data['wl'], data['fl']) # let's have a look at the data
plt.xlabel(r'Wavelength [$\AA$]');
```

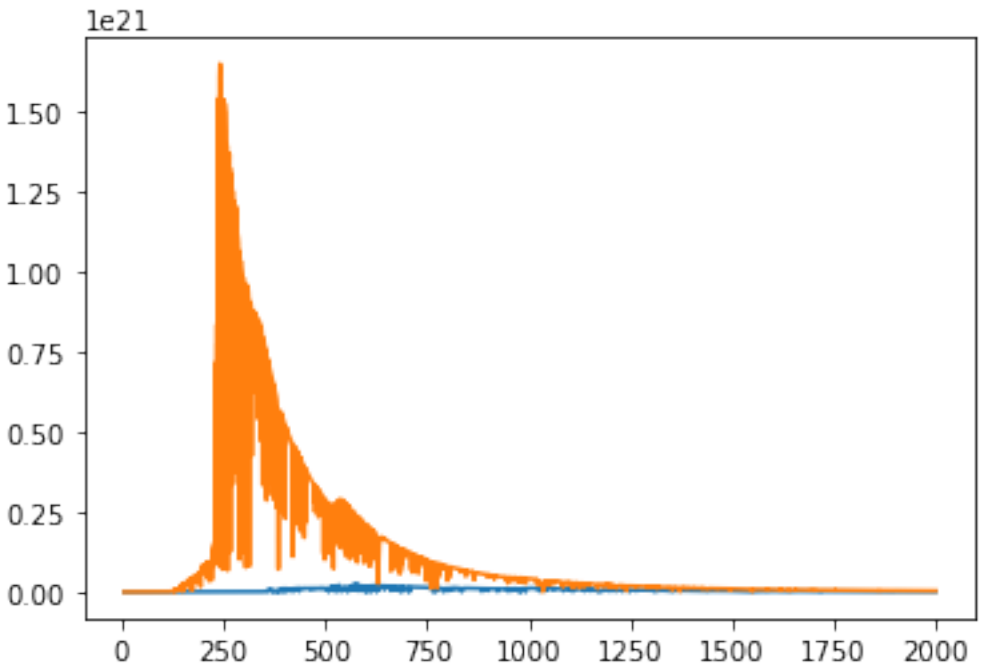


If we want to overplot another file, we only have to download it and follow the same process:

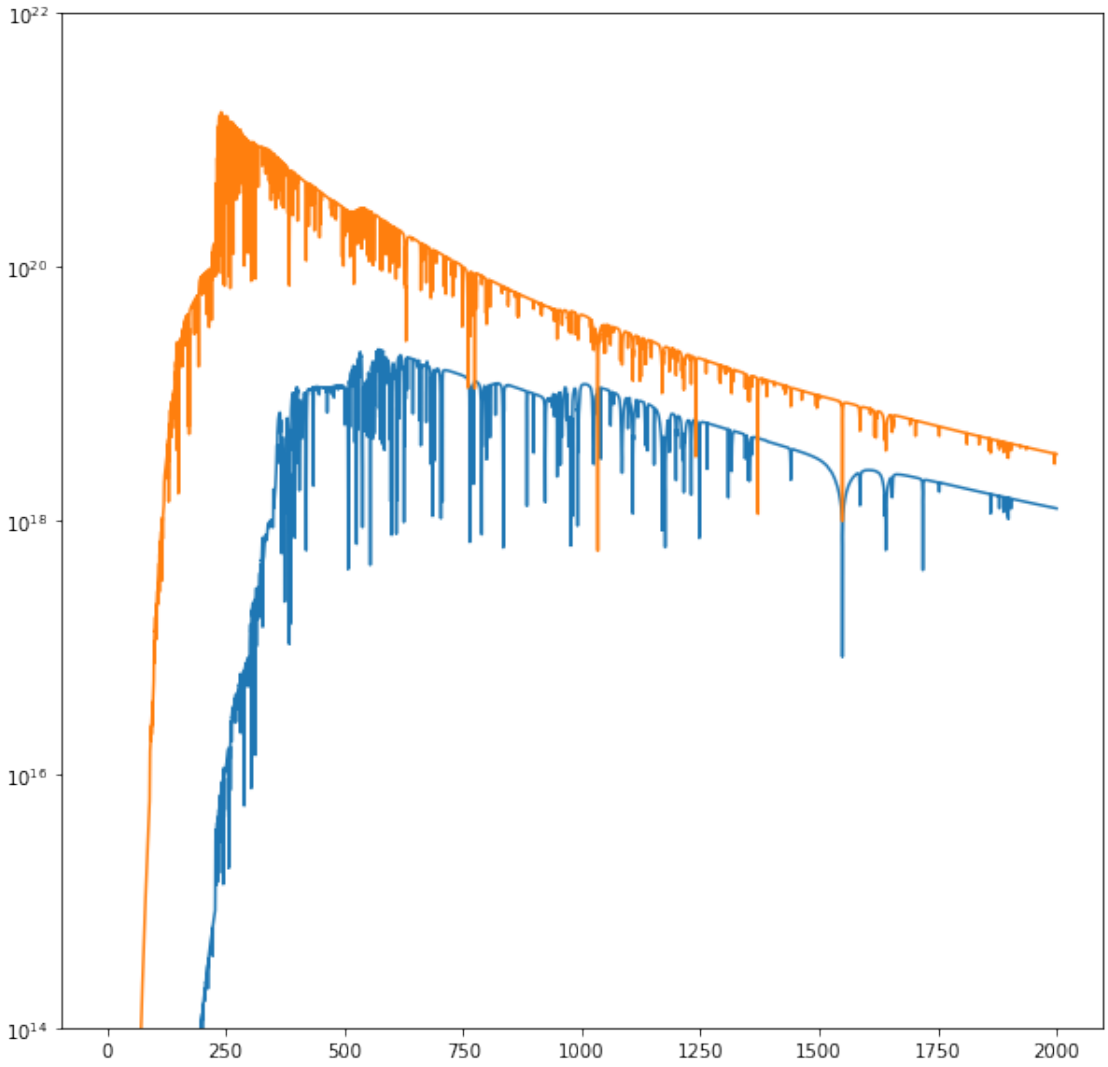
[9]:
```
filename2 = '0110000_7.00_33_50_02_15.bin_0.1.gz'
dlfile(filename2)
```

[10]:
```
data2 = np.genfromtxt(filename2, comments='*', names='wl, fl') # data and data2
↪contains the 2 different data sets
```

[11]:
```
plt.plot(data['wl'], data['fl'])
plt.plot(data2['wl'], data2['fl']);
```

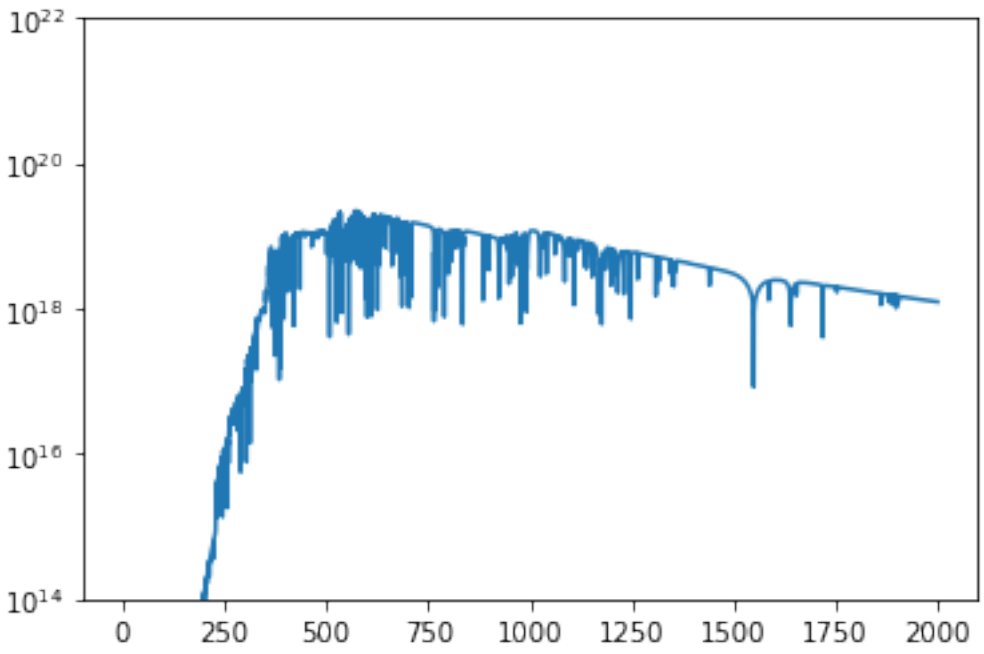


[12]:
```
fig, ax = plt.subplots(figsize=(10,10))
ax.plot(data['wl'], data['fl'])
ax.plot(data2['wl'], data2['fl'])
ax.set_yscale('log')
ax.set_ylim(1e14, 1e22);
```



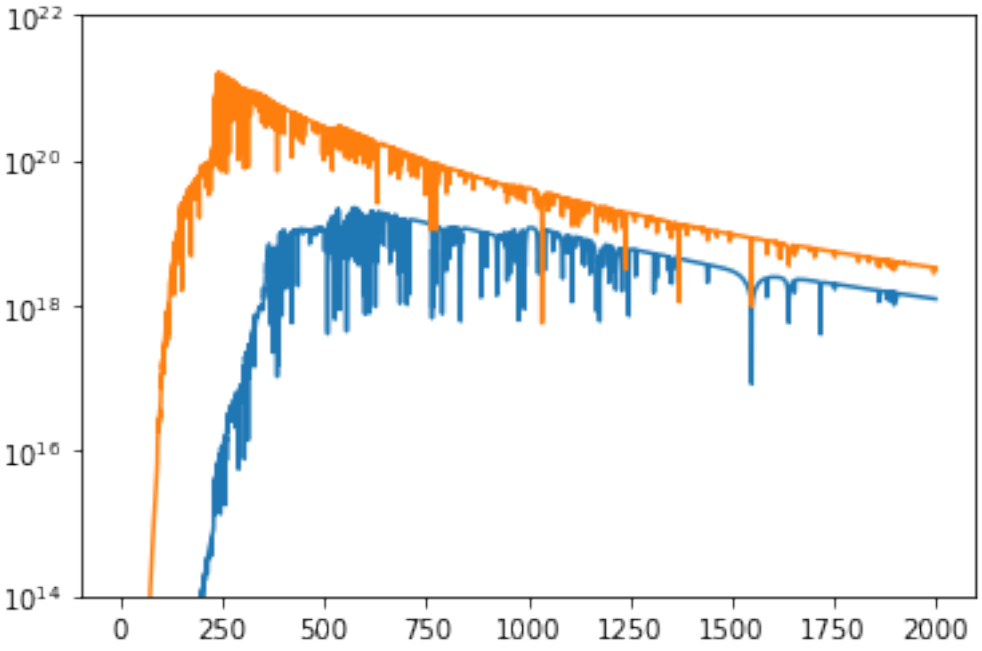
Great, but it would be better if everything were in the same place. Making a function more complete that deal with everything:

[13]:
```
def plot_spr(filename):
    dlfile(filename) # download the file
    data = np.genfromtxt(filename, comments='*', names='wl, fl') # read it
    fig, ax = plt.subplots()
    ax.plot(data['wl'], data['fl']) # plot it
    ax.set_yscale('log') # use log axes
    ax.set_ylim(1e14, 1e22)
plot_spr(filename)
```

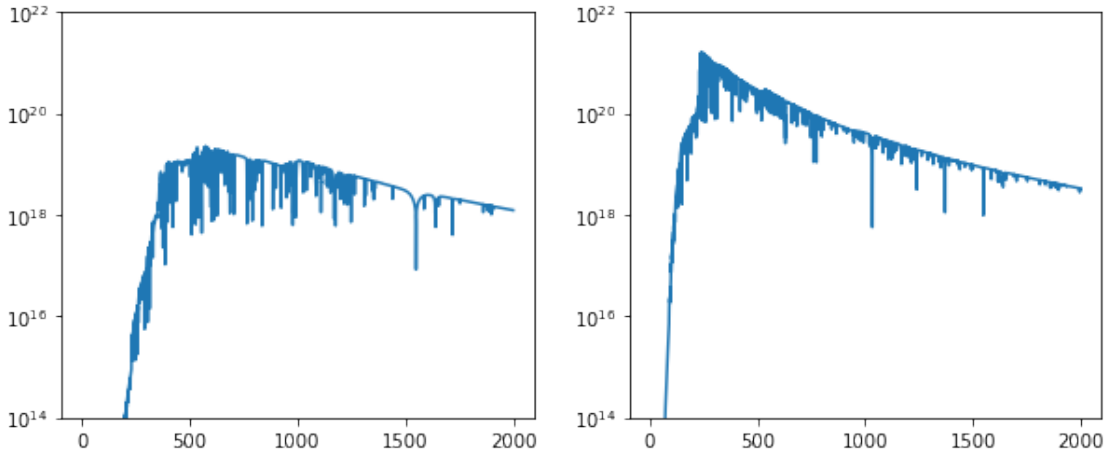


The main problem here is to superimpose the 2 plots. We can define the axis object outside and send it to the function:

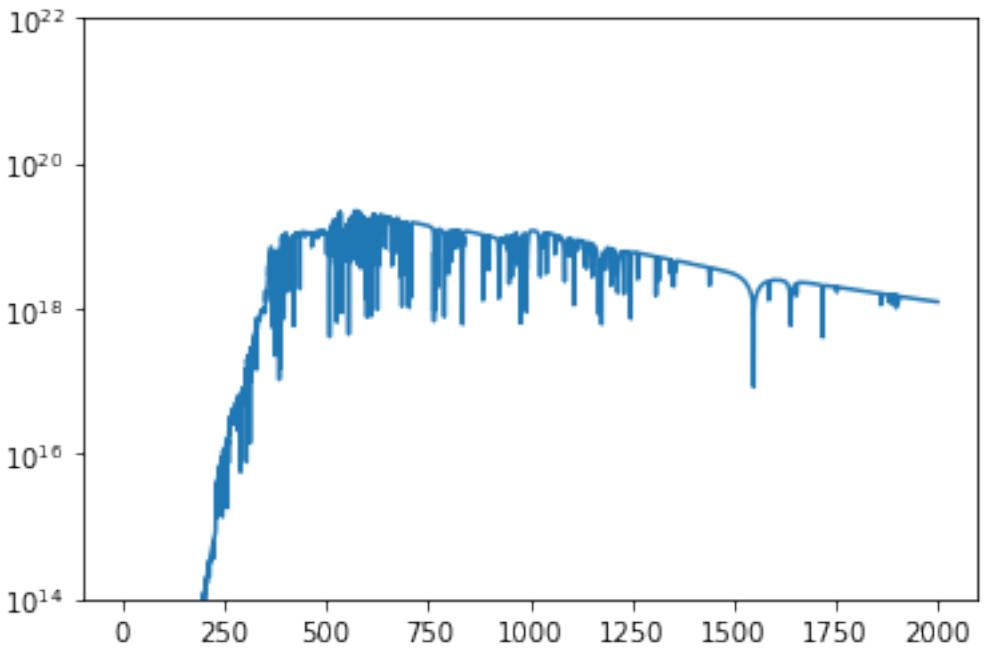
[14]:
```
def plot_spr(filename, ax=None): # default is no axis sent to the function
    dlfile(filename)
    data = np.genfromtxt(filename, comments='*', names='wl, fl')
    if ax is None: # make a figue if no axis is passed to the function
        fig, ax = plt.subplots()
    else:
        fig = plt.gcf()
    ax.plot(data['wl'], data['fl'])
    ax.set_yscale('log')
    ax.set_ylim(1e14, 1e22)

fig, ax = plt.subplots() # the figure and axis is buildt before calling the␣
 ↪plotting function
plot_spr(filename, ax=ax) # sending axis let the plots appear on the same figure
plot_spr(filename2, ax=ax);
```



[15]:
```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(10, 4)) # the figure and axis is␣
↪buildt before calling the plotting function
plot_spr(filename, ax=ax1) # sending axis let the plots appear on the same␣
↪figure
plot_spr(filename2, ax=ax2)
```



[16]:
```
# plot_spr is a function, but there is no return command. It nevertheless␣
↪return None.
a = plot_spr(filename)
```



[17]:
```
print(a)
```

```
None
```

But now that everything is compact, we don't have access to the data, they are INSIDE the function…

1.0.2 Classes and Objects

It's time to make a class and to instantiate objects. Classes are intelligent containers. The can hold variables and functions (called methods). The following terminology is from http://www.tutorialspoint.com/python/python_classes_objects.htm:

- *Class*: A user-defined prototype for an object that defines a set of attributes that characterize any object of the class. The attributes are data members (class variables and instance variables) and methods, accessed via dot notation.
- *Class variable or attribute*: A variable that is shared by all instances of a class. Class variables are defined within a class but outside any of the class's methods. Class variables aren't used as frequently as instance variables are.
- *Data member*: A class variable or instance variable that holds data associated with a class and its objects.
- *Function overloading*: The assignment of more than one behavior to a particular function. The operation performed varies by the types of objects (arguments) involved.
- *Instance variable or attribute*: A variable that is defined inside a method and belongs only to the current instance of a class.
- *Inheritance* : The transfer of the characteristics of a class to other classes that are derived from it.

- *Instance*: An individual object of a certain class. An object obj that belongs to a class Circle, for example, is an instance of the class Circle.
- *Instantiation* : The creation of an instance of a class.
- *Method* : A special kind of function that is defined in a class definition.
- *Object* : A unique instance of a data structure that's defined by its class. An object comprises both data members (class variables and instance variables) and methods.
- *Operator overloading*: The assignment of more than one function to a particular operator.

[18]:
```
class Stel_Spectrum(object):
    """
    This object downloads a file from http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/
    and is able to make some plots.
    """
    def __init__(self, filename): # This function will be called at the␣
↪instantiation of any object.
        self.filename = filename # we put the file name value into an instance␣
↪variable. That allows any method to access it.
        self._dlfile() # calling a method (defined below). No need for␣
↪argument, as filename is known
        self.data = np.genfromtxt(self.filename, comments='*', names='wl, fl')␣
↪# reading the data into an istance variable.

    def _dlfile(self): # method.
        if not os.path.exists(self.filename): # only donwload if not yet on the␣
↪disk
            stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/NLTE/
↪He+C+N+O/' +
                                        self.filename)
            output = open(self.filename,'wb')
            output.write(stel_file.read())
            output.close()

    def plot_spr(self, ax=None): # another method. Used to plot
        if ax is None:
            fig, ax = plt.subplots()
        else:
            fig = plt.gcf()
        ax.plot(self.data['wl'], self.data['fl'])
        ax.set_yscale('log')
        ax.set_ylim(1e14, 1e22)
```

[19]:
```
sp1 = Stel_Spectrum(filename) # instantiation of an object from the␣
↪Stel_Spectrum class
sp2 = Stel_Spectrum(filename2) # another object. They have the same structure,␣
↪but hols different data
```

[20]:
```
print(sp1.filename) # access the instance variable
print(sp2.filename)
```

```
0050000_7.00_33_50_02_15.bin_0.1.gz
0110000_7.00_33_50_02_15.bin_0.1.gz
```

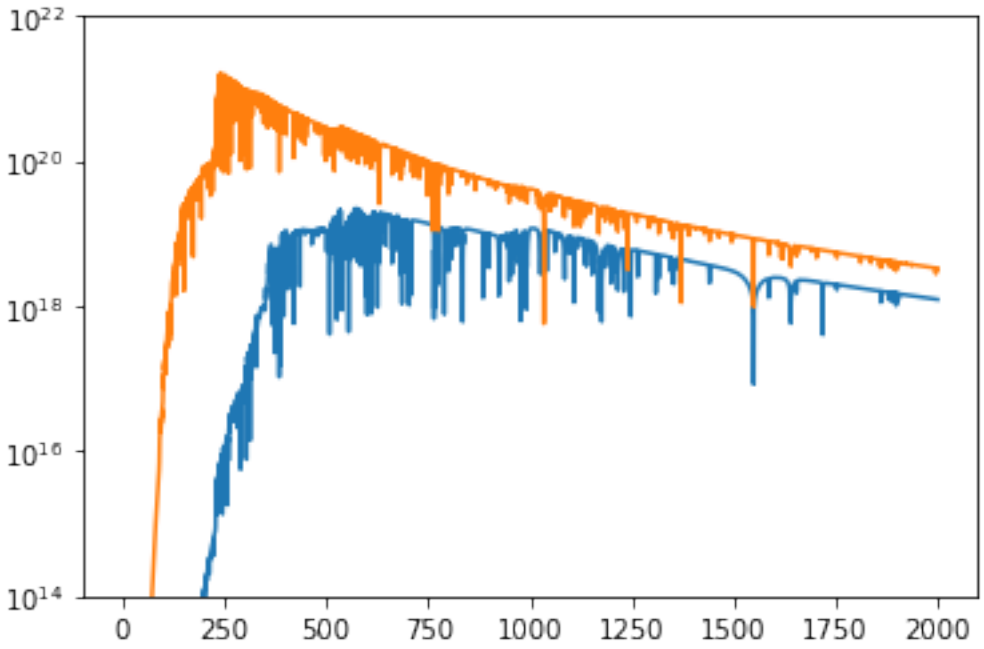
[24]:
```
sp1.TAB
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-24-c6c73c906223> in <module>
----> 1 sp1.TAB

AttributeError: 'Stel_Spectrum' object has no attribute 'TAB'
```

[22]:
```
sp2.data # the data are available.
```

[22]:
```
array([(   5. , 1.028e+03), (   5.1, 2.393e+03), (   5.2, 5.362e+03), …,
       (1999.8, 3.328e+18), (1999.9, 3.327e+18), (2000. , 3.326e+18)],
      dtype=[('wl', '<f8'), ('fl', '<f8')])
```

[23]:
```
fig, ax = plt.subplots()
sp1.plot_spr(ax=ax) # calling the metod
sp2.plot_spr(ax=ax)
```



[25]:
```
len(sp1.data) # the data from the object are like any other data.
```

[25]:
```
19951
```

We can add comments and a method that gives information about the object itself.

[26]:
```
class Stel_Spectrum(object):
    """
    This object downloads a file from http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/
    and is able to make some plots.
    """
    def __init__(self, filename):
        """
        Initialisation of the Stel_Spectrum object.
        Parameter:
            - filename e.g. 0050000_7.00_33_50_02_15.bin_0.1.gz
        """
        self.filename = filename
        self.dlfile()
        self.data = np.genfromtxt(filename, comments='*', names='wl, fl')

    def dlfile(self):
        """
        Downloading file if not already here
        """
        if not os.path.exists(self.filename):
            print('Downloading {}.'.format(self.filename))
            stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/NLTE/
↪He+C+N+O/' + self.filename)
            output = open(self.filename,'wb')
            output.write(stel_file.read())
            output.close()
        else:
            print('{} already on disk.'.format(self.filename))

    def plot_spr(self, ax=None):
        """
        Plot the spectrum.
        Parameter:
            - ax: an axis (optionnal). If None or absent, axis is created
        """
        if ax is None:
            fig, ax = plt.subplots()
        ax.plot(self.data['wl'], self.data['fl'])
        ax.set_yscale('log')
        ax.set_ylim(1e14, 1e22)
```

```
    def print_info(self):
        """
        Print out the filename and the number of points
        """
        print('Filename: {0}, number of points: {1}'.format(self.filename,␣
↪len(self.data)))
```

[27]:
```
sp1 = Stel_Spectrum(filename) # we have to instatiate again to take the changes␣
↪into account
sp2 = Stel_Spectrum(filename2)
sp1.print_info()
sp2.print_info()
```

```
0050000_7.00_33_50_02_15.bin_0.1.gz already on disk.
0110000_7.00_33_50_02_15.bin_0.1.gz already on disk.
Filename: 0050000_7.00_33_50_02_15.bin_0.1.gz, number of points: 19951
Filename: 0110000_7.00_33_50_02_15.bin_0.1.gz, number of points: 19951
```

[28]:
```
help(sp1) # the comments are easily accessible
```

```
Help on Stel_Spectrum in module __main__ object:

class Stel_Spectrum(builtins.object)
 |  Stel_Spectrum(filename)
 |
 |  This object downloads a file from http://astro.uni-
tuebingen.de/~rauch/TMAF/NLTE/He+C+N+O/
 |  and is able to make some plots.
 |
 |  Methods defined here:
 |
 |  __init__(self, filename)
 |      Initialisation of the Stel_Spectrum object.
 |      Parameter:
 |          - filename e.g. 0050000_7.00_33_50_02_15.bin_0.1.gz
 |
 |  dlfile(self)
 |      Downloading file if not already here
 |
 |  plot_spr(self, ax=None)
 |      Plot the spectrum.
 |      Parameter:
 |          - ax: an axis (optionnal). If None or absent, axis is created
 |
 |  print_info(self)
 |      Print out the filename and the number of points
```

```
 |
 |  ----------------------------------------------------------------------
 |  Data descriptors defined here:
 |
 |  __dict__
 |      dictionary for instance variables (if defined)
 |
 |  __weakref__
 |      list of weak references to the object (if defined)
```

[29]:
```
help(sp1.plot_spr)
```

```
Help on method plot_spr in module __main__:

plot_spr(ax=None) method of __main__.Stel_Spectrum instance
    Plot the spectrum.
    Parameter:
        - ax: an axis (optionnal). If None or absent, axis is created
```

[30]:
```
sp1.plot_spr?
```

```
Signature: sp1.plot_spr(ax=None)
Docstring:
Plot the spectrum.
Parameter:
    - ax: an axis (optionnal). If None or absent, axis is created
File:      ~/Google Drive/Pro/Python-MySQL/Notebooks/Notebooks/
 ↪<ipython-input-26-d9b748cf5b74>
Type:      method
```

[31]:
```
print(sp1)
```

```
<__main__.Stel_Spectrum object at 0x7fd488164050>
```

Adding more method and changing the name of the data to wl and fl. We can accept T and logg to define the filename and download it. Some error catching process are implemented. We laso add a method to compute the integrale of the flux over the wavelengths.

[32]:
```
class Stel_Spectrum(object):
    """
    This object downloads a file from http://astro.uni-tuebingen.de/~rauch/TMAF/
 ↪NLTE/He+C+N+O/
    and is able to make some plots.
    """
    def __init__(self, filename=None, T=None, logg=None, verbose=False):
```

```
        """
        Initialisation of the Stel_Spectrum object.
        Parameter:
            - filename
            - T: temperature in K, e.g. 150000
            - logg: e.g. 7.5
        The wl attribute is an array of wavelengths in Angstrom.
        The fl attribute is the flux in erg/s/cm2/A
        """
        self.verbose = verbose
        if filename is None:
            if T is not None and logg is not None:
                self.T = T
                self.logg = logg
                self.filename = '0{0:06.0f}_{1:.2f}_33_50_02_15.bin_0.1.gz'.
↪format(self.T, self.logg)
            else:
                raise TypeError("T and logg must be given")
        else:
            self.filename = filename
            self.T = float(filename.split('_')[0])
            self.logg = float(filename.split('_')[1])
        self.dlfile()
        if self.file_found:
            data = np.genfromtxt(self.filename, comments='*', names='wl, fl')
            self.fl = data['fl']
            self.wl = data['wl'] # in A
            self.fl /= 1e8 # F LAMBDA  GIVEN IN ERG/CM**2/SEC/CM -> erg/s/cm2/A
            if self.verbose:
                print('Data from {} read.'.format(self.filename))
        else:
            self.wl = None
            self.fl = None

    def dlfile(self):
        """
        Downloading file if not already here. Put it in the curremt directory
        """
        if not os.path.exists(self.filename):
            if self.verbose:
                print('Downloading {}'.format(self.filename))
            try:
                stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/' +
                                                self.filename)
                output = open(self.filename,'wb')
                output.write(stel_file.read())
```

```
                output.close()
                self.file_found=True
            except:
                print('file {} not found'.format(self.filename))
                self.file_found=False
        else:
            self.file_found=True

    def plot_spr(self, ax=None):
        """
        Plot the spectrum.
        Parameter:
            - ax: an axis (optionnal). If Noe or absent, axis is created
        """
        if self.wl is None:
            print('No data to plot')
            return
        if ax is None:
            fig, ax = plt.subplots()
        ax.plot(self.wl, self.fl, label='T={0:.0f} kK, logg={1}'.format(self.T/
↪1e3, self.logg))
        ax.set_yscale('log')
        ax.set_ylim(1e6, 1e14)
        ax.set_xlabel('Wavelength (A)')

    def print_info(self):
        """
        Print out the filename and the number of points
        """
        print(self.__repr__())

    def __repr__(self):
        """
        This is what is used when calling "print <obj>" or <obj> ENTER
        """
        if self.wl is None:
            return'Filename: {0}, No data'.format(self.filename)
        else:
            return'Filename: {0}, number of points: {1}'.format(self.filename,␣
↪len(self.wl))

    def get_integ(self):
        """
        Return the integral of Flambda over lambda, in erg/s/cm2
        """
        if self.wl is None:
            if self.verbose:
```

```
                print('No data')
            return None
        return simps(self.fl, self.wl) # perform the integral
```

[33]:
```
sp1 = Stel_Spectrum(T=130000, logg=6)
print(sp1)
```

```
Filename: 0130000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951
```

[34]:
```
sp3 = Stel_Spectrum(T=330000, logg=6, verbose=True)
print(sp3)
```

```
Downloading 0330000_6.00_33_50_02_15.bin_0.1.gz
file 0330000_6.00_33_50_02_15.bin_0.1.gz not found
Filename: 0330000_6.00_33_50_02_15.bin_0.1.gz, No data
```

[35]:
```
spectra = [] # we create an empty list
for T in np.linspace(40000, 190000, 16): # this is the list of available␣
 ↪temperature (check the site)
    spectra.append(Stel_Spectrum(T=T, logg=6, verbose=True)) # we fill the list␣
 ↪with the objects for each temperature
```

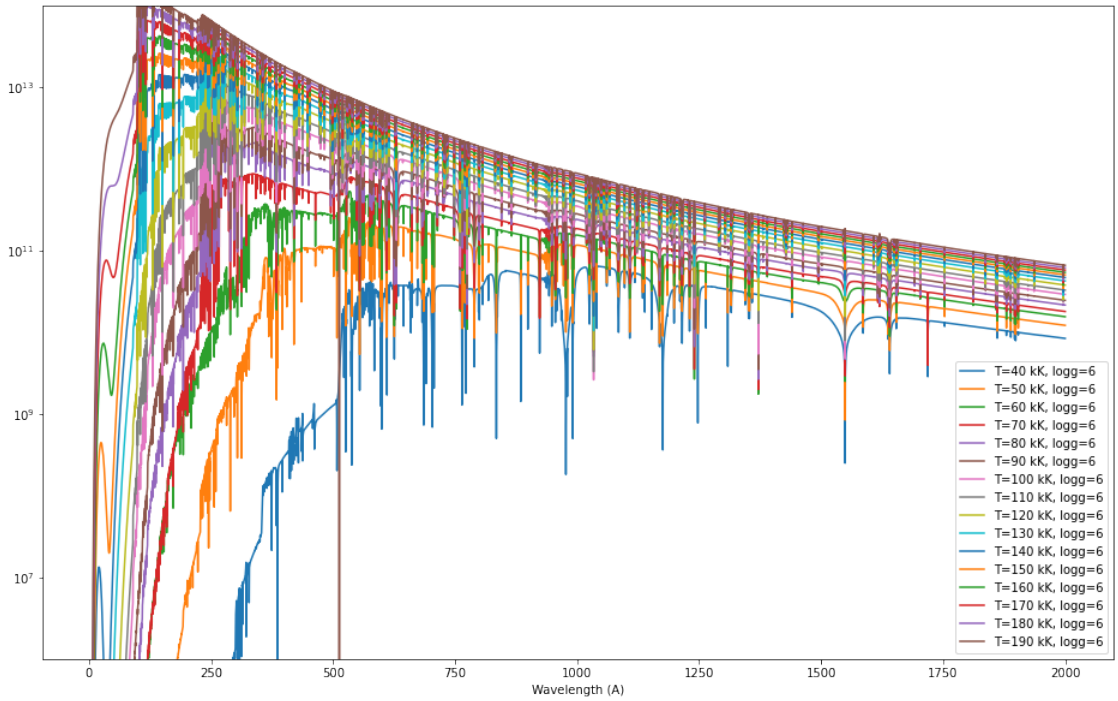
```
Downloading 0040000_6.00_33_50_02_15.bin_0.1.gz
Data from 0040000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0050000_6.00_33_50_02_15.bin_0.1.gz
Data from 0050000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0060000_6.00_33_50_02_15.bin_0.1.gz
Data from 0060000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0070000_6.00_33_50_02_15.bin_0.1.gz
Data from 0070000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0080000_6.00_33_50_02_15.bin_0.1.gz
Data from 0080000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0090000_6.00_33_50_02_15.bin_0.1.gz
Data from 0090000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0100000_6.00_33_50_02_15.bin_0.1.gz
Data from 0100000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0110000_6.00_33_50_02_15.bin_0.1.gz
Data from 0110000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0120000_6.00_33_50_02_15.bin_0.1.gz
Data from 0120000_6.00_33_50_02_15.bin_0.1.gz read.
Data from 0130000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0140000_6.00_33_50_02_15.bin_0.1.gz
Data from 0140000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0150000_6.00_33_50_02_15.bin_0.1.gz
Data from 0150000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0160000_6.00_33_50_02_15.bin_0.1.gz
Data from 0160000_6.00_33_50_02_15.bin_0.1.gz read.
```

```
Downloading 0170000_6.00_33_50_02_15.bin_0.1.gz
Data from 0170000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0180000_6.00_33_50_02_15.bin_0.1.gz
Data from 0180000_6.00_33_50_02_15.bin_0.1.gz read.
Downloading 0190000_6.00_33_50_02_15.bin_0.1.gz
Data from 0190000_6.00_33_50_02_15.bin_0.1.gz read.
```

[36]:
```
spectra # the list hold 16 objects, each one with its own data and methods
```

[36]:
```
[Filename: 0040000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0050000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0060000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0070000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0080000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0090000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0100000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0110000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0120000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0130000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0140000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0150000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0160000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0170000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0180000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951,
 Filename: 0190000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951]
```

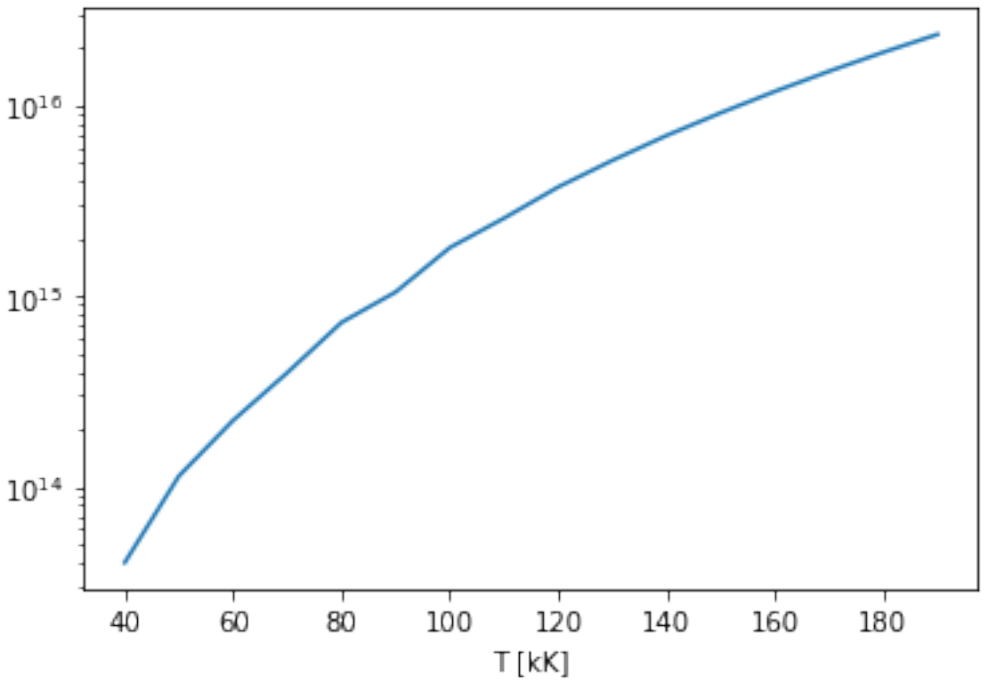
[37]:
```
fig, ax = plt.subplots(figsize=(16,10))
for sp in spectra: # easy to loop on the objects
    sp.plot_spr(ax=ax)
ax.legend(loc=4);
```



[38]:
```
for sp in spectra:
    print('T = {:6.0f} K, integral: {:.2e}'.format(sp.T, sp.get_integ()))
```

```
T =  40000 K, integral: 4.00e+13
T =  50000 K, integral: 1.14e+14
T =  60000 K, integral: 2.23e+14
T =  70000 K, integral: 3.96e+14
T =  80000 K, integral: 7.25e+14
T =  90000 K, integral: 1.05e+15
T = 100000 K, integral: 1.79e+15
T = 110000 K, integral: 2.55e+15
T = 120000 K, integral: 3.72e+15
T = 130000 K, integral: 5.13e+15
T = 140000 K, integral: 6.93e+15
T = 150000 K, integral: 9.11e+15
T = 160000 K, integral: 1.18e+16
T = 170000 K, integral: 1.51e+16
T = 180000 K, integral: 1.89e+16
T = 190000 K, integral: 2.35e+16
```

[39]:
```
# using list comprehension to compute on the fly the coordinates of the plot:
plt.semilogy([sp.T/1e3 for sp in spectra], [sp.get_integ() for sp in spectra])
plt.xlabel('T [kK]');
```

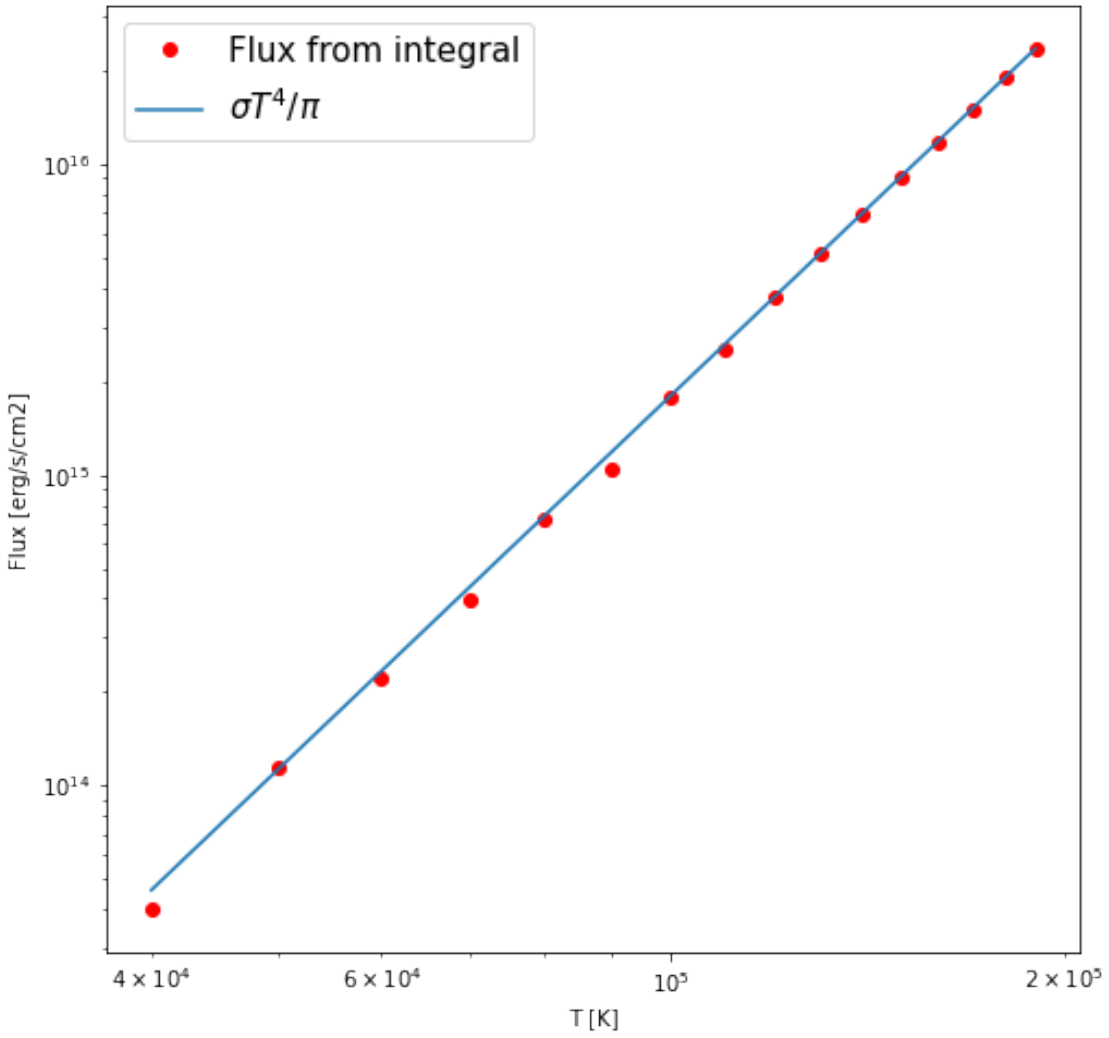


[40]:
```
# Better to put the values into a numpy array:
Ts = np.array([sp.T for sp in spectra])
Fs = np.array([sp.get_integ() for sp in spectra])
```

[41]:
```
# check that the luminosity increase like sigma.T**4
from astropy import __version__ as astropyversion
print(astropyversion)
```

```
4.0.2
```

[42]:
```
from astropy import constants # in real life, it is better to move this to the␣
↪top of the program
sigma = constants.sigma_sb.to('erg/(s K4 cm2)') # convert Steffen-Boltzmann␣
↪constant into cgs units
fig, ax = plt.subplots(figsize=(8,8))
ax.loglog(Ts, Fs, 'ro', label='Flux from integral')
ax.loglog(Ts, sigma.value * Ts**4 / np.pi, label=r'$\sigma T^4 / \pi$') #␣
↪overplot sigma . T^4 / pi
ax.legend(loc=2, fontsize=15)
ax.set_xlabel('T [K]')
ax.set_ylabel('Flux [erg/s/cm2]');
```



1.0.3 Using *args and **kwargs in functions

This allows to pass arguments (without and with keyword respectively) to function. No need to know what are the arguments when desining the function.

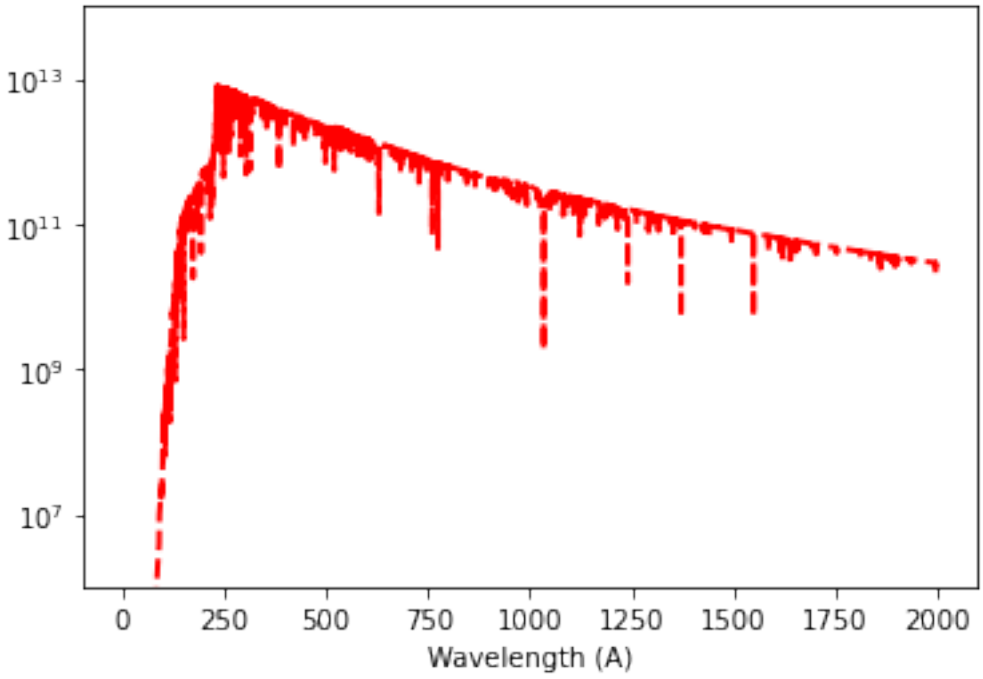
[43]:
```
class Stel_Spectrum(object):
    """
    This object downloads a file from http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/
    and is able to make some plots.
    """
    def __init__(self, filename=None, T=None, logg=None):
        """
        Initialisation of the Stel_Spectrum object.
        Parameter:
```

```
            - filename
            - T: temperature in K, e.g. 150000
            - logg: e.g. 7.5
        The wl variable is an array of wavelengths in Angstrom.
        The fl variable is the flux in erg/s/cm2/A
        """
        if filename is None:
            if T is not None and logg is not None:
                self.T = T
                self.logg = logg
                self.filename = '0{0:06.0f}_{1:.2f}_33_50_02_15.bin_0.1.gz'.
↪format(self.T, self.logg)
            else:
                raise TypeError("T and logg must be given")
        else:
            self.filename = filename
            self.T = float(filename.split('_')[0])
            self.logg = float(filename.split('_')[1])
        self.dlfile()
        if self.file_found:
            data = np.genfromtxt(self.filename, comments='*', names='wl, fl')
            self.fl = data['fl']
            self.wl = data['wl'] # in A
            self.fl /= 1e8 # F LAMBDA  GIVEN IN ERG/CM**2/SEC/CM -> erg/s/cm2/A
        else:
            self.wl = None
            self.fl = None

    def dlfile(self):
        """
        Downloading file if not already here. Put it in the curremt directory
        """
        if not os.path.exists(self.filename):
            print('Downloading {}'.format(self.filename))
            try:
                stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/' +
                                                self.filename)
                output = open(self.filename,'wb')
                output.write(stel_file.read())
                output.close()
                self.file_found=True
            except:
                print('file {} not found'.format(self.filename))
                self.file_found=False
        else:
            self.file_found=True
```

```
    def plot_spr(self, ax=None, *args, **kwargs):
        """
        Plot the spectrum.
        Parameter:
            - ax: an axis (optionnal). If Noe or absent, axis is created
            - any extra parameter is passed to ax.plot
        """
        if self.wl is None:
            print('No data to plot')
            return
        if ax is None:
            fig, ax = plt.subplots()
        ax.plot(self.wl, self.fl,
                label='T3={0:.0f}, logg={1}'.format(self.T/1e3, self.logg),
                *args, **kwargs) # Here are the transmissions of extra␣
↪parameters to plot
        ax.set_yscale('log')
        ax.set_ylim(1e6, 1e14)
        ax.set_xlabel('Wavelength (A)')

    def print_info(self):
        """
        Print out the filename and the number of points
        """
        print(self.__repr__())

    def __repr__(self):
        """
        This is what is used when calling "print <obj>" or <obj> ENTER
        """
        if self.wl is None:
            return'Filename: {0}, No data'.format(self.filename)
        else:
            return'Filename: {0}, number of points: {1}'.format(self.filename,␣
↪len(self.wl))

    def get_integ(self):
        """
        Return the integral of Flambda over lambda, in erg/s/cm2
        """
        if self.wl is None:
            print('No data')
            return None
        return simps(self.fl, self.wl) # perform the integral
```

[44]:
```
sp1 = Stel_Spectrum(T=100000, logg=5)
print(sp1)
fig, ax = plt.subplots()
sp1.plot_spr(ax, 'r', linewidth=2, linestyle='--') # any extra argument is␣
↪passed to plot
```

```
Downloading 0100000_5.00_33_50_02_15.bin_0.1.gz
Filename: 0100000_5.00_33_50_02_15.bin_0.1.gz, number of points: 19951
```



1.0.4 Class variables or class attributes

They are known and share between all the instanciations of a class. Usefull to count the number of objects of the same class.

[45]:
```
class Stel_Spectrum(object):
    """
    This object downloads a file from http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/
    and is able to make some plots.
    """

    spec_count = 0 # This attibute is at the level of the class, not of the␣
↪object.
    def __init__(self, filename=None, T=None, logg=None, verbose=False):
        """
```

```
        Initialisation of the Stel_Spectrum object.
        Parameter:
            - filename
            - T: temperature in K, e.g. 150000
            - logg: e.g. 7.5
        The wl variable is an array of wavelengths in Angstrom.
        The fl variable is the flux in erg/s/cm2/A
        """
        self.verbose = verbose
        if filename is None:
            if T is not None and logg is not None:
                self.T = T
                self.logg = logg
                self.filename = '0{0:06.0f}_{1:.2f}_33_50_02_15.bin_0.1.gz'.
↪format(self.T, self.logg)
            else:
                raise TypeError("T and logg must be given")
        else:
            self.filename = filename
            self.T = float(filename.split('_')[0])
            self.logg = float(filename.split('_')[1])
        self.dlfile()
        if self.file_found:
            data = np.genfromtxt(self.filename, comments='*', names='wl, fl')
            self.fl = data['fl']
            self.wl = data['wl'] # in A
            self.fl /= 1e8 # F LAMBDA  GIVEN IN ERG/CM**2/SEC/CM -> erg/s/cm2/A
            if verbose:
                print('Data read')
        else:
            self.wl = None
            self.fl = None
        Stel_Spectrum.spec_count += 1
        if self.verbose:
            print('Number of spectra: {}'.format(Stel_Spectrum.spec_count))

    def dlfile(self):
        """
        Downloading file if not already here. Put it in the curremt directory
        """
        if not os.path.exists(self.filename):
            print('Downloading {}'.format(self.filename))
            try:
                stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/' +
                                                self.filename)
                output = open(self.filename,'wb')
```

```
                output.write(stel_file.read())
                output.close()
                self.file_found=True
            except:
                print('file {} not found'.format(self.filename))
                self.file_found=False
        else:
            self.file_found=True

    def plot_spr(self, ax=None, *args, **kwargs):
        """
        Plot the spectrum.
        Parameter:
            - ax: an axis (optionnal). If None or absent, axis is created
            - any extra parameter is passed to ax.plot
        """
        if self.wl is None:
            print('No data to plot')
            return
        if ax is None:
            fig, ax = plt.subplots()
        ax.plot(self.wl, self.fl,
                label='T3={0:.0f}, logg={1}'.format(self.T/1e3, self.logg),
                *args, **kwargs) # Here are the transmissions of extra␣
↪parameters to plot
        ax.set_yscale('log')
        ax.set_ylim(1e6, 1e14)
        ax.set_xlabel('Wavelength (A)')

    def print_info(self):
        """
        Print out the filename and the number of points
        """
        print(self.__repr__())

    def __repr__(self):
        """
        This is what is used when calling "print <obj>" or <obj> ENTER
        """
        if self.wl is None:
            return'Filename: {0}, No data'.format(self.filename)
        else:
            return'Filename: {0}, number of points: {1}'.format(self.filename,␣
↪len(self.wl))

    def get_integ(self):
        """
```

```
        Return the integral of Flambda over lambda, in erg/s/cm2
        """
        if self.wl is None:
            print('No data')
            return None
        return simps(self.fl, self.wl) # perform the integral

    def __del__(self):
        Stel_Spectrum.spec_count -= 1
```

[46]:
```
sp1 = Stel_Spectrum(T=100000, logg=5, verbose=True)
sp2 = Stel_Spectrum(T=100000, logg=6, verbose=True)
sp3 = Stel_Spectrum(T=100000, logg=7, verbose=True)
print(Stel_Spectrum.spec_count)
print(sp3.spec_count)
```

```
Data read
Number of spectra: 1
Data read
Number of spectra: 2
Downloading 0100000_7.00_33_50_02_15.bin_0.1.gz
Data read
Number of spectra: 3
3
3
```

[47]:
```
del sp1
print(Stel_Spectrum.spec_count)
```

```
2
```

[48]:
```
for logg in (5, 6, 7, 8):
    sp = Stel_Spectrum(T=100000, logg=logg)
print(Stel_Spectrum.spec_count) # the deleted objects are not count (it would␣
 ↪have been the case without the __del__ method)
```

```
Downloading 0100000_8.00_33_50_02_15.bin_0.1.gz
3
```

[49]:
```
sp = 'tralala'
print(Stel_Spectrum.spec_count)
```

```
2
```

That can be used for example to change a value for a class variable used everywhere (e.g. the reddening correction to be applied to all the spectra before plotting them…)

1.0.5 Adding functionnality to classes and objects (monkey-patch)

[50]:
```
sp1 = Stel_Spectrum(T=100000, logg=5) # Instanciation of a class
def print_ok(): # defining a function outside the class
    print('ok')
sp1.print_ok = print_ok # include the function to the object
sp1.print_ok() # works, the instance is modified
```

```
ok
```

[51]:
```
def print_ok2(self):
    print(self.T)
Stel_Spectrum.print_ok2 = print_ok2 # include the function to the class
sp1.print_ok2() # the class has been modified, and it applies immediatly on the␣
 ↪already instatiated objects

print_ok2(sp1)
```

```
100000
100000
```

[52]:
```
def print_info_ori(self):
    print(self.__repr__())
Stel_Spectrum.print_info_ori = print_info_ori

def print_info(self):
    print('NEW ONE: ',self.__repr__())
Stel_Spectrum.print_info = print_info
sp3 = Stel_Spectrum(T=100000, logg=6)
sp3.print_info_ori()
sp3.print_info()
```

```
Filename: 0100000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951
NEW ONE:  Filename: 0100000_6.00_33_50_02_15.bin_0.1.gz, number of points: 19951
```

[53]:
```
sp2 = Stel_Spectrum(T=100000, logg=6)
sp2.print_ok2()
sp2.print_ok() # ERROR : the print_ok was only included to an object, not to␣
 ↪the class
```

```
100000
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-53-26ba81054fcd> in <module>
      1 sp2 = Stel_Spectrum(T=100000, logg=6)
      2 sp2.print_ok2()
```

```
----> 3 sp2.print_ok() # ERROR : the print_ok was only included to an object,␣
 ↪not to the class

AttributeError: 'Stel_Spectrum' object has no attribute 'print_ok'
```

[54]:
```
def print_T(self): # self could have been named otherwise
    print(self.T)
sp1.print_T = print_T # adding to the object
sp1.print_T() # ERROR: the object has no self reference
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-54-6bfba988aee7> in <module>
      2     print(self.T)
      3 sp1.print_T = print_T # adding to the object
----> 4 sp1.print_T() # ERROR: the object has no self reference

TypeError: print_T() missing 1 required positional argument: 'self'
```

[55]:
```
Stel_Spectrum.print_T = print_T # Adding to the class
sp2 = Stel_Spectrum(T=100000, logg=5) # works immediatly
sp2.print_T()
```

```
100000
```

[56]:
```
def print_T(self): # changing the definition of print_T
    print('T={}'.format(self.T))
sp2.print_T() # does NOT affect the class nor the object
```

```
100000
```

[57]:
```
Stel_Spectrum.print_T = print_T # Adding to the class
sp2.print_T() # now it changes the behaviour
```

```
T=100000
```

[58]:
```
# The same function can also be called passing the object. Good for testing and␣
 ↪developping
print_T(sp2)
```

```
T=100000
```

The monkey patch is usefull for testing purpose. When everything is working fine, better to incorporate the method to the class definition.

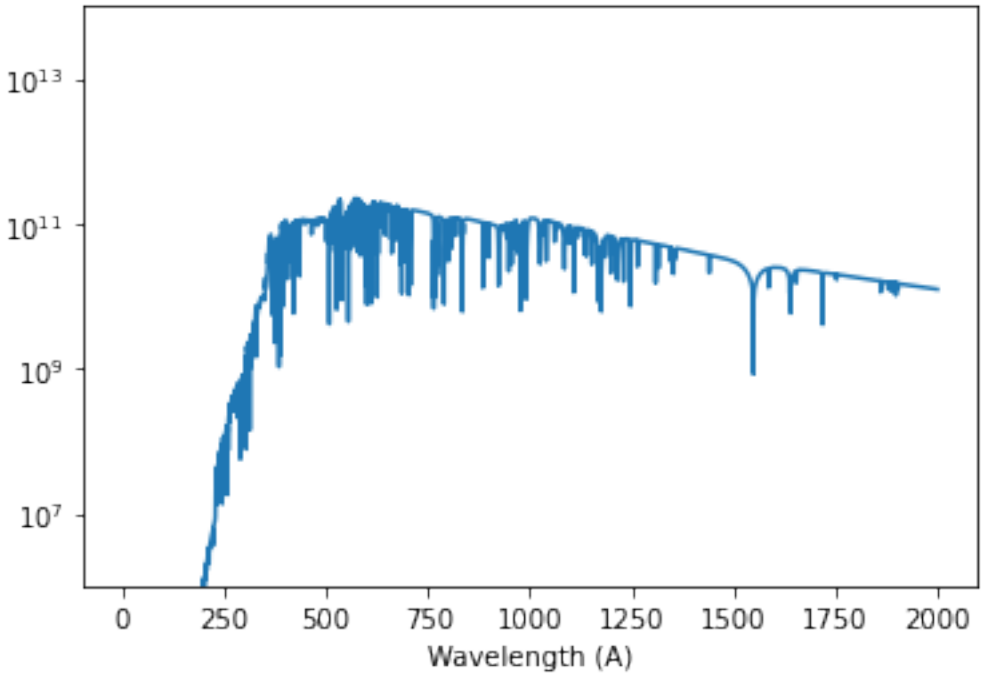
1.0.6 Class inheritance

This is very easy to create a new class from an existing one.

[59]:
```
class Stel_Sp2(Stel_Spectrum):

    def __init__(self, *args, **kwds):
        super(Stel_Sp2, self).__init__(*args, **kwds)

    def print_logg(self):
        print('logg = {}'.format(self.logg))
```

[60]:
```
print(filename)
sp2 = Stel_Sp2(filename)
sp2.plot_spr()
sp2.print_logg()
```

```
0050000_7.00_33_50_02_15.bin_0.1.gz
logg = 7.0
```



[61]:
```
# One can even overwrite methods
class Stel_Sp2(Stel_Spectrum):

    def __init__(self, *args, **kwds):
        super(Stel_Sp2, self).__init__(*args, **kwds)

    def print_logg(self):
        print('logg = {}'.format(self.logg))
```

```
    def print_info(self):
        """
        Print out new information
        """
        print('File: {}, T={}, logg={}'.format(filename, self.T, self.logg))

sp1 = Stel_Spectrum(T=100000, logg=5)
sp2 = Stel_Sp2(T=100000, logg=5)
sp1.print_info()
sp2.print_info()
```

```
NEW ONE:  Filename: 0100000_5.00_33_50_02_15.bin_0.1.gz, number of points: 19951
File: 0050000_7.00_33_50_02_15.bin_0.1.gz, T=100000, logg=5
```

One can mix inheritances, using multiple parents to generate children (!). A lot of examples on the web…

1.0.7 Properties

It is sometimes useful to have things that behave like attributes (print A.b, A.c = 2), but that call some routines. This is the goal of the properties.

For example here, we want the data to be updated if one change T or logg.

[62]:
```
class Stel_Spectrum(object):
    """
    This object downloads a file from http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/
    and is able to make some plots.
    """

    spec_count = 0 # This attibute is at the level of the class, not of the␣
↪object.
    def __init__(self, filename=None, T=None, logg=None, verbose=False):
        """
        Initialisation of the Stel_Spectrum object.
        Parameter:
            - filename
            - T: temperature in K, e.g. 150000
            - logg: e.g. 7.5
            - verbose: if True, some info are printed out
        The wl variable is an array of wavelengths in Angstrom.
        The fl variable is the flux in erg/s/cm2/A
        The variables T and logg are properties: changing them will reload the␣
↪data
        """
        self.verbose = verbose
        if filename is None:
```

```
            if T is not None and logg is not None:
                self.__T = T # We need to initialize the hidden values, as logg␣
↪is still not defined
                self.logg = logg
                self.filename = '0{0:06.0f}_{1:.2f}_33_50_02_15.bin_0.1.gz'.
↪format(self.T, self.logg)
            else:
                raise TypeError("T and logg must be given")
        else:
            self.filename = filename
            self.__T = float(filename.split('_')[0]) # We need to initialize␣
↪the hidden values, as logg is still not defined
            self.logg = float(filename.split('_')[1])
        Stel_Spectrum.spec_count += 1
        if self.verbose:
            print('Instantiation done')

    def dlfile(self):
        """
        Downloading file if not already here. Put it in the current directory
        """
        if not os.path.exists(self.filename):
            if self.verbose:
                print('Downloading {}'.format(self.filename))
            try:
                stel_file = urlopen('http://astro.uni-tuebingen.de/~rauch/TMAF/
↪NLTE/He+C+N+O/' +
                                                self.filename)
                output = open(self.filename,'wb')
                output.write(stel_file.read())
                output.close()
                self.file_found=True
            except:
                if self.verbose:
                    print('file {} not found'.format(self.filename))
                self.file_found=False
        else:
            if self.verbose:
                print('{} already on disk'.format(self.filename))
            self.file_found=True

    def read_data(self):
        """
        read the data from the file
        """
        if self.file_found:
            data = np.genfromtxt(self.filename, comments='*', names='wl, fl')
```

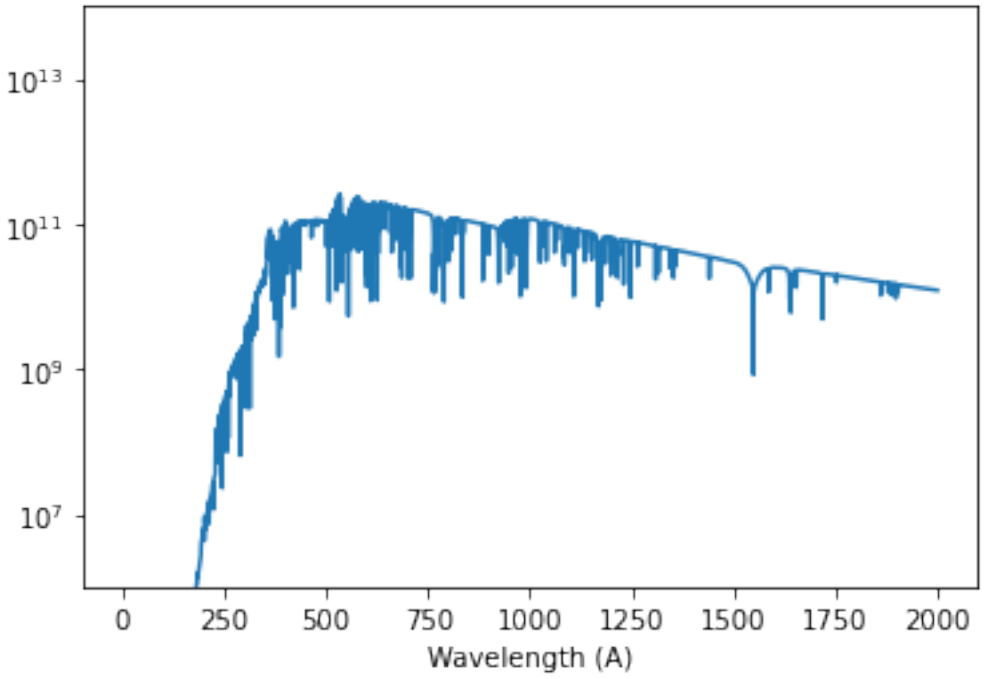
```
            self.fl = data['fl']
            self.wl = data['wl'] # in A
            self.fl /= 1e8 # F LAMBDA  GIVEN IN ERG/CM**2/SEC/CM -> erg/s/cm2/A
            if self.verbose:
                print('Read data from {}'.format(self.filename))
        else:
            if self.verbose:
                print('file not found {}'.format(self.filename))
            self.wl = None
            self.fl = None

    def plot_spr(self, ax=None, *args, **kwargs):
        """
        Plot the spectrum.
        Parameter:
            - ax: an axis (optionnal). If Noe or absent, axis is created
            - any extra parameter is passed to ax.plot
        """
        if self.wl is None:
            print('No data to plot')
            return
        if ax is None:
            fig, ax = plt.subplots()
        ax.plot(self.wl, self.fl,
                label='T3={0:.0f}, logg={1}'.format(self.T/1e3, self.logg),
                *args, **kwargs) # Here are the transmissions of extra␣
↪parameters to plot
        ax.set_yscale('log')
        ax.set_ylim(1e6, 1e14)
        ax.set_xlabel('Wavelength (A)')

    def get_integ(self):
        """
        Return the integral of Flambda over lambda, in erg/s/cm2
        """
        if self.wl is None:
            print('No data')
            return None
        return simps(self.fl, self.wl) # perform the integral

    def __getT(self):
        return self.__T

    def __setT(self, value):
        if not isinstance(value, (int, float)): # check the type of the input
            raise TypeError('T must be an integer or a float')
```

```
        if float(value) not in np.linspace(40000, 190000, 16): # check the␣
↪value of the input
            raise ValueError('T value must be between 40000 and 190000K, by␣
↪10000K steps')
        elif self.__T != value:
            self.__T = value
            self.filename = '0{0:06.0f}_{1:.2f}_33_50_02_15.bin_0.1.gz'.
↪format(self.T, self.logg)
            self.dlfile() # will download new data
            self.read_data() # will update the data

    def __delT(self):
        print('T is needed')

    T = property(__getT, __setT, __delT, "Stellar effective temperature in K")

    def __getlogg(self):
        return self.__logg

    def __setlogg(self, value):
        try:
            self.__logg
        except:
            self.__logg = -1
        if not isinstance(value, (int, float)):
            raise TypeError('logg must be an integer or a float')
        if float(value) not in (-1., 5., 6., 7. ,8., 9.):
            raise ValueError('Error, logg must be 6, 7, 8, or 9')
            self.__logg = None
        elif self.__logg != value:
            self.__logg = value
            self.filename = '0{0:06.0f}_{1:.2f}_33_50_02_15.bin_0.1.gz'.
↪format(self.T, self.logg)
            self.dlfile() # will download new data
            self.read_data() # will update the data

    def __dellogg(self):
        print('logg is needed')

    logg = property(__getlogg, __setlogg, __dellogg, "Stellar logg")

    def print_info(self):
        """
        Print out the filename and the number of points
        """
        print(self.__repr__())
```

```
    def __repr__(self):
        """
        This is what is used when calling "print <obj>" or <obj> ENTER
        """
        if self.wl is None:
            return'Filename: {0}, No data'.format(self.filename)
        else:
            return'Filename: {0}, number of points: {1}'.format(self.filename,␣
↪len(self.wl))

    def __del__(self):
        Stel_Spectrum.spec_count -= 1
```

[63]:
```
sp2 = Stel_Spectrum(T=50000, logg=6, verbose=True)
print(sp2.T)
sp2.plot_spr()
```

```
0050000_6.00_33_50_02_15.bin_0.1.gz already on disk
Read data from 0050000_6.00_33_50_02_15.bin_0.1.gz
Instantiation done
50000
```



[64]:
```
# The properties are used to control type and values of the inputs
sp2.T = 1800
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-64-eea1af526407> in <module>
      1 # The properties are used to control type and values of the inputs
----> 2 sp2.T = 1800

<ipython-input-62-ece890eea052> in __setT(self, value)
    109             raise TypeError('T must be an integer or a float')
    110         if float(value) not in np.linspace(40000, 190000, 16): # check␣
 ↪the value of the input
--> 111             raise ValueError('T value must be between 40000 and 190000K ␣
 ↪by 10000K steps')
    112         elif self.__T != value:
    113             self.__T = value

ValueError: T value must be between 40000 and 190000K, by 10000K steps
```

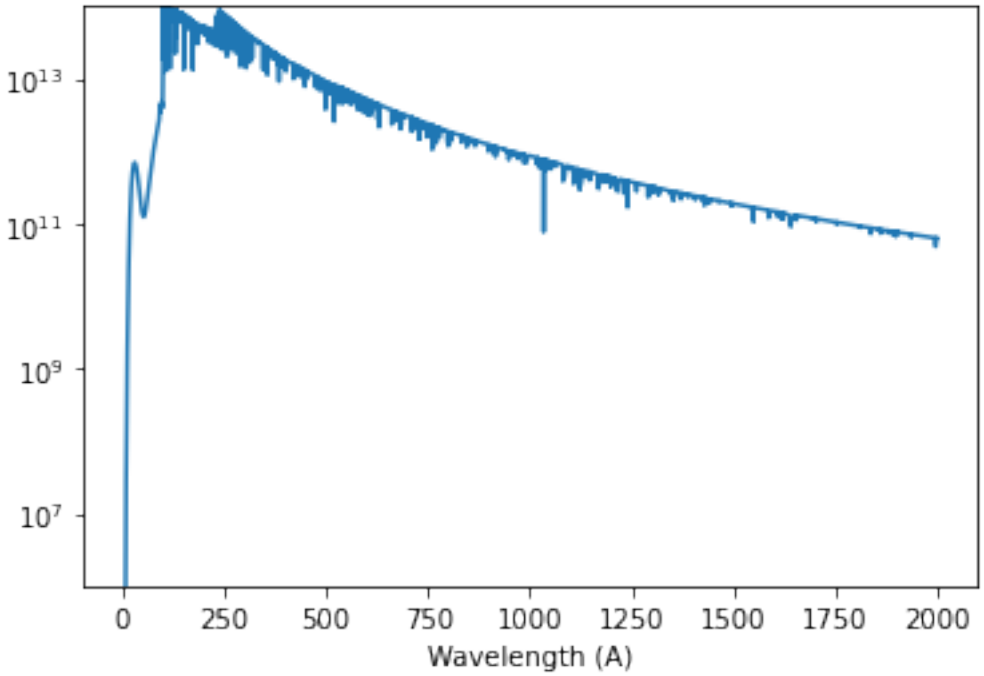
[65]:
```
sp2.logg = 'tralala'
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-65-11c6a7e42c4b> in <module>
----> 1 sp2.logg = 'tralala'

<ipython-input-62-ece890eea052> in __setlogg(self, value)
    130             self.__logg = -1
    131         if not isinstance(value, (int, float)):
--> 132             raise TypeError('logg must be an integer or a float')
    133         if float(value) not in (-1., 5., 6., 7. ,8., 9.):
    134             raise ValueError('Error, logg must be 6, 7, 8, or 9')

TypeError: logg must be an integer or a float
```

[66]:
```
sp2.T = 180000
sp2.logg = 7
print(sp2)
print(sp2.T)
```

```
0180000_6.00_33_50_02_15.bin_0.1.gz already on disk
Read data from 0180000_6.00_33_50_02_15.bin_0.1.gz
Downloading 0180000_7.00_33_50_02_15.bin_0.1.gz
Read data from 0180000_7.00_33_50_02_15.bin_0.1.gz
Filename: 0180000_7.00_33_50_02_15.bin_0.1.gz, number of points: 19951
180000
```

[67]:
```
sp2.plot_spr()
```



[68]:
```
del sp2.T
```

T is needed

[69]:
```
sp2.T
```

[69]: 180000

[70]:
```
del sp2.filename
```

[71]:
```
sp2.filename
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-71-f80b8bf97f4b> in <module>
----> 1 sp2.filename

AttributeError: 'Stel_Spectrum' object has no attribute 'filename'
```

[72]:
```
print(sp2)
```

```
---------------------------------------------------------------------------
```

```
AttributeError                            Traceback (most recent call last)
<ipython-input-72-867eef20b42b> in <module>
----> 1 print(sp2)

<ipython-input-62-ece890eea052> in __repr__(self)
    158             return'Filename: {0}, No data'.format(self.filename)
    159         else:
--> 160             return'Filename: {0}, number of points: {1}'.format(self.
 ↪filename, len(self.wl))
    161
    162     def __del__(self):

AttributeError: 'Stel_Spectrum' object has no attribute 'filename'
```

[73]:
```
print(sp2.__T)
```

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-73-2f6c79d0deae> in <module>
----> 1 print(sp2.__T)

AttributeError: 'Stel_Spectrum' object has no attribute '__T'
```

[74]:
```
sp2.T?
```

```
Type:        property
String form: <property object at 0x7fd48ccb9bf0>
Docstring:   Stellar effective temperature in K
```

[75]:
```
sp2.fl?
```

```
Type:            ndarray
String form:     [2.467e+02 4.019e+02 6.448e+02 … 6.261e+10 6.260e+10 6.259e+10]
Length:          19951
File:            ~/anaconda3/lib/python3.7/site-packages/numpy/__init__.py
Docstring:       <no docstring>
Class docstring:
ndarray(shape, dtype=float, buffer=None, offset=0,
        strides=None, order=None)

An array object represents a multidimensional, homogeneous array
of fixed-size items.  An associated data-type object describes the
format of each element in the array (its byte-order, how many bytes it
occupies in memory, whether it is an integer, a floating point number,
or something else, etc.)
```

```
Arrays should be constructed using `array`, `zeros` or `empty` (refer
to the See Also section below).  The parameters given here refer to
a low-level method (`ndarray(…)`) for instantiating an array.

For more information, refer to the `numpy` module and examine the
methods and attributes of an array.

Parameters
----------
(for the __new__ method; see Notes below)

shape : tuple of ints
    Shape of created array.
dtype : data-type, optional
    Any object that can be interpreted as a numpy data type.
buffer : object exposing buffer interface, optional
    Used to fill the array with data.
offset : int, optional
    Offset of array data in buffer.
strides : tuple of ints, optional
    Strides of data in memory.
order : {'C', 'F'}, optional
    Row-major (C-style) or column-major (Fortran-style) order.

Attributes
----------
T : ndarray
    Transpose of the array.
data : buffer
    The array's elements, in memory.
dtype : dtype object
    Describes the format of the elements in the array.
flags : dict
    Dictionary containing information related to memory use, e.g.,
    'C_CONTIGUOUS', 'OWNDATA', 'WRITEABLE', etc.
flat : numpy.flatiter object
    Flattened version of the array as an iterator.  The iterator
    allows assignments, e.g., ``x.flat = 3`` (See `ndarray.flat` for
    assignment examples; TODO).
imag : ndarray
    Imaginary part of the array.
real : ndarray
    Real part of the array.
size : int
    Number of elements in the array.
itemsize : int
    The memory use of each array element in bytes.
```

```
nbytes : int
    The total number of bytes required to store the array data,
    i.e., ``itemsize * size``.
ndim : int
    The array's number of dimensions.
shape : tuple of ints
    Shape of the array.
strides : tuple of ints
    The step-size required to move from one element to the next in
    memory. For example, a contiguous ``(3, 4)`` array of type
    ``int16`` in C-order has strides ``(8, 2)``.  This implies that
    to move from element to element in memory requires jumps of 2 bytes.
    To move from row-to-row, one needs to jump 8 bytes at a time
    (``2 * 4``).
ctypes : ctypes object
    Class containing properties of the array needed for interaction
    with ctypes.
base : ndarray
    If the array is a view into another array, that array is its `base`
    (unless that array is also a view).  The `base` array is where the
    array data is actually stored.

See Also
--------
array : Construct an array.
zeros : Create an array, each element of which is zero.
empty : Create an array, but leave its allocated memory unchanged (i.e.,
        it contains "garbage").
dtype : Create a data-type.

Notes
-----
There are two modes of creating an array using ``__new__``:

1. If `buffer` is None, then only `shape`, `dtype`, and `order`
   are used.
2. If `buffer` is an object exposing the buffer interface, then
   all keywords are interpreted.

No ``__init__`` method is needed because the array is fully initialized
after the ``__new__`` method.

Examples
--------
These examples illustrate the low-level `ndarray` constructor.  Refer
to the `See Also` section above for easier ways of constructing an
ndarray.
```

```
First mode, `buffer` is None:

>>> np.ndarray(shape=(2,2), dtype=float, order='F')
array([[0.0e+000, 0.0e+000], # random
       [     nan, 2.5e-323]])

Second mode:

>>> np.ndarray((2,), buffer=np.array([1,2,3]),
…             offset=np.int_().itemsize,
…             dtype=int) # offset = 1*itemsize, i.e. skip first element
array([2, 3])
```