RESOLVED STELLAR POPULATION MODELING

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PHOENIX dwarf
The Color-Magnitude Diagram
PHOENIX dwarf
The Star Formation History
DERIVING THE SFH - OUTLINE

1. Compute a “mother” stellar population with constant SFR for wide age and metallicity ranges. It has associated a “mother” mCMD

   \[ \psi_S(t, z) = 1 \]

2. Simulate uncompleteness, crowding, blending and all the observational effects on mCMD

3. Divide the mother population into several simple (age and metallicity) ones

   \[ \psi_i(t, z) = \begin{cases} 1 & t_i \leq t < t_i + \Delta_i t, \quad z_i \leq z < z_i + \Delta_i z \\ 0 & \text{otherwise} \end{cases} \]

4. Any SFH can be obtained as:

   \[ \psi(t, z) = \sum_i \alpha_i \psi_i(t, z) \]

5. Parameterize the observational and the simple iCMDs using boxes or grid

6. The stellar distribution on the associated CMD is given by:

   \[ M_j = \sum_i \alpha_i M_{i,j} \]

7. Find best solution using a merit function:

   \[ \chi^2 = \sum_j \frac{(M_j - O_j)^2}{O_j} \]

   \[ \chi^2 = \frac{(M_j + \min(M_j, 1) - O_j)^2}{O_j + 1} \]

   \[ \chi^2 = \frac{\chi^2_{\gamma}}{\nu} \]
SOLVING THE SFH:
Mother synthetic stellar population
IAC-STAR

SYNTHETIC COLOR-MAGNITUDE DIAGRAM COMPUTATION ALGORITHM

Last IAC-STAR warnings and changelogs

Run IAC-STAR

IAC-STAR input/output details  [html]  [ps]  [pdf]


Feedback and Contacting IAC-STAR

Acknowledging using IAC-STAR

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IAC-STAR

SYNTHETIC COLOR-MAGNITUDE DIAGRAM COMPUTATION ALGORITHM

A. Your Personal Data

Name
Institution
E-mail

B. Libraries

- Bertelli 94
- Teramo
- Girardi00

- Castelli & Kurucz 2002
- Girardi et al. 2002
- Origlia & Leitherer 2000
  (HST)

C. Control Parameters

Total number of computed stars (n) 10,000,000

Number of stars saved to output file (m) 10,000

Limiting magnitude for stars to be written in the output file 0

D. Star Formation Rate

Two forms are possible

1. Proportion sampling points n, [(1-n), SFR(1-n)] \text{, (max n=20, t(m) is the present age (in Gyr) of the system)}
2. Exponential law of the form SFR=exp(F \cdot \phi) \text{, (T is the present age (in Gyr))}

\[ \text{\_{0, 0.13, 1, 1}} \]

Done
E. Metallicity Law

E.1) Defined by sampling points

<table>
<thead>
<tr>
<th>Lower or unique law</th>
<th>Upper law (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n, Z^{(10)}$</td>
<td>$n, Z^{(10)}$</td>
</tr>
<tr>
<td>$n, Z^{(0)}$</td>
<td>$n, Z^{(0)}$</td>
</tr>
<tr>
<td>$Z^{(10)}, 0.02$</td>
<td>$Z^{(10)}, 0.02$</td>
</tr>
<tr>
<td>$Z^{(0)}$</td>
<td>$Z^{(0)}$</td>
</tr>
</tbody>
</table>

E.2) Defined by physical parameters (all parameters 0 to ignore)

<table>
<thead>
<tr>
<th>Lower or unique law</th>
<th>Upper law (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting $Z$</td>
<td>Starting $Z$</td>
</tr>
<tr>
<td>Final $Z$</td>
<td>Final $Z$</td>
</tr>
<tr>
<td>Final gas fraction $\mu$</td>
<td>Final gas fraction $\mu$</td>
</tr>
<tr>
<td>Initial parameter $\alpha$</td>
<td>Initial parameter $\alpha$</td>
</tr>
<tr>
<td>Outflow parameter $\beta$</td>
<td>Outflow parameter $\beta$</td>
</tr>
</tbody>
</table>

F. Initial Mass Function

```
IMF: n, m [1->n], x [1->(n+1)]
```

4, 0.1, 0.5, 1; 3.0; 0.135; 0.2; 0.7

G. Binary Stars

<table>
<thead>
<tr>
<th>Fraction of binary stars</th>
<th>Minimum mass ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

H. Random Number Generator

```
Seed: 95744505
```

Submit  Reset
SOLVING THE SFH:
CMD of the mother synthetic population

Stellar evolution library: TERAMO
(Pietrinferni et al. 2004)
Bolometric correction library:
(Castelli & Kurucz 2002)
SOLVING THE SFH:
CMD of the mother synthetic population including observational effects simulation

Stellar evolution library: TERAMO
Observational effects: simulated
DERIVING THE SFH - OUTLINE

1. Compute a “mother” stellar population with constant SFR for wide age and metallicity ranges. It has associated a “mother” mCMD
   \[ \psi_s(t, z) = 1 \]

2. Simulate uncompleteness, crowding, blending and all the observational effects on mCMD

3. Divide the mother population into several simple (age and metallicity) ones
   \[ \psi_i(t, z) = 1 \quad t_i \leq t < t_i + \Delta_i t \quad z_i \leq z < z_i + \Delta_i z \]
   \[ \psi_i(t, z) = 0 \quad \text{otherwise} \]

4. Any SFH can be obtained as:
   \[ \psi(t, z) = \sum_i \alpha_i \psi_i(t, z) \]

5. Parameterize the observational and the simple iCMDs using boxes or grid

6. The stellar distribution on the associated CMD is given by:
   \[ M_j = \sum_i \alpha_i M_{i, j} \]

7. Find best solution using a merit function:
   \[ \chi^2 = \sum_j \frac{(M^j - O^j)^2}{O^j} \]
   \[ \chi_\gamma^2 = \frac{(M_j + \min(M_j, 1) - O_j)^2}{O_j + 1} \]
   \[ \chi_v^2 = \frac{\chi_\gamma^2}{v} \]
IAC-pop test:
Fake stellar population
IAC-pop test:
CMDs for the fake population and the mother synthetic population

Stellar evolution library: PADUA (Bertelli et al. 1994)
Bolometric correction library: (Castelli & Kuruckz 2002)
IAC-pop test:
CMDs for the fake population and the mother synthetic population

Stellar evolution library: PADUA
Observational effects: simulated
IAC-pop test:
CMD parameterization: GRID

FAKE

MOTHER
IAC-pop test:
CMD parameterization: BOXES
IAC-pop test:
SFH solution for GRID

Stellar evolution library:
PADUA
IAC-pop test:
SFH solution for BOXES and different stellar evolution libraries

Stellar evolution library for fake: PADUA
for solution: TERAMO
Two burst
Fake stellar population
Input fake population SFH

SFH solution for BOXES and same stellar evolution libraries

Stellar evolution library
for fake: PADUA
for solution: PADUA
Input fake population SFH

SFH solution for BOXES and different stellar evolution libraries

Stellar evolution library for fake: PADUA for solution: TERAMO
PHOENIX dwarf
PHOENIX dwarf

The Color-Magnitude Diagram
PHOENIX: The Star Formation History

Stellar evolution library: PADUA
PHOENIX: The Star Formation History

Stellar evolution library: TERAMO
PHOENIX:
Spatial sampling
PHOENIX:
Spatial distribution of $\psi(t, z)$

Stellar evolution library: PADUA
PHOENIX:
Age at 5% and 95% of the age distribution
PHOENIX:
Metallicity law

Common parameters:
$Z_{ini}=0.0001$; infall=0; yield=0.014

<table>
<thead>
<tr>
<th>Z(t)</th>
<th>$z_f$</th>
<th>$\lambda$</th>
<th>$\mu_f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z_1$</td>
<td>0.0020</td>
<td>120</td>
<td>0.00</td>
</tr>
<tr>
<td>$Z_2$</td>
<td>0.0020</td>
<td>65</td>
<td>0.01</td>
</tr>
<tr>
<td>$Z_3$</td>
<td>0.0020</td>
<td>50</td>
<td>0.05</td>
</tr>
<tr>
<td>$Z_4$</td>
<td>0.0021</td>
<td>40</td>
<td>0.10</td>
</tr>
<tr>
<td>$Z_5$</td>
<td>0.0020</td>
<td>35</td>
<td>0.20</td>
</tr>
<tr>
<td>$Z_6$</td>
<td>0.0030</td>
<td>30</td>
<td>0.05</td>
</tr>
</tbody>
</table>
CONCLUSIONS:

1. CMD inversion based on synthetic CMDs is a powerful method to obtain the SFH of nearby systems, including metallicity law

2. The method is internally consistent and robust against stellar evolution input physics and computation

3. Short frequency fluctuations and biases are, however, expectable in the solution

4. The method is particularly powerful for relative SFH computation

5. Phoenix shows a star formation region shrinking with time