α-enhanced stellar population models for studying massive galaxies

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Galaxy Formation
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Massive Early-Type Galaxies (ETGs) are generally known to be mainly old, unlike their low-mass counterparts.
Massive galaxies show $[\text{Mg/Fe}]>0$

$SFR$ vs. $\log \sigma_0$ (km/sec)

$[\text{Mg/Fe}]$: how fast the bulk of the stellar populations formed (e.g. Matteucci & Greggio 86)
Massive galaxy colours

Luminous Red Galaxy sample from SDSS/DR7 in the nearby Universe: stellar population synthesis models do not match accurately the optical SDSS colours:
Updated last week!

New version of MILES library & models

Falcón-Barroso+11 arXiv: 1107.2303
stellar population synthesis models
Computing integrated spectra for a parametric SFH:

\[ N \text{ BURST} \]
\[ t_1 \Delta m_1 Z_1 \]
\[ t_2 \Delta m_2 Z_2 \]
\[ \ldots \]

\[ \text{TRUNCATED} \]
\[ t_{\text{form}} t_{\text{trunc}} Z_1 \]

\[ \text{EXP} \]
\[ SFR(t) = \left( \frac{t_{\text{form}} - t}{t_{\text{form}}} \right)^n \exp\left( -\frac{t_{\text{form}} - t}{\tau} \right) \]
\[ t_{\text{form}}, \tau, n, Z \]

\[ \text{EXP + BURST} \]
\[ t_{\text{form}}, \tau, n, Z \]
\[ t_1 \Delta m_1 Z_1 \ldots \]

http://miles.iac.es
Integrated spectra for user-defined SFH

- Example of SFH for massive galaxies in hydrodynamical simulations (MASCLET code, Quilis 04)

- Up to 100 SFHs computed in one query
- Chemical evolution allowed

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α-enhanced models

Base models:

Scaled-solar isochrones + MILES spectra
(s-s @ solar metallicity; α @ low metallicity)

Scaled-solar models:

Scaled-solar Isochrones
+
Scaled-solar MILES spectra

α-enhanced models:

α-enhanced isochrones
+
α-enhanced MILES spectra
Scaled-solar

α-enhanced

Dwarfs

Giants

Converting

\([\text{O/H}] \sim [\text{Z/H}]\]

\([\text{Fe/H}]\)

Converting to

\([\text{Fe/H}]\)

coverage: model reliability
Ratios of enhanced / solar star spectra

Theoretical (Coelho+07)

Empirical (MILES)

\[
\frac{\alpha}{Fe} = +0.4 \quad \text{and} \quad \frac{\alpha}{Fe} = 0.0
\]

Dwarf stars

Teff=5500K, Log(g)=4.0, [Z/H]=0.0
Preliminary SSP SEDs

SSP(α-enhanced) / SSP(scaled-solar)

[Mg/Fe]-enhancement affects mainly the blue part of the spectrum:

(u-g)α=(u-g)ss-0.2 mag  (for α=0.4)
(g-r)α=(g-r)ss-0.05 mag  (for α=0.4)
**MIUSCAT composite stellar library**

**MILES:**
985 stars, 3535-7429 Å
(Sánchez-Blázquez+06)
http://miles.iac.es

**CaT:**
706 stars, 8348-9020 Å
(Cenarro+03)
http://miles.iac.es

**INDO-US: (Valdes+04):**
1273 stars, 3460-9464 Å; good stellar parameter coverage
not well flux calibrated, gaps in the spectra, telluric absorption
537 useful stars
228/204 stars in common with MILES/CaT
238 no matches \(\rightarrow\) MILES and CaT stars have been interpolated
MIUSCAT models

UBVRI colours can now be measured
MIUSCAT models provide better match than those based on theoretical stellar libraries.
LRG color evolution

Luminous Red Galaxy sample from SDSS/DR7 for $z<0.6$

LRG colors are consistent with a passive evolution model (SSP) assuming $z_f=5$, solar metallicity and Kroupa IMF.
α-enhanced SSP colours

α-enhanced SSP models fit better nearby LRG colours from the SDSS
Next step: Expanding [Mg/Fe] coverage

Current sample  Newly observed  Next run

Dwarfs

Giants