New opportunities for Stellar population modeling using MILES

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The MILES Collaboration

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Telescope : INT La Palma
Spectrograph : IDS
Resolution : 2.3Å FWHM
Spectral Range : 3500 - 7500Å
Sampling : 0.9Å/pix
Observed : 985 stars with a large range in Temperature, Gravity and Metallicity
INT-IDS
De-commissioned February 2002
Re-introduced August 2006
Atmospheric parameters coverage of different libraries compared with the parameter coverage of MILES
Gravity-temperature diagram for the library stars. Different symbols are used to indicate stars of different metallicities, as shown in the key.
Spectra sample of different spectral types

- $T_{\text{eff}} = 8560 \text{K}$
  - HD 74721, A0 V ($\log g = 3.57$)

- $T_{\text{eff}} = 5727 \text{K}$
  - HD 4307, G2 V ($\log g = 4.07$)

- $T_{\text{eff}} = 4570 \text{K}$
  - CD-26 10417, K5 V ($\log g = 4.50$)

- $T_{\text{eff}} = 3344 \text{K}$
  - HD 1326, M1.5 V ($\log g = 5.30$)

- $T_{\text{eff}} = 7325 \text{K}$
  - HD 2629, A7 III ($\log g = 3.57$)

- $T_{\text{eff}} = 5013 \text{K}$
  - HD 2685, G5 III ($\log g = 2.35$)

- $T_{\text{eff}} = 4731 \text{K}$
  - HD 221345, K0 III ($\log g = 2.63$)

- $T_{\text{eff}} = 3487 \text{K}$
  - HD 184786, M4.5III ($\log g = 0.60$)
The MILES stars are well flux-calibrated

Comparison of B-V colour measured on the MILES spectra with the Lausanne photometric database (Mermilliod).
The flux-calibration for other libraries is not as good:

BC03 : RMS = 0.10 mag
The resolution of MILES is 2.3 +/- 0.1A

Resolution measured on the individual reduced spectra by fitting a linear combination of higher resolution spectra to it (from INDO-US) and fitting the broadening that is needed (using PPXF). Errorbars give the RMS of the stars.
The indices measured on MILES do not contain noticeable systematic errors.

Index\textsubscript{Jones, STELIB, ELODIE} = \text{slope} \times \text{Index} \textsubscript{MILES} + \text{a}_0

<table>
<thead>
<tr>
<th></th>
<th>Jones</th>
<th></th>
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<th>STELIB</th>
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<td></td>
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<td>RMS</td>
<td>slope</td>
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<td>slope</td>
<td>(a_0)</td>
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<td>0.988</td>
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<td>0.973</td>
<td>0.001</td>
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</table>
A poor man’s way to obtain homogeneous stellar parameters

Field Stars:
- Choose one standard reference (Soubiran, Katz, Cayrel 1997)
- Take all references with at least 25 stars in common, and determine a linear transformation between their and our parameters ($T_e$, $\log g$, $[\text{M/H}]$)
- For all other references, determine simple offsets in the three parameters (similar to Cenarro et al. 2001)

Cluster Stars:
- Use uniform colour – temperature conversion
- Determine gravity by isochrone fitting
**MILES Papers:**

2. The stellar parameters of MILES (Cenarro et al. 2006), MNRAS, to be submitted July 15
3. Stellar population models with MILES (Vazdekis et al. 2006), MNRAS, to be submitted August/September

**Availability of MILES to the community through a dedicated website:**

1. **SSP Models: preliminary version on July 3**
2. **Stars: December 15 (during IAUS 241)**
An application of MILES: separating emission and absorption lines
An example: separating absorption and emission:

1. Fit a linear combination of MILES stars or SSP models + polynomials (for continuum) to an emission-free region to obtain the stellar kinematics.
2. Keeping stellar kinematics fixed, fit now a linear combination of stars/models + gaussians roughly at the place of the emission lines. This gives kinematics + strengths of the various emission lines.

3. The absorption lines can now be calculated to an accuracy of 0.1-0.2A (Sarzi et al. 2006).
A test in the blue (WHT-ISIS data, test done by Katia Ganda, Groningen)

NGC2964 - centre

NGC2964 - spiral arm ~25”
Stellar kinematics: fitting options

- Single template, mult polynomials
- Per-bin template, mult polynomials
- Single template, add polynomials
- Per-bin template, add polynomials
Gas Cleaning: a test

- Applying the pPXF-gas method to some Balmer lines
- **Question:** is there any difference in the amount of predicted emission between a ‘full-range’ fit and a fit performed on a short _range_ around the line?
- **Test to answer this question:** comparison of the measured emission line ratio with the theoretical one: $H/_\lambda/H_\lambda = 0.55$
Full range fit - tied kinematics: All three lines fitted together (plus models)

Full range fit - free kinematics

Short range - tied kinematics: each line fitted on a small range around it

Best result

Short range fit - free kinematics
An example, NGC 4314 (SAURON)

Intensity 

Mg b 

H beta 

Fe 5015 

HST

1. Center: old stellar populations 
2. In ring: combination of old and very young (10^7 y) 
3. Outside ring: young (10^{8.5} y) (+ old)
Other applications:

- Study fainter absorption lines
- Study galaxies at non-zero redshift (no Lick corrections)
- Define new and better line indices
- Derive abundances of more individual elements
- Do much more accurate work, since we are not limited any more by the stellar library
- etc.
A possible new age-indicator:

A possible new metallicity indicator: