1 Initial outtakes about emission lines measurements

Rubén words:

```
Tal y como están hechos los ajustes ahora, todo los resultados se guardan.
Pero seguro que hay resultados que no son buenos. Un primer check sería
ver si "pos", la longitud de onda central, está cerca del valor esperado
(en reposo). Hay algunas veces que no hay linea, por ejemplo de [OII],
pero cerca hay algún glitch o cualquier otra cosa y el programa lo mide.
Poniendo una tolerancia de, digamos 2 o 3 Angtroms, eliminaría las líneas
que se desvian de la posición central "teórica" fuera de esa tolerancia.
Otro método de limpieza quizás serían FHWM absurdamente grandes, o EW.
Pero creo que uno muy fiable a priori es el de la posición central de la
línea''
```

This kind of filter was not applied to this results. Maybe this has to be the next thing to do and do not appear to be a heavy thing to code, given a central lambda table.

Only zones with Hα, Hβ, [O III] and [N II] signal to noise ratio ≤ 3 are used.

2 The morphologic types

The morphologic types used are evaluated using `get_morfologia()` by ES.Enrique:

```
[‘E0’,’E1’,’E2’,’E3’,’E4’,’E5’,’E6’,’E7’,’S0’,’S0a’,’Sa’,’Sab’,’Sb’,
[   0,   1,   2,   3,   4,   5,   6,   7,   8,  8.5,   9,  9.5,  10,
’Sbc’,’Sc’,’Scd’,’Sd’,’Sdm’,’Sm’,’Ir’]
 10.5,  11, 11.5,  12, 12.5,  13,  14]
```

3 Age range

The ages used to stellar $\tau_V^\star$, SFR* and $\Sigma^\star$ calculations are:

$(10.01, 25.2, 63.2, 100.1, 158.6, 199.6, 1400.2) * 10^6$ years

The smallest light fraction (in the $flag_t$-ageMax age range) deemed to be OK for our stats is 0.05. Also the minimum $\tau_V^\star$ to be taken seriously: 0.05.

4 Calculations

ALL THE CALCULATIONS ARE BY ZONE!! ZERO calculations are made by radius whatsoever.

L_λ and $\epsilon(L_\lambda)$:

$$L_\lambda = 4\pi d^2 F_\lambda \quad (1)$$

$$\epsilon(L_\lambda) = 4\pi d^2 \epsilon(F_\lambda) \quad (2)$$

$L^{int}_{\mathrm{H}\alpha}$ and $\tau_{\mathrm{V}}^{\mathrm{NEB}}$:

$$
\begin{aligned}
L^{obs}_{\lambda} &= L^{int}_{\lambda} e^{-\tau_{\lambda}} && (3)\\
L^{obs}_{\lambda} &= L^{int}_{\lambda} e^{-(\frac{\tau_{\lambda}}{\tau_{\mathrm{V}}})\tau_{\mathrm{V}}} && (4)\\
\frac{\tau_{\lambda}}{\tau_{\mathrm{V}}} &= q_{\lambda} && (5)\\
L^{obs}_{\lambda} &= L^{int}_{\lambda} e^{-q_{\lambda}\tau_{\mathrm{V}}} && (6)\\
\frac{L^{obs}_{\lambda}}{L^{obs}_{\lambda'}} &= \frac{L^{int}_{\lambda} e^{-q_{\lambda}\tau_{\mathrm{V}}}}{L^{int}_{\lambda'} e^{-q_{\lambda'}\tau_{\mathrm{V}}}} && (7)\\
\ln\left(\frac{L^{obs}_{\lambda}}{L^{obs}_{\lambda'}}\right) &= \tau_{\mathrm{V}}(q_{\lambda'} - q_{\lambda}) \ln\left(\frac{L^{int}_{\lambda}}{L^{int}_{\lambda'}}\right) && (8)\\
\tau_{\mathrm{V}} &= \frac{1}{(q_{\lambda'} - q_{\lambda})}\left[\ln\left(\frac{L^{obs}_{\lambda}}{L^{obs}_{\lambda'}}\right) - \ln\left(\frac{L^{int}_{\lambda}}{L^{int}_{\lambda'}}\right)\right] && (9)\\
\tau_{\mathrm{V}} &= \frac{1}{(q_{\lambda'} - q_{\lambda})}\left[\ln\left(\frac{F^{obs}_{\lambda}}{F^{obs}_{\lambda'}}\right) - \ln\left(\frac{F^{int}_{\lambda}}{F^{int}_{\lambda'}}\right)\right] && (10)\\
\tau_{\mathrm{V}}^{\mathrm{NEB}} &= \frac{1}{(q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha})} \ln\left(\frac{F^{obs}_{\mathrm{H}\alpha}/F^{obs}_{\mathrm{H}\beta}}{F^{int}_{\mathrm{H}\alpha}/F^{int}_{\mathrm{H}\beta}}\right) && (11)\\
L^{int}_{\mathrm{H}\alpha} &= L^{obs}_{\mathrm{H}\alpha} e^{(q_{\mathrm{H}\alpha}\tau_{\mathrm{V}}^{\mathrm{NEB}})} && (12)
\end{aligned}
$$

$\epsilon(L^{int}_{\mathrm{H}\alpha})$ error propagation:

$$
\begin{aligned}
L^{int}_{\mathrm{H}\alpha} &\equiv L^{int}_{\mathrm{H}\alpha}(L^{obs}_{\mathrm{H}\alpha}, \tau_{\mathrm{V}}^{\mathrm{NEB}}) \equiv L^{int}_{\mathrm{H}\alpha}(L^{obs}_{\mathrm{H}\alpha}, L^{obs}_{\mathrm{H}\beta}) && (13)\\
\epsilon(L^{int}_{\mathrm{H}\alpha}) &= \sqrt{\left(\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial L^{obs}_{\mathrm{H}\alpha}}\right)^2 \epsilon(L^{obs}_{\mathrm{H}\alpha})^2 + \left(\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial L^{obs}_{\mathrm{H}\beta}}\right)^2 \epsilon(L^{obs}_{\mathrm{H}\beta})^2} && (14)\\
\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial L^{obs}_{\mathrm{H}\alpha}} &= e^{(q_{\mathrm{H}\alpha}\tau_{\mathrm{V}}^{\mathrm{NEB}})} && (15)\\
\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial L^{obs}_{\mathrm{H}\beta}} &= \left(\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}\right)\left(\frac{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}{\partial L^{obs}_{\mathrm{H}\beta}}\right) && (16)\\
\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}} &= L^{obs}_{\mathrm{H}\alpha} q_{\mathrm{H}\alpha} e^{(q_{\mathrm{H}\alpha}\tau_{\mathrm{V}}^{\mathrm{NEB}})} && (17)\\
\frac{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}{\partial L^{obs}_{\mathrm{H}\beta}} &= -\frac{1}{L^{obs}_{\mathrm{H}\beta}(q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha})} && (18)\\
\frac{\partial L^{int}_{\mathrm{H}\alpha}}{\partial L^{obs}_{\mathrm{H}\beta}} &= -\left(\frac{q_{\mathrm{H}\alpha}}{q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha}}\right)\left(\frac{L^{obs}_{\mathrm{H}\alpha}}{L^{obs}_{\mathrm{H}\beta}}\right) && (19)\\
\epsilon(L^{int}_{\mathrm{H}\alpha}) &= e^{(q_{\mathrm{H}\alpha}\tau_{\mathrm{V}}^{\mathrm{NEB}})} \sqrt{\epsilon(L^{obs}_{\mathrm{H}\alpha})^2 + \left(\frac{q_{\mathrm{H}\alpha}}{q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha}}\right)^2 \left(\frac{L^{obs}_{\mathrm{H}\alpha}}{L^{obs}_{\mathrm{H}\beta}}\right)^2 \epsilon(L^{obs}_{\mathrm{H}\beta})^2} && (20)
\end{aligned}
$$

$\tau_{\mathrm{V}}^{\mathrm{NEB}}$ error propagation:

$$\begin{aligned}
\tau_{\mathrm{V}}^{\mathrm{NEB}} &\equiv \tau_{\mathrm{V}}^{\mathrm{NEB}}(L_{\mathrm{H}\alpha}^{obs}, L_{\mathrm{H}\beta}^{obs}) && (21)\\
\epsilon(\tau_{\mathrm{V}}^{\mathrm{NEB}}) &= \sqrt{\left(\frac{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}{\partial L_{\mathrm{H}\alpha}^{obs}}\right)^2 \epsilon(L_{\mathrm{H}\alpha}^{obs})^2 + \left(\frac{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}{\partial L_{\mathrm{H}\beta}^{obs}}\right)^2 \epsilon(L_{\mathrm{H}\beta}^{obs})^2} && (22)\\
\frac{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}{\partial L_{\mathrm{H}\alpha}^{obs}} &= \frac{1}{L_{\mathrm{H}\alpha}^{obs}(q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha})} && (23)\\
\frac{\partial \tau_{\mathrm{V}}^{\mathrm{NEB}}}{\partial L_{\mathrm{H}\beta}^{obs}} &= -\frac{1}{L_{\mathrm{H}\beta}^{obs}(q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha})} && (24)\\
\epsilon(\tau_{\mathrm{V}}^{\mathrm{NEB}}) &= \frac{1}{(q_{\mathrm{H}\beta} - q_{\mathrm{H}\alpha})} \sqrt{\left(\frac{\epsilon(L_{\mathrm{H}\alpha}^{obs})}{L_{\mathrm{H}\alpha}^{obs}}\right)^2 + \left(\frac{\epsilon(L_{\mathrm{H}\beta}^{obs})}{L_{\mathrm{H}\beta}^{obs}}\right)^2} && (25)
\end{aligned}$$

$F_{\mathrm{H}\alpha}^{obs}/F_{\mathrm{H}\beta}^{obs}$ error propagation:

$$\begin{aligned}
F_{Balmer}^{obs} &= \frac{F_{\mathrm{H}\alpha}^{obs}}{F_{\mathrm{H}\beta}^{obs}} && (26)\\
F_{Balmer}^{obs} &\equiv F_{Balmer}^{obs}(F_{\mathrm{H}\alpha}^{obs}, F_{\mathrm{H}\beta}^{obs}) && (27)\\
\epsilon(F_{Balmer}^{obs}) &= \sqrt{\left(\frac{\partial F_{Balmer}^{obs}}{\partial F_{\mathrm{H}\alpha}^{obs}}\right)^2 \epsilon(F_{\mathrm{H}\alpha}^{obs})^2 + \left(\frac{\partial F_{Balmer}^{obs}}{\partial F_{\mathrm{H}\beta}^{obs}}\right)^2 \epsilon(F_{\mathrm{H}\beta}^{obs})^2} && (28)\\
\frac{\partial F_{Balmer}^{obs}}{\partial F_{\mathrm{H}\alpha}^{obs}} &= \frac{1}{F_{\mathrm{H}\beta}^{obs}} && (29)\\
\frac{\partial F_{Balmer}^{obs}}{\partial F_{\mathrm{H}\beta}^{obs}} &= -\frac{F_{\mathrm{H}\alpha}^{obs}}{F_{\mathrm{H}\beta}^{obs2}} && (30)\\
\epsilon(F_{Balmer}^{obs}) &= \frac{1}{F_{\mathrm{H}\beta}^{obs}} \sqrt{\epsilon(F_{\mathrm{H}\alpha}^{obs})^2 + \left(\frac{F_{\mathrm{H}\alpha}^{obs}}{F_{\mathrm{H}\beta}^{obs}}\right)^2 \epsilon(F_{\mathrm{H}\beta}^{obs})^2} && (31)
\end{aligned}$$

$O3N2$ ([O III]/[N II]) and $\log Z_{neb}$:

$$\begin{aligned}
O3N2 &= \frac{F_{[\mathrm{O\,III}]}^{int}}{F_{[\mathrm{N\,II}]}^{int}} = \frac{F_{[\mathrm{O\,III}]}^{obs}}{F_{[\mathrm{N\,II}]}^{obs}} e^{\tau_{\mathrm{V}}^{\mathrm{NEB}}(q_{[\mathrm{O\,III}]} - q_{[\mathrm{N\,II}]})} && (32)\\
\log Z_{neb} &= -0.14 - 0.25 \log O3N2 && (33)\\
& && (34)
\end{aligned}$$

$O3N2$ and $\log Z_{neb}$ error propagation:

$$O3N2 \equiv O3N2(F^{obs}_{[\mathrm{O\,III}]}, F^{obs}_{[\mathrm{N\,II}]}, F^{obs}_{\mathrm{H}\alpha}, F^{obs}_{\mathrm{H}\beta}) \tag{35}$$

$$\frac{\partial O3N2}{\partial F^{obs}_{[\mathrm{O\,III}]}} = e^{\tau_{\mathrm{V}}^{\mathrm{NEB}}(q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]})} \left(\frac{1}{F^{obs}_{[\mathrm{N\,II}]}}\right) \tag{36}$$

$$\frac{\partial O3N2}{\partial F^{obs}_{[\mathrm{N\,II}]}} = -e^{\tau_{\mathrm{V}}^{\mathrm{NEB}}(q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]})} \left(\frac{F^{obs}_{[\mathrm{O\,III}]}}{{F^{obs}_{[\mathrm{N\,II}]}}^{2}}\right) \tag{37}$$

$$\frac{\partial O3N2}{\partial F^{obs}_{\mathrm{H}\alpha}} = e^{\tau_{\mathrm{V}}^{\mathrm{NEB}}(q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]})} \left(\frac{q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]}}{q_{\mathrm{H}\beta}-q_{\mathrm{H}\alpha}}\right) \left(\frac{F^{obs}_{[\mathrm{O\,III}]}}{F^{obs}_{[\mathrm{N\,II}]} F^{obs}_{\mathrm{H}\alpha}}\right) \tag{38}$$

$$\frac{\partial O3N2}{\partial F^{obs}_{\mathrm{H}\beta}} = -e^{\tau_{\mathrm{V}}^{\mathrm{NEB}}(q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]})} \left(\frac{q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]}}{q_{\mathrm{H}\beta}-q_{\mathrm{H}\alpha}}\right) \left(\frac{F^{obs}_{[\mathrm{O\,III}]}}{F^{obs}_{[\mathrm{N\,II}]} F^{obs}_{\mathrm{H}\beta}}\right) \tag{39}$$

$$\begin{aligned}\epsilon(O3N2) = {} & \frac{e^{\tau_{\mathrm{V}}^{\mathrm{NEB}}(q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]})}}{F^{obs}_{[\mathrm{N\,II}]}} \sqrt{\epsilon(F^{obs}_{[\mathrm{O\,III}]})^2 + \left(\frac{F^{obs}_{[\mathrm{O\,III}]}}{F^{obs}_{[\mathrm{N\,II}]}}\right)^2 \epsilon(F^{obs}_{[\mathrm{N\,II}]})^2 + \ldots} \\ & \overline{\ldots + \left(\frac{q_{[\mathrm{O\,III}]}-q_{[\mathrm{N\,II}]}}{q_{\mathrm{H}\beta}-q_{\mathrm{H}\alpha}}\right)^2 \left[\left(\frac{F^{obs}_{[\mathrm{O\,III}]}}{F^{obs}_{\mathrm{H}\alpha}}\right)^2 + \left(\frac{F^{obs}_{[\mathrm{O\,III}]}}{F^{obs}_{\mathrm{H}\beta}}\right)^2\right]}\end{aligned} \tag{40}$$

$$\epsilon(\log Z_{neb}) = \sqrt{\frac{\partial \log Z_{neb}}{\partial O3N2}^2 \epsilon(O3N2)^2} \tag{41}$$

$$\frac{\partial \log Z_{neb}}{\partial O3N2} = \frac{0.25}{\ln(10)} \frac{1}{O3N2} \tag{42}$$

$$= \frac{0.25}{\ln(10)} \left(\frac{\epsilon(O3N2)}{O3N2}\right) \tag{43}$$

$SFR_{\mathrm{H}\alpha}$ calibration using the solar value for BC03 + Padova1994 + Salpeter:

$$SFR_{\mathrm{H}\alpha} = 3.17 \left(M_{\odot} yr^{-1}\right) \times \frac{L(\mathrm{H}\alpha)}{10^8} \tag{44}$$

Σ_{SFR}. Σ_{gas} and logDGR:

$$\Sigma_{SFR} = \frac{SFR_{\mathrm{H}\alpha}}{A_{zone}} \tag{45}$$

$${\Sigma_{gas}}^{1.4} = \frac{10^6 \Sigma_{SFR}}{1.6 \times 10^{-4}} \tag{46}$$

$$\log DGR = C + \log\left(\frac{\tau_V^{neb}}{\Sigma_{gas}}\right) \tag{47}$$