EVOLUTION OF DWARF GALAXIES: characterizing star formation scenarios

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**HII galaxies**: Metal poor systems with massive ionizing stars

**Are they really young galaxies?**

- Intermediate age and old stars found, even in I Zw18
  

- **EW(Hβ) vs. O/H**: Only possible due to galactic evolution.

- **EW(Hβ) vs. color**: HII galaxies show more redder colours than expected at low EW
  
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SSPs: Mollá et al. 2009
Obs.data: Hoyos & Díaz 2006
Terleivich et al. 1991

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* Then, how is the star formation history?
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What is the SFH of dwarf galaxies?

There are 3 star formation scenarios postulated:

- **Bursting SF**: short and intense SF bursts + long quiescent periods
  
  \[(Davies & Phillips 1988, Bradamante et al. 1998)\]

- **Gasping SF**: long moderate SF bursts + short quiescent periods
  
  \[(Tosi et al. 1991)\]

- **Continuous SF**: low intensity continuous SF + sporadic bursts
  
  \[(Legrand 2000)\]
The self-consistent star-bursting evolutionary models

based on Martin-Manjon et al 2008

Successive bursts star formation $t=0-13.2$ Gyrs, $M_{\text{tot}}=10^8 M_{\odot}$

**Initial Efficiency ($\varepsilon$):**
The amount of gas consumed to form stars in the 1st burst of SF.
- High efficiency
- Low efficiency

**Attenuation:**
The strength of the successive bursts:
- soft attenuation
- strong attenuation

**Time between bursts ($\Delta t$):**
The quiet periods
$\Delta t= 1.3$ Gyr - 0.1 Gyr - 0.05 Gyr

Different scenarios can be reproduced by changing these three parameters

- **Gasping:** + attenuation, $-\Delta t$; **Continuous:** $-\Delta t$, $-\varepsilon$

**TOOLS:**

**Chemical evolution code** (Mollá&Díaz 2005): SFH, evolution of metallicity and abundances


+ **Photoionization code** (CLOUDY, Ferland 1998): emission lines
Initial Efficiency ($\varepsilon$)

Determines the SFR and the initial oxygen abundance (Hoyos et al. 2004, Hoyos & Diaz 2006).

The initial efficiency also drives the behavior of the ionized gas:

The emission lines are produced by the ionizing photons of the massive stars born in the current burst.

- **High efficiency**: high excitation and high abundance galaxies, high [OIII]/H$_\beta$
- **Low efficiency**: less metallic galaxies, with high [OIII]/H$_\beta$ and low [OII]/H$_\beta$ ratios.
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**Attenuation**

The strength of the bursts determines the contribution of the underlying non ionizing population:

The higher attenuation the larger contribution from the previous bursts to the total SED.

- **EW(Hβ) vs. O/H:** cover both time scales.
- **EW(Hβ) vs. color:** The contribution of the underlying population to the total continuum must be higher than the contribution of the current burst which dominates the emission line spectrum.

**Inter-burst time (Δt)**

Sets the age of the underlying population.

The EW(Hβ) decreases more from burst to burst but the colours can be bluer!!
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$\lambda$ EW(H$\beta$) vs. O/H:

cover both time scales.

$\lambda$ EW(H$\beta$) vs. color:

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Inter-burst time \((\Delta t)\)

Sets the age of the underlying population.

The \( \text{EW}(\text{H}_\beta) \) decreases more from burst to burst but the colours can be bluer !!
Summarizing...

In order to reproduce the characteristics of HII galaxies under an specific star formation scenario... 3 parameters must be set:

**Initial efficiency, Attenuation, Inter-burst time**

Our models can reproduce every observable feature of HII galaxies - abundances, colors and emission lines - simultaneously.

How can we use the models?

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Martín-Manjón et al. MNRAS 2008
Martín Manjón et al. 2008 (arXiv0901.1186)
Martín Manjón et al. 2008 (ASPC)
Martín Manjón et. al 2010 (Popstars)
Martín Manjón et al. 2011 (in prep)
χ² tests: II Zw40

It measures the goodness of fit models-observations

We will obtain for the observed galaxy:

- age of the current ionizing population
- age of the underlying population.

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<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Error (%)</th>
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<tr>
<td>[OII]3727Å</td>
<td>0.275</td>
<td>5</td>
</tr>
<tr>
<td>[NeIII]3869Å</td>
<td>0.347</td>
<td>15</td>
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<tr>
<td>[OIII]4363Å</td>
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<tr>
<td>[HeI]4471Å</td>
<td>0.033</td>
<td>30</td>
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<tr>
<td>[OIII]4959Å</td>
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<tr>
<td>[OIII]5007Å</td>
<td>8.095</td>
<td>5</td>
</tr>
<tr>
<td>[HeI]5876Å</td>
<td>0.134</td>
<td>15</td>
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<tr>
<td>[OI]6300Å</td>
<td>0.019</td>
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<td>EW(Hβ)</td>
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<td>I3730/I5010</td>
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<tr>
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<tbody>
<tr>
<td>N/H</td>
<td>20×10⁻⁷</td>
<td>1×10⁻⁷</td>
</tr>
<tr>
<td>O/H</td>
<td>500×10⁻⁷</td>
<td>6×10⁻⁷</td>
</tr>
<tr>
<td>S/H</td>
<td>140×10⁻⁷</td>
<td>50×10⁻⁷</td>
</tr>
<tr>
<td>(V-I)</td>
<td>0.020</td>
<td>0.01</td>
</tr>
<tr>
<td>(R-I)</td>
<td>-0.230</td>
<td>0.01</td>
</tr>
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χ² = \sum_{n=1}^{15} \frac{(O_n - T_n)^2}{\sigma_n^2}

Terlevich et al. 1991
Díaz et al. 2007
Telles & Terlevich 1997
Ionizing population: 3 Myr
Underlying population: aprox 2.6 Gyr
**I Zw 18**

MODEL: low efficiency, intermediate attenuation, $\Delta t = 50\text{Myr}$

Ionizing population: 4 Myr

Age (underlying pop.) approx. 100 Myr

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**SBS1415**

MODEL: low efficiency, strong attenuation, $\Delta t = 1.3\text{ Gyr}$

Ionizing population: 4 - 4.7 Myr

Age (underlying pop.) 1.3 - 2.6 Gyr

Aloisi et al. (2005), underlying $> 1.3\text{ Gyr}$,
Yakobchuk (2008), underlying $< 2\text{ Gyr}$,
Ionizing $< 5\text{ Myr}$

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Martin-Manjon et al 2011 (in prep)