Spectral analysis of galaxies

Apostila do Cid – 2012/2

Section 2 – Building composite stellar populations

Marcus – 24/06/2013

1 - How does Spectral Synthesis work?

2 - Building composite stellar populations

- 2.1 - SFR(t) α exp
- 2.2 - SFR(t) constant
- 2.3 - SFR(t) burst-like

3 - Calculating ages

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What is an ordinary galaxy made of?

Figure from Cid's talk @ IAG

Well-behaved galaxies...

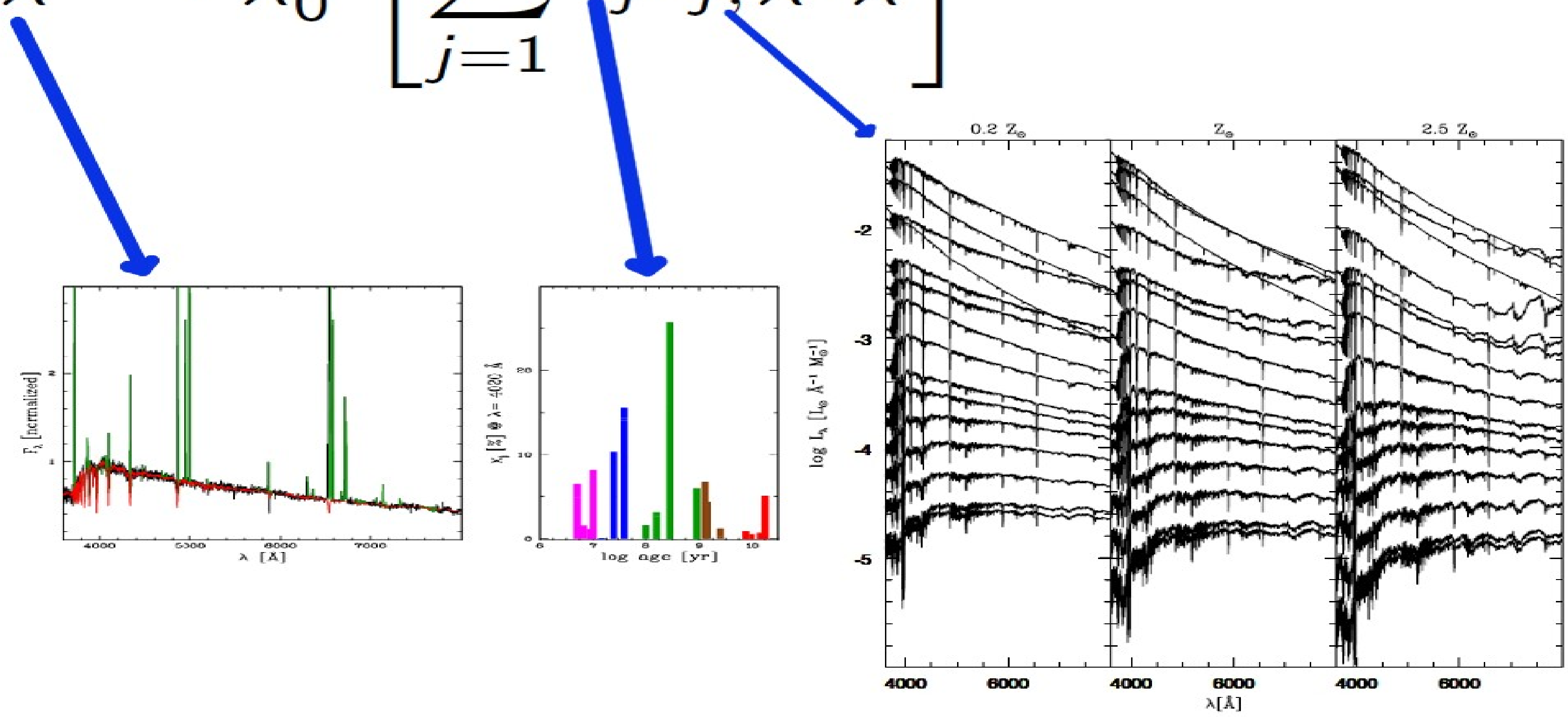
Spectral continnum → light from stars + dust

The emission/absorption lines → HII regions, AGNs, etc

Spectral Synthesis

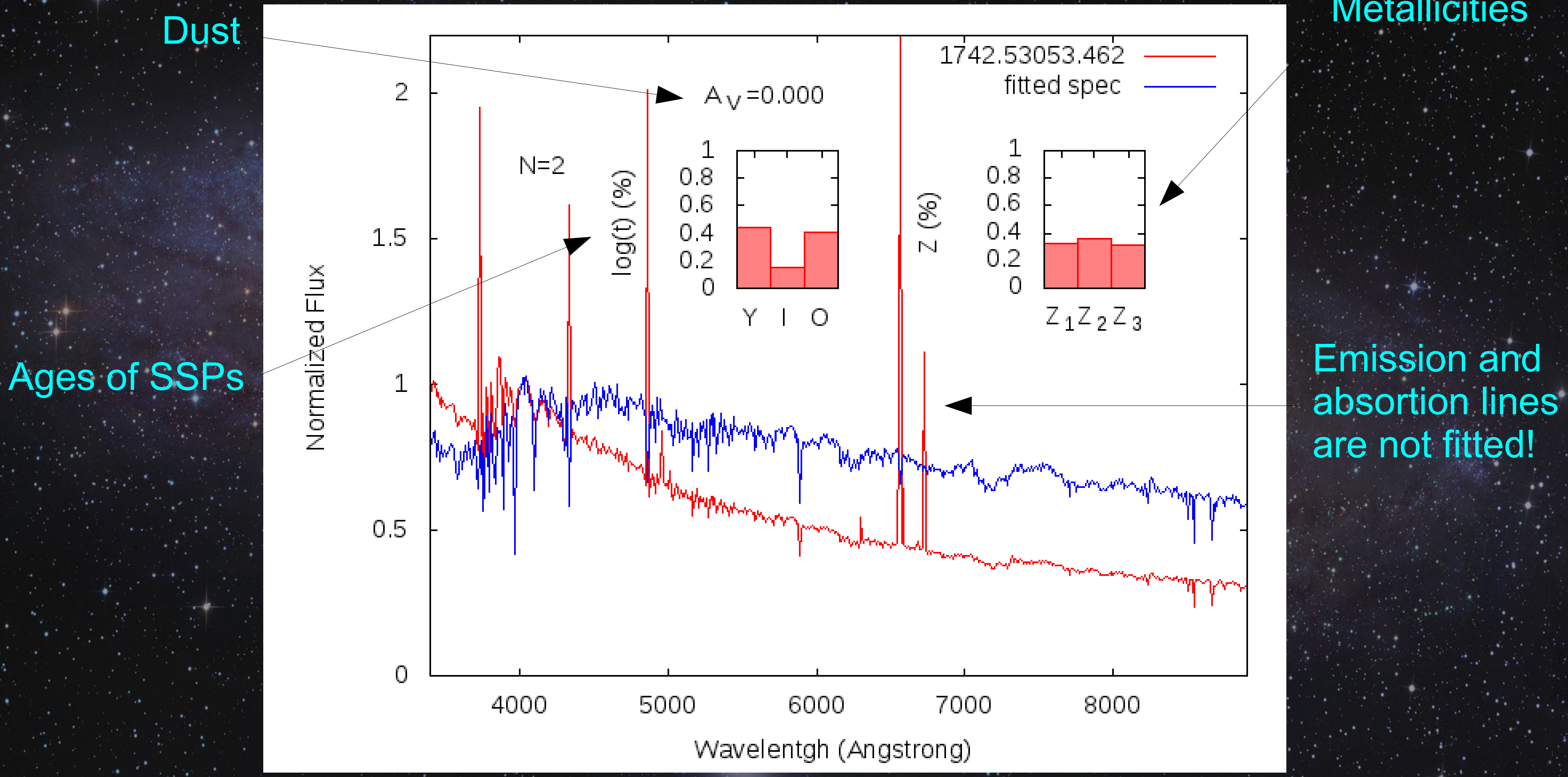
STARLIGHT (Cid Fernandes et al 2005)

$$F_\lambda = F_{\lambda_0} \left[\sum_{j=1}^{N_\star} x_j b_{j,\lambda} r_\lambda \right]$$



How does Spectral Synthesis work?

Spectral Synthesis



Fitting the continnum one can obtain stellar population properties and extinction from galaxies.

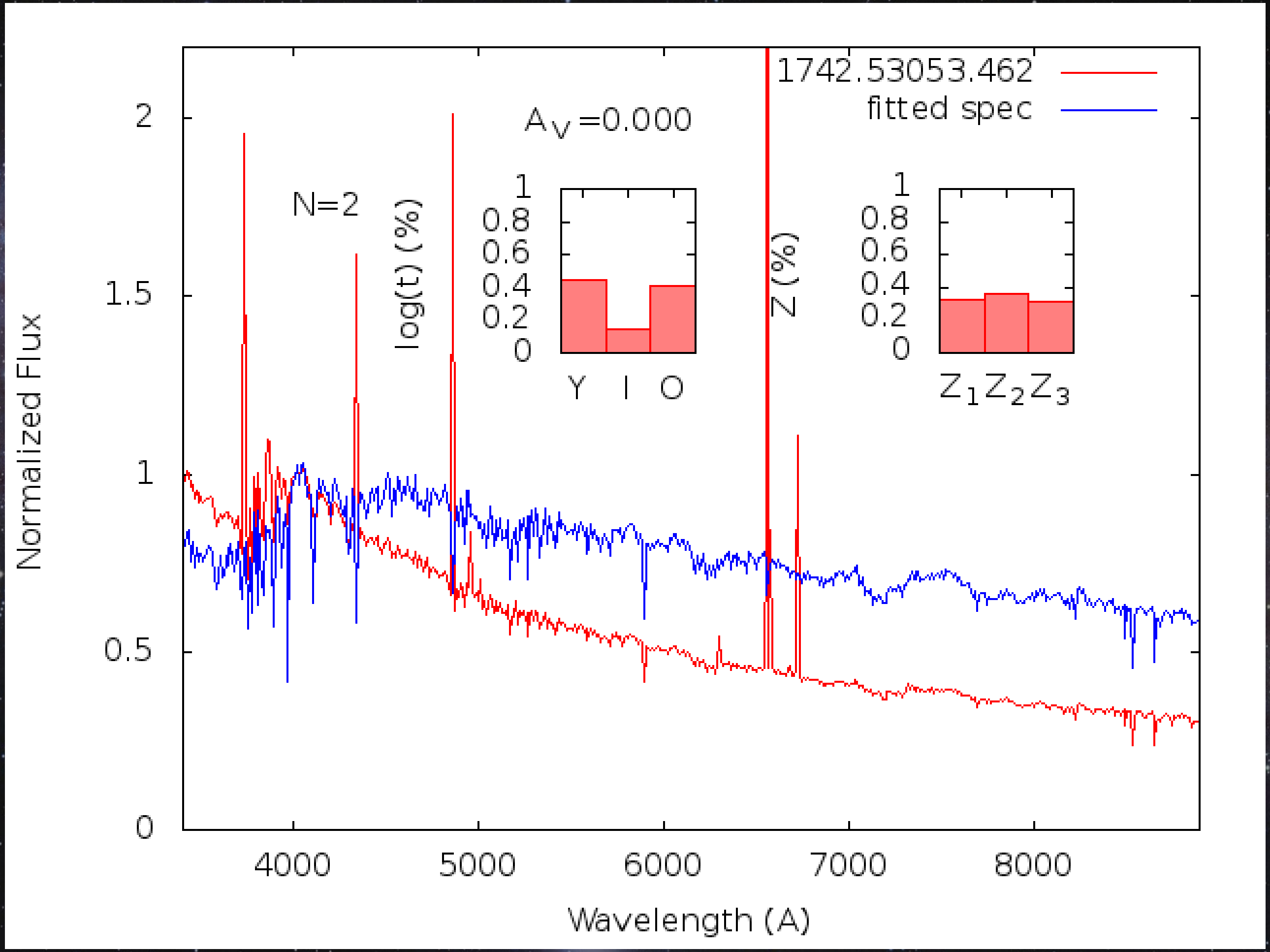
Spectral Synthesis

Dust

Metallicities

Ages of SSPs

Emission and absorption lines are not fitted!



Fitting the continnum one can obtain stellar population properties and extinction from galaxies.

Building composite stellar populations

SFR(t) :

$$\psi(t, t_0, \tau) = \begin{cases} Ae^{-(t-t_0)/\tau} & t \leq t_0 \\ 0 & t > t_0 \end{cases}$$

Building composite stellar populations

SFR(t) :

$$\psi(t, t_0, \tau) = \begin{cases} Ae^{-(t-t_0)/\tau} & t \leq t_0 \\ 0 & t > t_0 \end{cases}$$

Making composite spectra...

$$l_\lambda \rightarrow [L_\odot/\mathring{A}/M_\odot]$$

$$A = \frac{M_\star}{\tau(e^{t_0/\tau} - 1)}$$

$$L_\lambda = \sum_{t \leq T} l_\lambda(t) \Delta M_i$$

$$X(t) = \frac{M(t)}{M_\star} = \frac{(e^{-t/\tau} - 1)}{(e^{-t_0/\tau} - 1)}$$

$$M(t) = \int_0^t \psi(t')dt'$$

$$\Delta M_{1-2} = \int_{t_1}^{t_2} \psi(t)dt = \frac{M_\star(e^{-t_1/\tau} - e^{-t_2/\tau})}{(1 - e^{-t_0/\tau})}$$

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Building composite stellar populations

SFR(t) :

$$\psi(t, t_0, \tau) = \begin{cases} Ae^{-(t-t_0)/\tau} & t \leq t_0 \\ 0 & t > t_0 \end{cases}$$

SFR units:

$$\psi(t, t_0, \tau) \rightarrow [M_\odot / yr]$$

Mass converted to stars

$$M(t) = \int_0^t \psi(t')dt'$$

Normalization factor

$$A = \frac{M_\star}{\tau(e^{t_0/\tau} - 1)}$$

Percentage of mass converted to stars

$$X(t) = \frac{M(t)}{M_\star} = \frac{(e^{-t/\tau} - 1)}{(e^{-t_0/\tau} - 1)}$$

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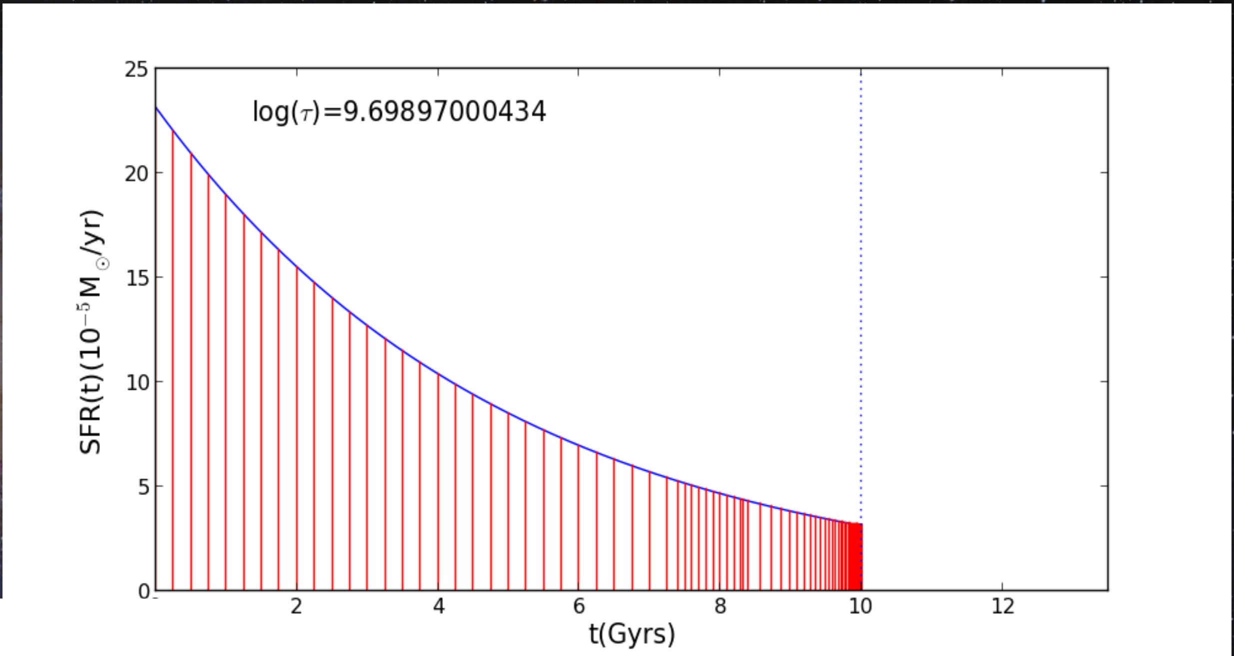
Building composite stellar populations

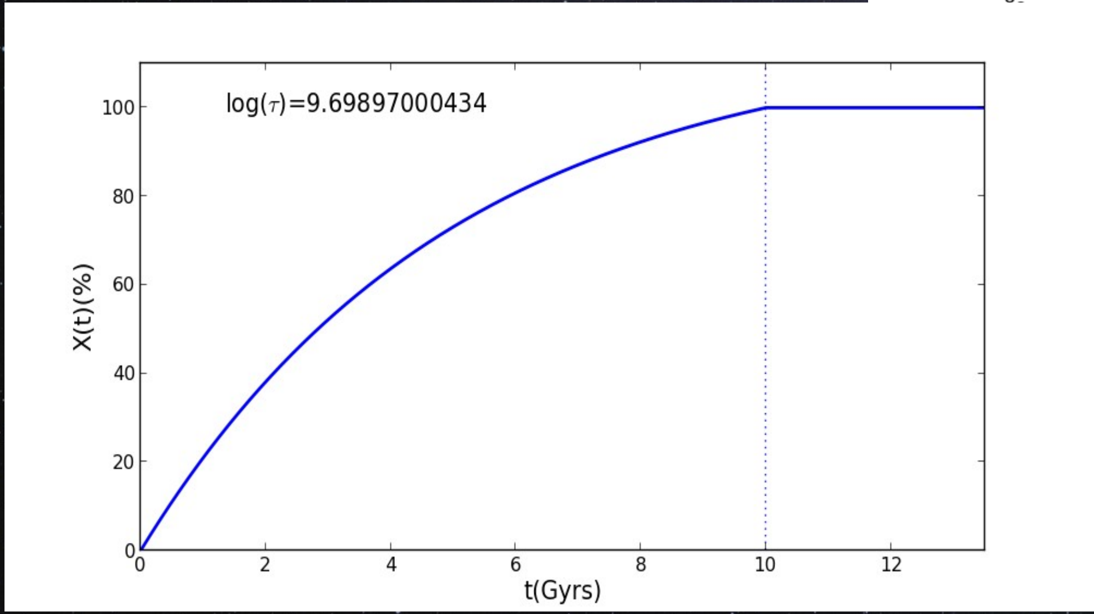
SFR(t) :

$$\psi(t, t_0, \tau) = \begin{cases} Ae^{-(t-t_0)/\tau} & t \leq t_0 \\ 0 & t > t_0 \end{cases}$$

Decaying exponential (t_0~T):

t_0 = 1e10 yrs
T = 5e9 yrs
M_* = 1e6 Msun





$$l_\lambda \rightarrow [L_\odot/\AA/M_\odot]$$

$$L_\lambda = \sum_{t \leq T} l_\lambda(t) \Delta M_i$$

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Building composite stellar populations

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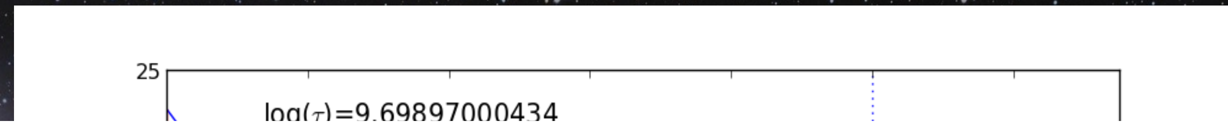

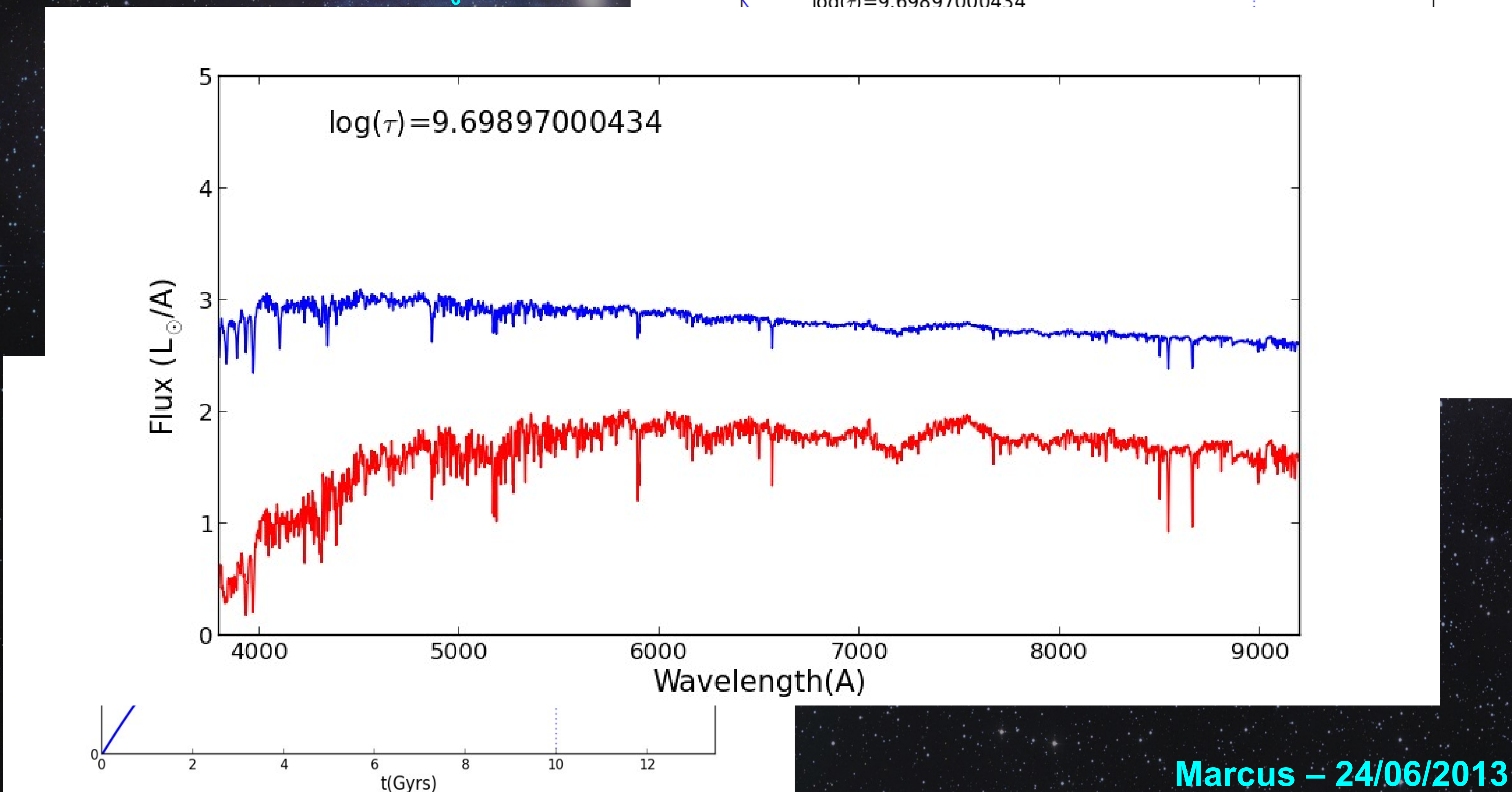

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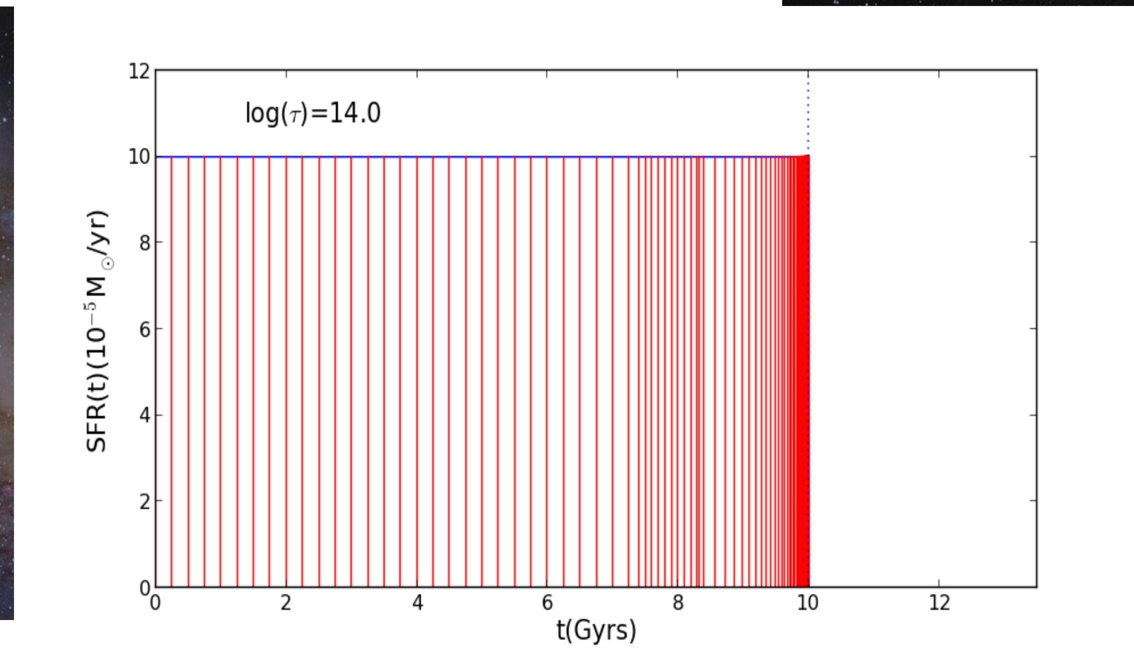
Building composite stellar populations

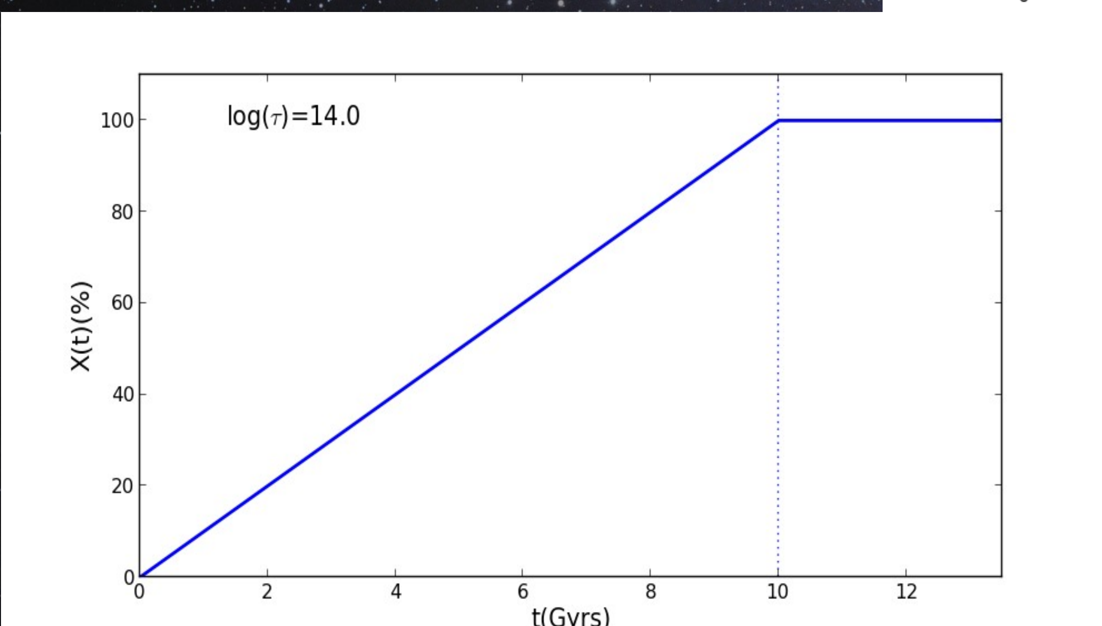
SFR(t) :

$$\psi(t, t_0, \tau) = \begin{cases} Ae^{-(t-t_0)/\tau} & t \leq t_0 \\ 0 & t > t_0 \end{cases}$$

Constant (t_0<<T) :

t_0 = 1e10 yrs
T = 1e14 yrs
M_* = 1e6 Msun





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Building composite stellar populations

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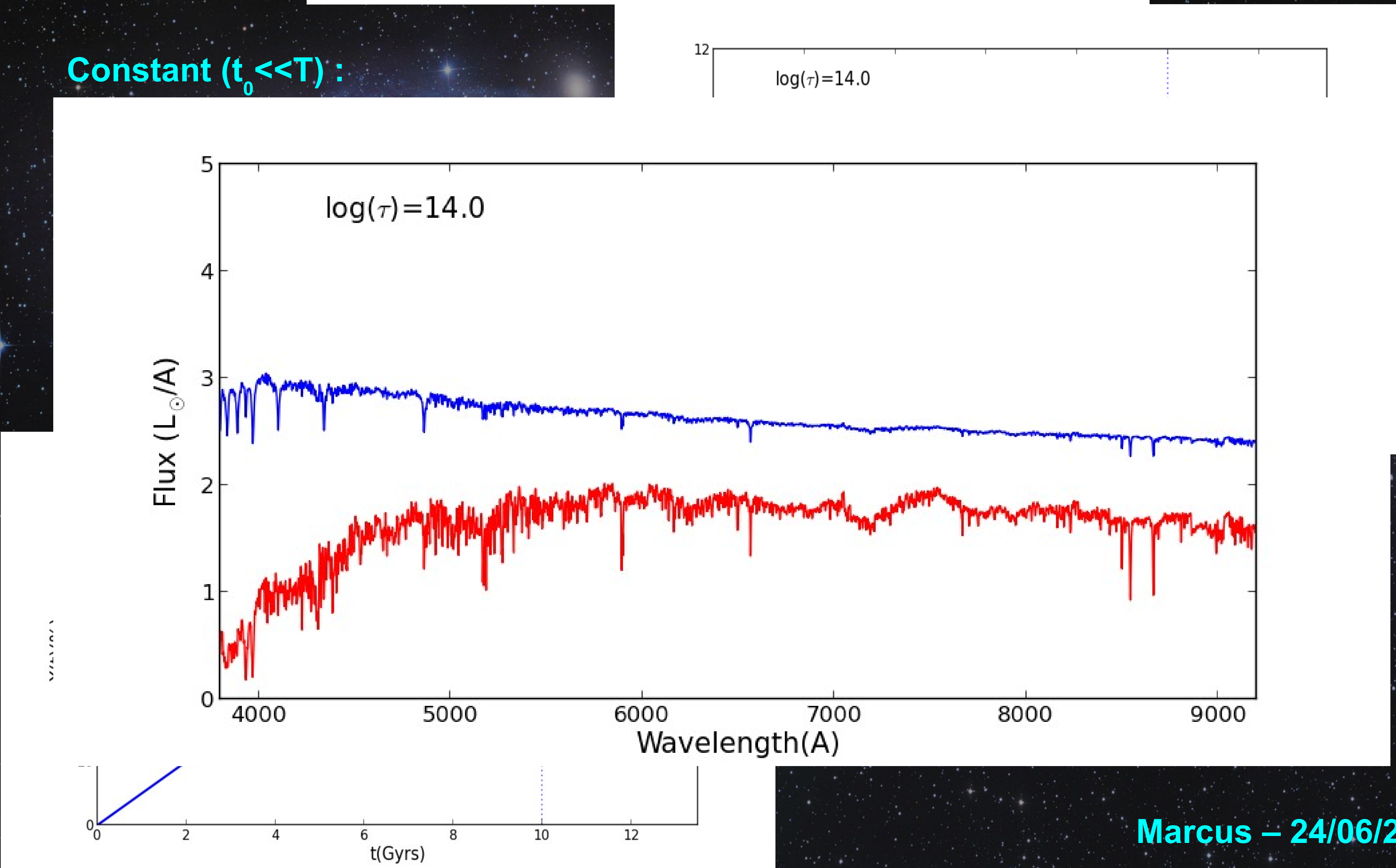


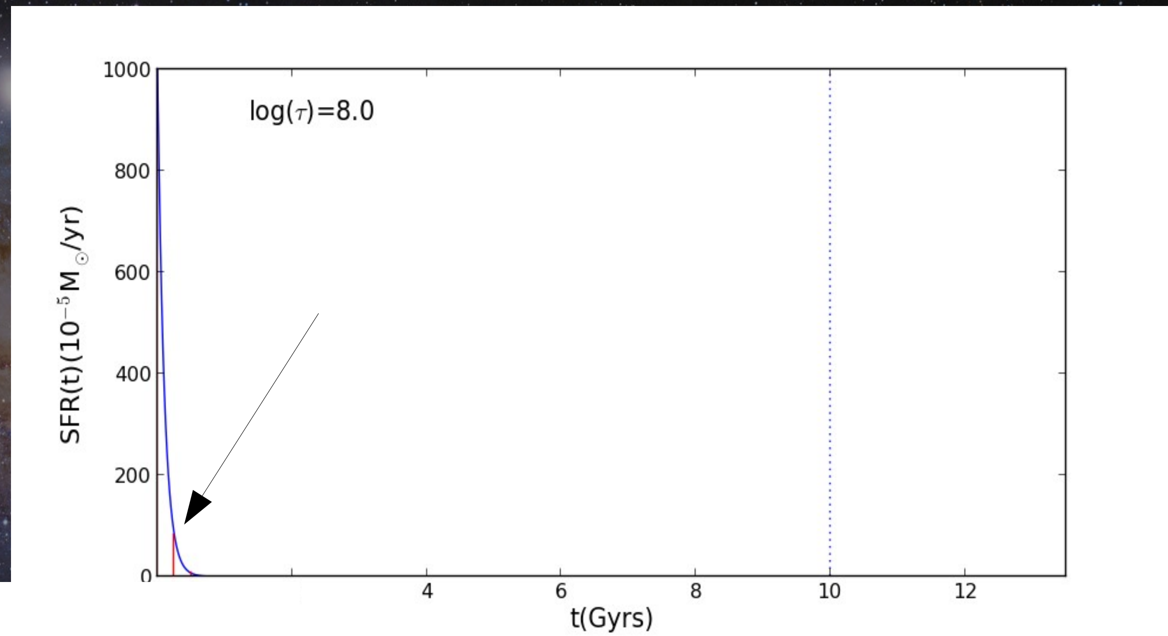
Building composite stellar populations

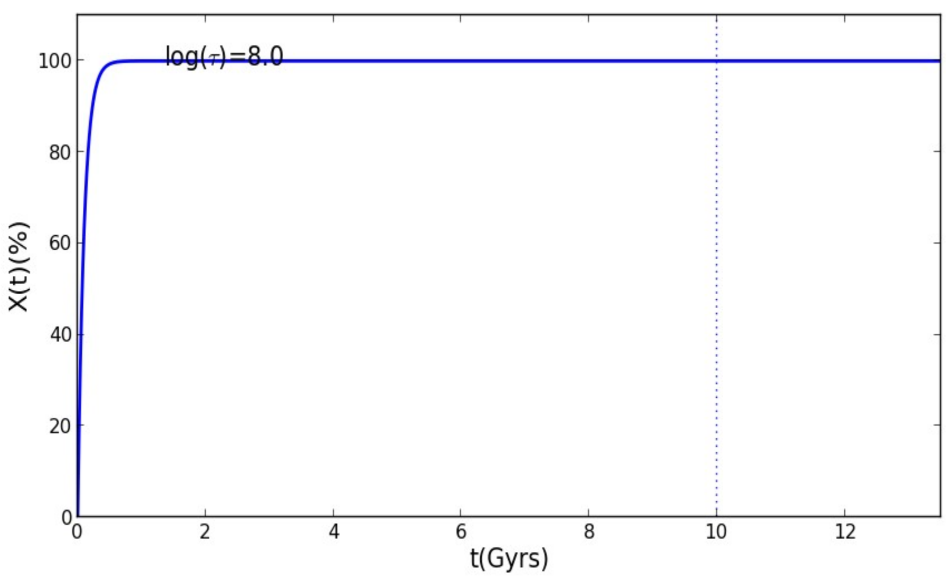
SFR(t) :

$$\psi(t, t_0, \tau) = \begin{cases} Ae^{-(t-t_0)/\tau} & t \leq t_0 \\ 0 & t > t_0 \end{cases}$$

Burst-like ($t_0 >> T$) :

t_0 = 1e10 yrs
T = 1e8 yrs
M_* = 1e6 Msun





All stars are formed roughly at t=0!
The spectra looks like a SSP!

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Building composite stellar populations

SFR(t) :

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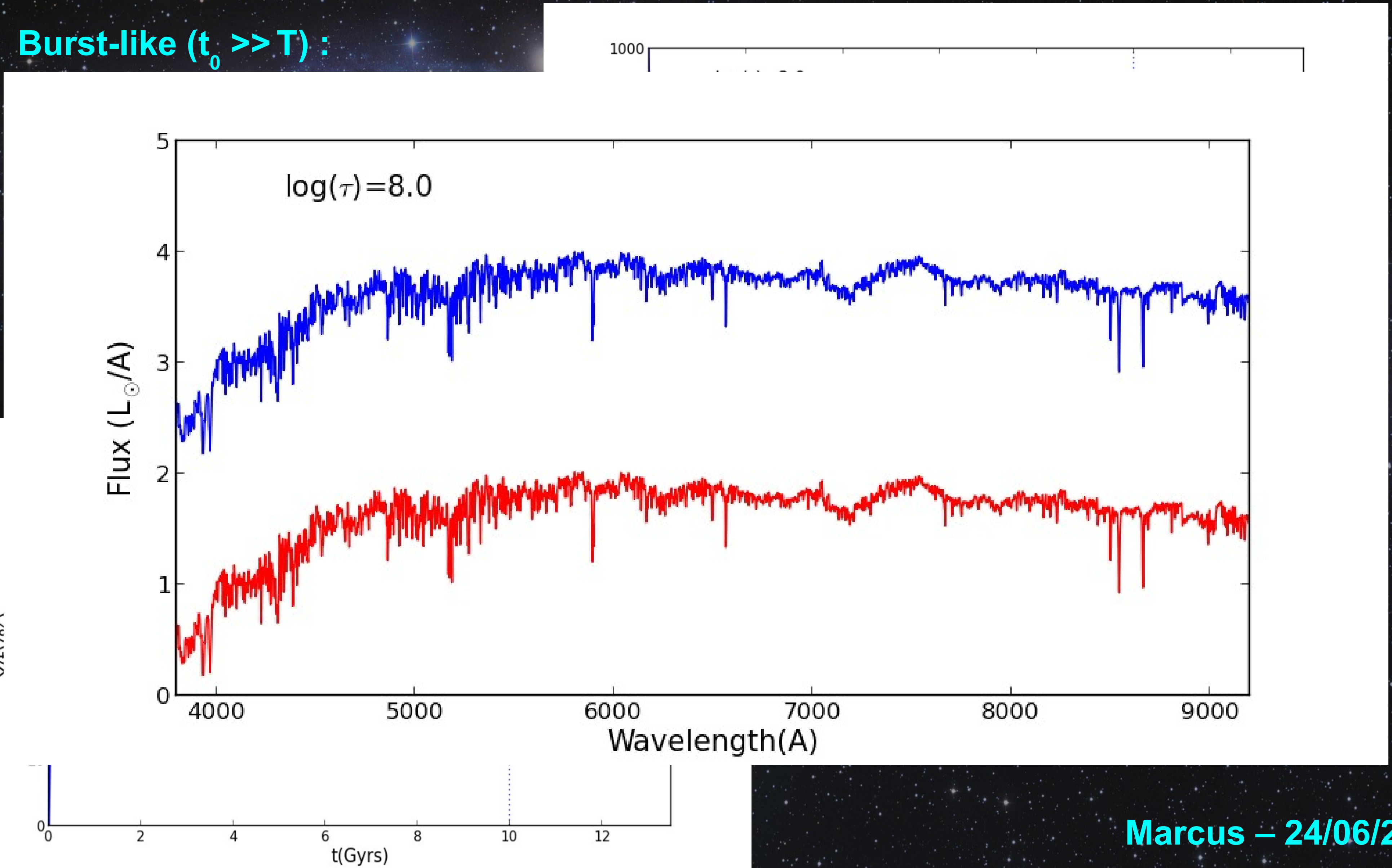
Burst-like ($t_0 >> T$) :



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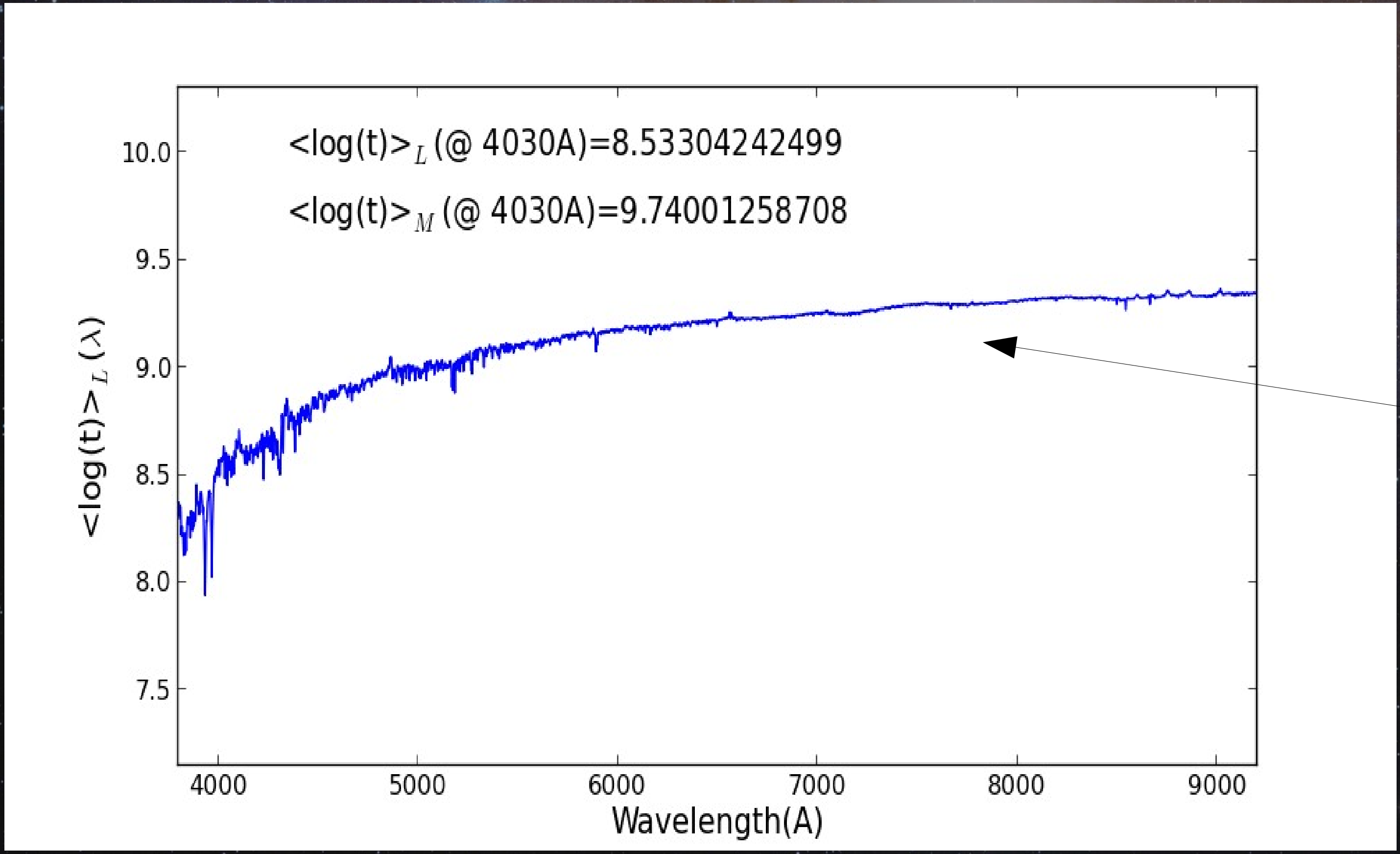
Calculate ages...

$$< log(t) >_M = \frac{\sum_i log(t_i) \Delta M_i}{\sum_i \Delta M_i}$$

Age weighted by mass

$$< log(t) >_L (\lambda) = \frac{\sum_i log(t_i) F_\lambda \Delta M_i}{\sum_i F_\lambda \Delta M_i} = \frac{\sum_i log(t_i) \Delta L_i}{\sum_i \Delta L_i}$$

Age weighted by light



Decaying Exponential SFR(t)

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Calculate ages...

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Age weighted by mass

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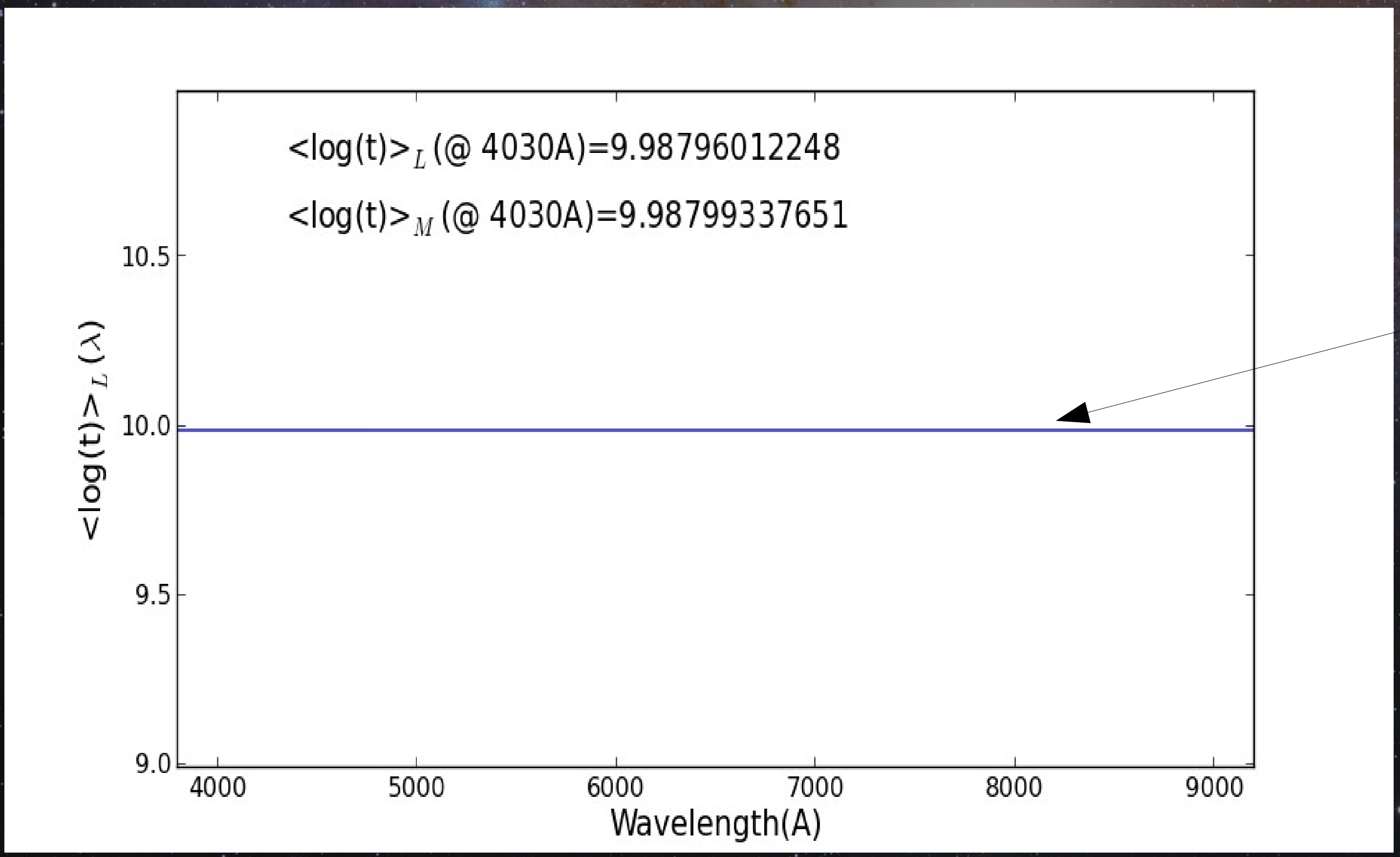
Age weighted by light



Burst-like SFR(t)
T=1e8 yr

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