PHOTOMETRIC PROPERTIES OF STAR CLUSTERS WITH YOUNG OR MIXED AGE STELLAR POPULATIONS

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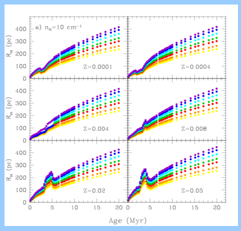
SUMMARY

- ☐ The main goal of this work is to present and discuss the synthetic photometrical properties of stellar clusters resulting from the PopStar code.
- ☐ Colors in Johnson and SDSS systems, Hα and Hβ luminosities and equivalent widths, and ionizing region size, have been computed for a wide range of metallicities Z = 0.0001, 0.0004, 0.004,0.008,0.02 and 0.05, and ages, from 0.1Myr to 20 Gyr in Mollá et al. (2009, Paper I). Emission lines are shown in Martín-Manjón et al. (2010, Paper II).
- ☐ Now we calculate colors with the emission lines contribution to the broad band color, so colors include stellar and nebular components, plus the emission lines following the evolution of the cluster and the region geometry in a consistent way.
- ☐ We compare the Single Stellar Populations contaminated and uncontaminated colors (in both Johnson and SDSS systems) and show the importance of emission lines contribution when photometry is used as a tool to characterize stellar populations.
- ☐ With these models we may determine the physical properties of young ionizing clusters when only photometrical observations are available and these correspond to the isolated star forming regions, subtracted the contribution of the underlying population
- ☐ In most cases, however, the ionizing population is usually embedded in a large and complex system, and the observed photometrical properties are the result of the combination of both the young star-forming burst and the host-underlying older population.
- ☐ The second objective of our work is therefore to provide a grid of models for nearby galaxies able to interpret mixed regions where the separation of young and old population is not possible or reliable enough.
- ☐ We obtain a set of PopStar Spectral Energy Distributions (available at PopStar site and also in VO) and derived colors for mixed populations where an underlying host population is combined in different mass ratios with a recent, metal-rich ionizing burst
- ☐ These colors, together with other photometrical parameters, like Hα radius of the ionized region, and Balmer lines Equivalent Width and Luminosity allow to infer the physical properties of star-forming regions without any spectroscopic information.

HII REGIONS PROPERTIES: SIZES AND Hα LUMINOSITIES



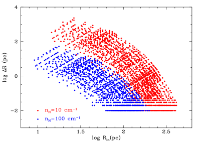
- ➢ We assume a scenario in which a perturbation produces the birth of a stellar cluster where there is gas enough to be ionized and we may detect the emission lines.
- ➢ As far as the cluster evolves, the mechanical energy of the massive stars winds starts to sweep the gas away, stacking this material and producing a shell.
- ➢ The radius of the shock, limiting the inner border of the shell, Rin, evolves as

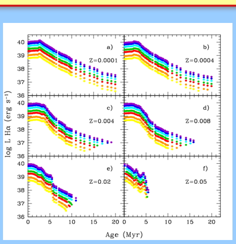
$$R_{in} = 1.6(\epsilon/n)^{1/5} t^{3/5}\ (\mathrm{pc})$$

where ε is the injected mechanical energy per unit time, n is the ISM density and t is the age of the shell

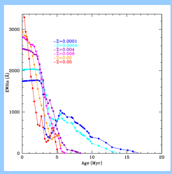
- ➢ This radius is shown in Fig.1 for n=10 cm^{-1}

- ➢ The material is staking due to the shock wave providing a compression.
- ➢ Once the ionized front is trapped, the previously ionized material will recombine
- ➢ The shell thickness ΔR begin very large when Rin is very small. When the cluster evolves Rin increases and simultaneously ΔR decreases as shown in Fig.2

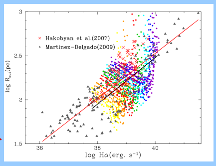




The luminosity of Hα is represented in Fig. 3 for different cluster masses (with different colors) and for the six different metallicities Z

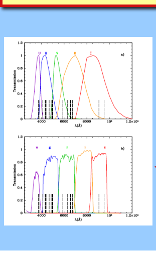


The equivalent width EW Hα is shown in Fig. 4 for different Zs



- ➢ Relation of the outer radius Rout (the observed one) vs luminosity LHα in Fig.5
- ➢ The colored full dots are our models for n_H=10 cm-^{1}, selected for ΔR > 0.55 pc
- ➢ Grey triangles are data from Martinez-Delgado et al. (2010) while red stars are from Hakobyan et al. (2007.)
- ➢ The black and red lines are the corresponding least-squares fit to models and data, respectively

CONTRIBUTION OF EMISSION LINES TO BROAD BAND FILTER COLORS



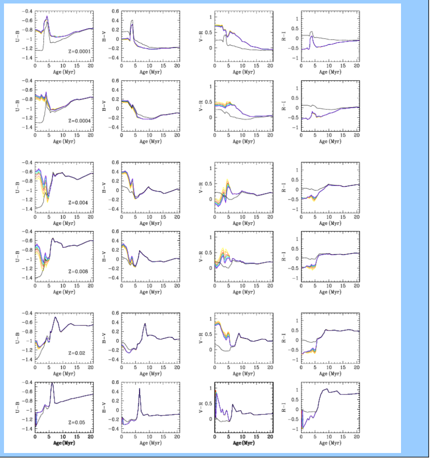
- ➢ Once the photoionization models with SSP-SEDs have been included as inputs of CLOUDY, we get the intensities of the optical emission lines.
- ➢ Some intense emission lines fall in the Johnson and SDSS broad band filters. The contribution depends on the filter transmission curve and the redshift, which places a given line in a different wavelength within the passband.
- ➢ We have calculated the contribution at z=0 in the U, B,V, R, I, and Z Johnson filters and the u, g, r, i and z SDSS filters. (see Fig.6)
- ➢ We include the contributions of the emission line to the magnitudes calculation:

$$m = -2.5 log \int_{\lambda_1}^{\lambda_2} L_\lambda d\lambda + \sum_{i=1}^{20} T_i \times L_i + C$$

Fig.7:

Colors for the youngest clusters (age< 10Myr) are greatly modified.

Hα keeps its influence over the R and r bands until almost 20 Myr for the lowest metallicities



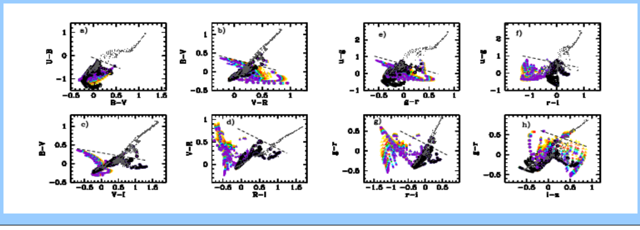
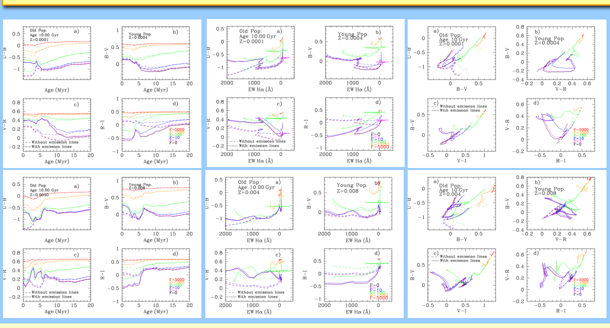


Fig.8:

The contribution of the emission lines to the color-color diagrams: points go out of the stellar population region each time that a burst of star formation takes places falling in a region impossible to reach in any other way. The position of young SSP populations in color-color diagrams changes considerably.

PHOTOMETRIC PROPERTIES OF STAR CLUSTERS WITH MIXED STELLAR POPULATIONS



We have mixed two populations, young (t < 10^8 yr) and old (t > 10^8 yr): the resulting colors are quite different than the ones synthesized without the emission lines contribution.

Fig.9

Resulting colors as a function of age (left), EWHα (medium) or as color-color diagram (right) for two mixed populations (top and bottom panels respectively) for which the old stellar population age and metallicity and the metallicity of the young one are defined as labelled

In each panel the evolution with the age of the young population is given for different proportions of the old stellar populations as given by F=Mass old pop./Mass young pop.

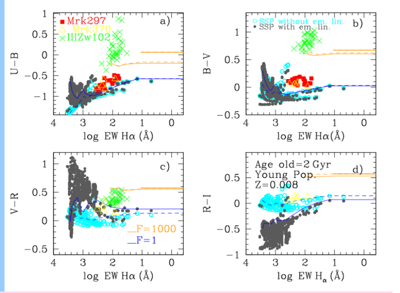


Fig.10 Color vs EWHa, cyan and grey dots represent the SSP results without and with emission lines. Solid lines are results for mixed stellar populations with F= 1000 and F=1. Data are from Martinez-Delgado (2010). Galaxies Mrk 297 and Mrk 370 are well fitted with F=1 or F=10, but IIIZw102 needs a high proportion of underlying old stellar population to explain the red colors with high EW Hα