PyNeb_manual_5

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1 The extinction class: RedCorr()

In [1]:
```
%matplotlib inline
%config InlineBackend.figure_format = 'svg'
import numpy as np
import matplotlib.pyplot as plt
import pyneb as pn
```

The class RedCorr manages the extinction (reddening) correction. It can compute the logarithmic extinction at Hβ by comparing an observed ratio to a theoretical one (usually Hα/Hβ, but any other ratio can be used). The object is also able to compute the correction to be applied to any intensity, given the wavelength of the line.

Various extinction laws are included in the class, and any user-defined function can also be implemented. The available extinction laws can be listed by entering (here no need to instantiate an object):

To explore some properties, you can directly use the class methods:

In [2]:
```
pn.RedCorr().printLaws()
```

```
'No correction':
        No correction, return 0.0



'CCM89':
        Cardelli, Clayton & Mathis 1989, ApJ 345, 245
        http://adsabs.harvard.edu/abs/1989ApJ...345..245C

        Comments: Depends on R_V, default value being 3.1

        Scope: Applicable to both dense and diffuse ISM
        Range: UV through IR



'CCM89 Bal07':
        Galactic extinction law based on Cardelli et al 1989, modified by Blagrave et al 2007
        for 3.3 < x < 8 (1250 < lambda < 3030)

        Blagrave et al 2007, ApJ, 655, 299
        http://adsabs.harvard.edu/abs/2007ApJ...655..299B
        Cardelli, Clayton & Mathis 1989, ApJ 345, 245
        http://adsabs.harvard.edu/abs/1989ApJ...345..245C

        Comments:
        Same as CCM89 for x<3.3 and x>8
        Revised values for 3.3<x<8
```

Based on observation of Orion stars
Depends on R_V, default value being 3.1

Range: UV through IR

'CCM89 oD94':

Galactic extinction law based on Cardelli et al 1989, modified by O'Donnell 1994
for 1.1 < x < 3.3 (9100 < lambda < 3030)

O'Donnell 1994, ApJ, 422, 1580
http://adsabs.harvard.edu/abs/1994ApJ...422..158O
Cardelli, Clayton & Mathis 1989, ApJ 345, 245
http://adsabs.harvard.edu/abs/1989ApJ...345..245C

Comments:
Same as CCM89 for x<1.1 and x>3.3
Revised values for 1.1<x<3.3
Produces lower correction in the near UV at low R_V

Scope: Galactic
Range: UV through IR

'S79 H83 CCM89':

Galactic extinction law (0-33000 A range):
- In the UV, from Seaton 1979
- In the opt/NIR (3600-9100) Howarth 1983
- In the FIR (9100-33000) Cardelly et al 1989

Seaton 1979, MNRAS, 187, 73) and
http://adsabs.harvard.edu/abs/1979MNRAS.187P..73S
Howarth 1983, MNRAS, 203, 301) Galactic law
http://adsabs.harvard.edu/abs/1983MNRAS.204.1091H
Cardelli, Clayton and Mathis 1989, ApJ, 345, 245
http://adsabs.harvard.edu/abs/1989ApJ...345..245C

Scope: Galactic
Range: UV through IR

'K76':

Kaler 1976, ApJS, 31, 517
http://adsabs.harvard.edu/abs/1976ApJS...31..517K

Comments:
This function returns the correction relative to Hbeta (f_lambda) and not
the extinction law (X(1/lambda)).
It cannot be used for absolute correction.

Range: 3000 to >20000

'SM79 Gal':

```
        Galactic extinction law
        Savage & Mathis 1979, ARA&A, 17, 73
        http://adsabs.harvard.edu/abs/1979ARA%26A..17...73S

        Comments:
        Average of several extinction laws
        R_V=3.1

        Scope: Galactic
        Range: UV through IR


'G03 LMC':
        Extinction curve for the LMC
        Gordon et al. (2003, ApJ, 594,279)
        http://adsabs.harvard.edu/abs/2003ApJ...594..279G

        Comments:
        Average curve for the LMC
        R_V = 3.41

        Scope: LMC
        Range: 1200 through fIR


'MCC99 FM90 LMC':
        In the UV, this method returns the extinction curve proposed for the LMC
        by Misselt et al 1999 based on the 1990 variant of the Fitzpatrick & Massa law
        In the opt/IR, it returns the Fitzpatrick & Massa 1990 law.

        Misselt, Clayton & Gordon 1999 , ApJ, 515, 128
        http://adsabs.harvard.edu/abs/1999ApJ...515..128M
        Fitzpatrick & Massa 1990, ApJS, 72, 163
        http://adsabs.harvard.edu/abs/1990ApJS...72..163F

        Comments:
        The Fitzpatrick & Massa 1990 law in the UV depends on 6 parameters, stored in RedCorr.FitzParams
        The method sets RedCorr.FitzParams to the values of set in the Fitzpatrick 1999 paper,
        which includes an explicit dependence on R_V.
        R_V must be provided, as the law depends on its value.
        We refer to FM90 and not to the original FM88 because the value of a constant in F(lambda) sligh
        The value of another constant of F(lambda) appears to change from FM90 to MCC99, but it is proba

        Scope: LMC


'F99-like':
        In the UV, it returns the Fitzpatrick & Massa 1990 law.
        In the opt/IR, it returns the Fitzpatrick & Massa 1990 law.

        Fitzpatrick 1999, PASP, 11, 63
        http://adsabs.harvard.edu/abs/1999PASP..111...63F
        Fitzpatrick & Massa 1990, ApJS, 72, 163
        http://adsabs.harvard.edu/abs/1990ApJS...72..163F
```

```
        Comments:
        The FM90 depends on 6 parameters which must be set by the user and are stored in RedCorr.FitzPa
        For the predefined set of parameters defined in FM99, use instead the F99 law.
        R_V must be provided, as the law depends on it. The dependence with R_V follows Table 4 in the F

        Range: UV through IR


'F99':
        This method returns the R-dependent IR-through-UV extinction curve proposed by Fitzpatrick 1999

        Fitzpatrick 1999, PASP, 11, 63
        http://adsabs.harvard.edu/abs/1999PASP..111...63F
        based on:
        Fitzpatrick & Massa 1990, ApJS, 72, 163
        http://adsabs.harvard.edu/abs/1990ApJS...72..163F

        Comments:
        The Fitzpatrick & Massa 1990 law in the UV depends on 6 parameters, stored in RedCorr.FitzParams
        The method sets RedCorr.FitzParams to the values of set in the Fitzpatrick 1999 paper,
        which includes an explicit dependence on R_V.
        R_V must be provided, as the law depends on its value.

        Range: UV through IR


'F88 F99 LMC':
        This method returns:
        - in the UV, the average LMC extinction curve derived by Fitzpatrick & Massa 1988
        - in the opt/IR, the R-dependent extinction curve proposed by Fitzpatrick 1999.

        Fitzpatrick 1999, PASP, 11, 63
        http://adsabs.harvard.edu/abs/1999PASP..111...63F
        Fitzpatrick & Massa 1988, ApJ, 328, 734
        http://adsabs.harvard.edu/abs/1988ApJ...328..734F

        Comments:
        The Fitzpatrick and Massa law in the UV depends on 6 parameters, stored in RedCorr.FitzParams a
        here set to the LMC values derived in FM88
        R_V must be provided, as the law depends on it

        Scope: LMC
        Range: UV through IR
```

Less detailed output is obtained with:

```
In [3]: pn.RedCorr().getLaws()
```

```
Out[3]: dict_keys(['No correction', 'CCM89', 'CCM89 Bal07', 'CCM89 oD94', 'S79 H83 CCM89', 'K76', 'SM79
```

To apply a correction, you need to instantiate the object:

```
In [4]: rc = pn.RedCorr(E_BV = 1.2, R_V = 3.2, law = 'F99')
```

The parameters can also be defined and modified after the instantiation:

```
In [5]: rc = pn.RedCorr()
        rc.E_BV = 1.34
        rc.law = 'S79 H83 CCM89'
```

$c(H\beta)$ and E_{B-V} are related through:

$$(1 - f_\lambda).c(H\beta) = 0.4 E_{B-V} X_\lambda$$

applied to $\lambda = 4861$, with $f_\beta = 0.$ so that, once one of the two parameters is defined, the other is also automatically defined; to output its value, enter:

```
In [6]: rc.cHbeta
```

```
Out[6]: 1.9457101047071228
```

```
In [7]: rc.cHbeta = 2.
        print(rc.E_BV)
```

```
1.37738915654
```

The reddening of a given spectrum is determined by using the ratio of two observed line intensities relative to the theoretical value, for example:

```
In [8]: rc.setCorr(obs_over_theo=6.5 / 2.86, wave1=6563., wave2=4861.)
```

```
In [9]: print(rc.cHbeta)
```

```
1.11340937767
```

Once a law and either c(Hβ) or E$_{B-V}$ are defined, the correction for any wavelength is obtained by:

```
In [10]: wave = 5007.0
         corr = rc.getCorr(wave)
         print(corr)
```

```
11.8468982794
```

where **wave** can either be a single wavelength or a list or array of wavelengths.

The correction relative to the Hβ correction is given by:

```
In [11]: corr = rc.getCorrHb(wave)
         print(corr)
```

```
0.912421020017
```

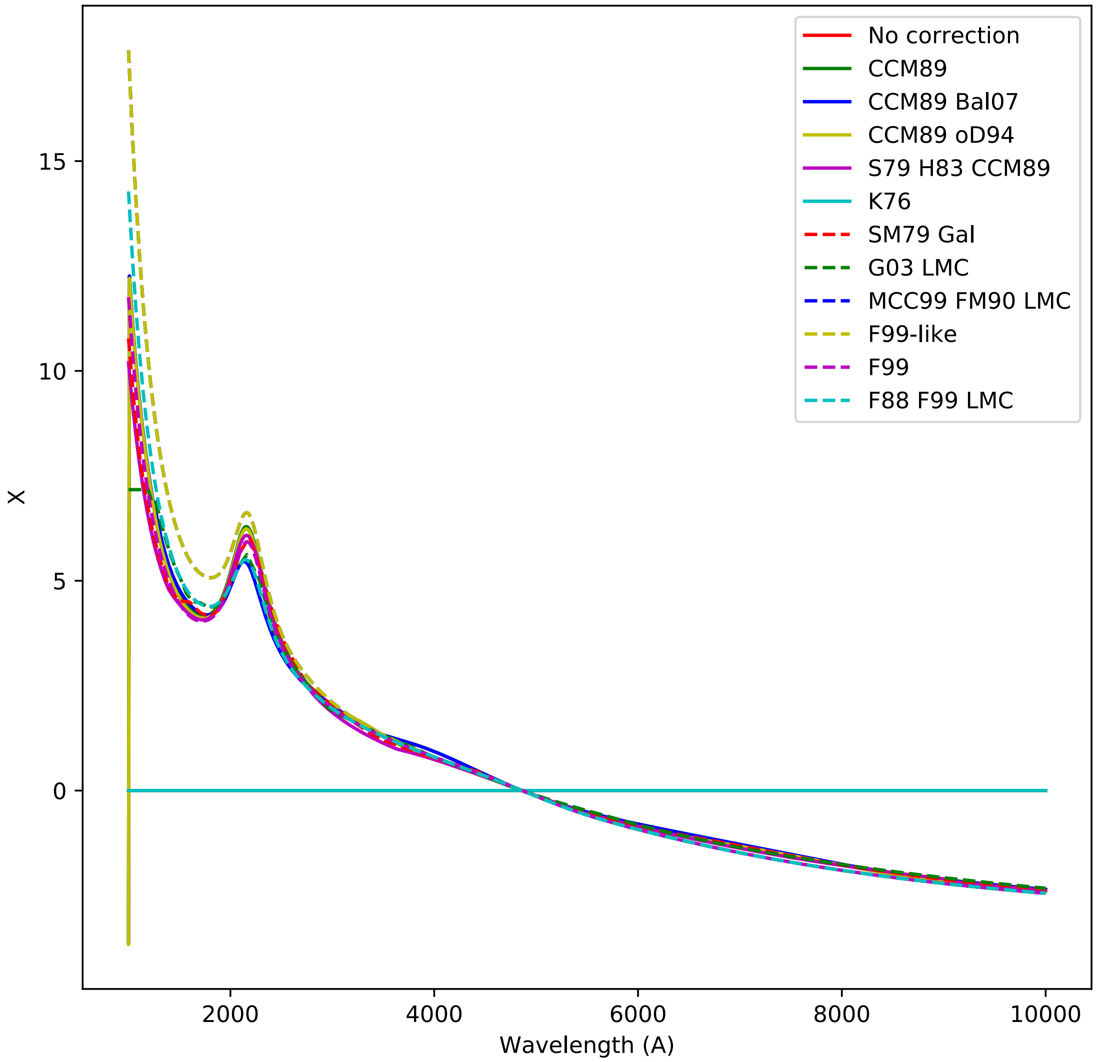
and the correction relative to any other wavelength (p. ej., Hα) is given by:

```
In [12]: corr = rc.getCorr(5007., 6563.)
         print(corr)
```

```
2.07325069463
```

The class includes a plotting tool to have a quick look at the different extinction laws:

```
In [13]: f, ax = plt.subplots(figsize=(8,8))
         rc.plot(laws = 'all', ax=ax)
```



A user-defined method can also be used. User-defined methods must accept 2 parameters: the first is the wavelength (or wavelength array), in Angstrom, and the second is an optional parameter (which can also be a list). The method must return $X(\lambda) = A(\lambda)/E_{B-V} = R_V A(\lambda)/A_V$. The correction is then: $10^{0.4 E_{B-V} X(\lambda)}$

Here is an example of a user-defined function:

```
In [14]: def my_X(wave, params = [5000., 1., 2., 3.]):
             return params[1] * (wave/params[0]) + params[2] * (wave/params[0])**-1 + params[3] * (wave/
         rc.UserFunction = my_X
         rc.UserParams = [6000., 1., 5., 1.]
         rc.law = 'user'
         print(rc.getCorr(5007))
```

```
342.093161202
```