The Color-Magnitude Relation of Early-Type Galaxies through the Analysis of Lick Indices

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Understanding the processes involved in the formation and evolution of galaxies is a hot topic in Astronomy. In particular, early-type galaxies display an interesting property that make them good targets to try to unveil such processes: in a color-magnitude diagram, they follow a strong photometric relation that displays similar characteristics regardless the environment in which they reside. That relation is known as *red sequence* or *color-magnitude relation* (hereafter, CMR) and it is interpreted as a mass-metallicity relation. However, it is not clear yet how the different chemical species that dominate the stellar populations of these kind of galaxies contribute to establish its features. The Lick/IDS absorption-line indices allow to derive ages and metallicities of old stellar systems from low-resolution spectra and through their comparison with stellar population models. Also, each index is dominated by specific chemical species. In this poster we present preliminary results of the analysis of the CMR defined by early-type galaxies located in the Virgo cluster and the Stripe-82 region, through their Lick indices obtained from SDSS spectra. Our aim is to try to disentangle if the CMR can be explained through the dependencies of the colors and/or luminosities on particular indices and, as a consequence, on specific chemical species.

The samples

The first sample is composed by 125 early-type galaxies of the Virgo Cluster Catalogue (VCC; Binggeli et al. 1985) and 23 objects of the Extended Virgo Cluster Catalogue (EVCC; Kim et al. 2014) that were not previously included in the VCC. We also choose a sample of 200 early-type galaxies that are located in the STRIPE 82 region. The spectral data were obtained from SDSS DR13. We selected spectra that do not show emission lines and display a median signal-to-noise ratio S/N > 10 (per Å). The spectrograph of SDSS uses optic fibers with a size of 3" of diameter . To the distance of the Virgo Cluster (<(m-M)>=31.15 which translates into <D>=16.5 Mpc; Mei et al. 2007), this diameter covers the very central ~0.26 kpc of the galaxies. The modulus distance of the galaxies of the STRIPE 82 sample ranges from 35 to 43. For this reason, the area covered by the optic fibers in these galaxies is bigger than that covered in the Virgo Cluster sample (i.e. 1.45 < d < 58 Kpc). In order to take into account the reddening produced by the redshift in these galaxies, we had applied the K-corrections provided by the SDSS. Magnitudes used in this work are given by SDSS. We also used the M_B absolute magnitude given by the S-PLUS survey transformed to M_g magnitudes for the STRIPE 82 sample.

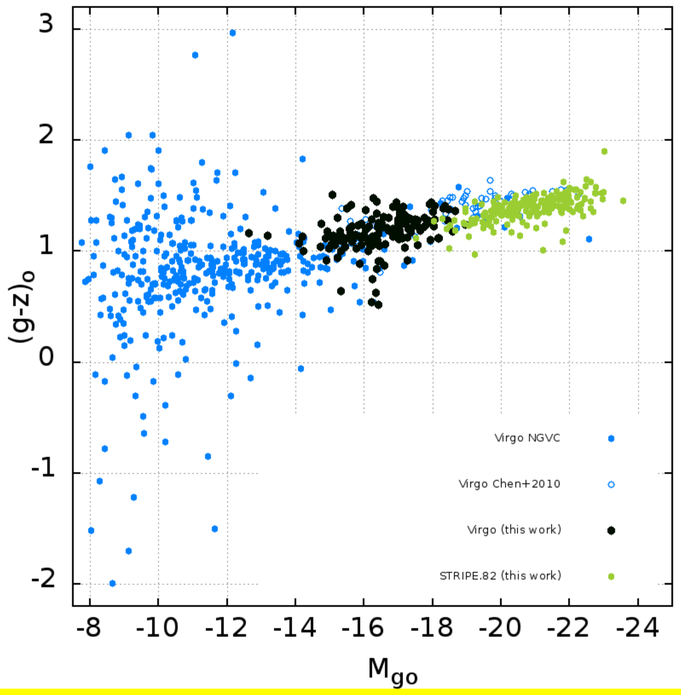

Figure 1: The location of our Virgo (black points) and Stripe 82 (green points) samples in the (g-z) vs Mg color-magnitude diagram. As a reference, we show the CMR of the Virgo Cluster from Chen et al. (2010) (open blue points) and the Next Generation Virgo Cluster Survey (NGVCS, Ferrarese et al. 2012; filled blue points).

Lick Indices

The Lick system (Worthey 1994; Worthey & Ottavini 1997) defines absorption-line indices that can be used, through the comparison with stellar population models, to derive ages and metallicities of stellar systems from low resolution spectra (~9 Å). In the present work, these 25 indices were calculated using Lick_ew code which is provided as part of the EZ_AGES package (Graves & Schiavon 2008). The rutine calculate errors of the indices following equations given by Cardiel el al. (1998) and using the error spectra given by SDSS. The strength of absorption features in stellar spectra are measured in a bandpass centered on the feature of interest, flanked to the blue and the red by "pseudocontinuum" bandpasses. The average flux (in wavelength and magnitudes units) is found for the flanking pseudocontinua, and a straight line is drawn between the centers of the pseudocontinua. The index is measured by integrating the ratio of feature/continuum flux over the feature bandpass.

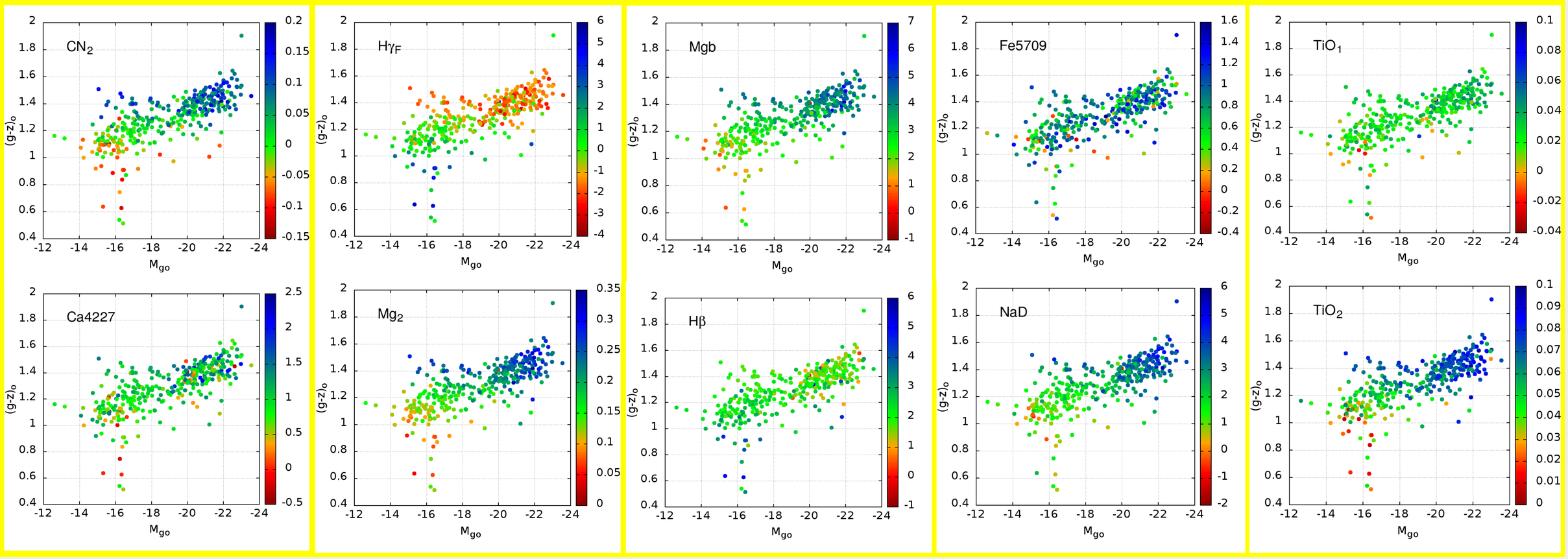

Figure 2: The color-magnitude relation (CMR) defined by our sample. Colored points show how the indices TiO1, TiO2, NaD, Mgb, Mg2, CN2, Ca4227, Fe5270, Fe5709 and H_γ vary along the CMR.

Results and future work:

We can see that some Lick indices seem to define a pattern in the CMR: higher values of the index correspond to redder photometric colors. This patterns can be seen more clearly in the Virgo sample than in the Stripe 82 sample. This effect could arise for several reasons. It could be due to environmental and/or luminosity differences between both samples. However, we can not rule out that errors in the determination of the absolute magnitude for the STRIPE82 sample may be blurring the trends. In addition, the fiber within which the indices are measured, cover different regions of the galaxies depending on their distances. It is known that the CMR in early-type galaxies is mainly driven by changes in metallicity than in age. As we see in Figure 2, indices like TiO1, Fe5709 and Ca4227 do not show marked patterns, while, for example, TiO2 does. With all of this in mind, it would be possible to interpret that the chemical species that dominates TiO1, Fe5709 and Ca4227 have less influence on the shaping of the CMR than those that dominates, for example, the TiO2, Mg group, CN group, NaD and H_γ. In the near future we hope to be able to clarify these points, as well as to evaluate if these patterns are also detected in a CMR built with narrow band colors as those provided by S-PLUS.

References

- Binggeli, B., Sandage, A., & Tammann, G. A. 1985, AJ, 90, 1681.
- Cardiel, N., Gorgas, J., Cenarro, J., Gonzalez, J., 1998, A&AS, v.127, p.597-605.
- Chen, Ch.-W., Côté, P., West, A., Peng, E. W., Ferrarese, L., 2010, ApJS,191,1.
- Ferrarese, L., Côté, P., & Cuillandre, J.-C. et al. 2012, ApJS, 200, 4.
- Graves, Schiavon, 2008, ApJS, 177, Issue 2, 446-464.
- Kim, S., Rey, S.-Ch., Jerjen, H., Lisker, T., et al., 2014, ApJS, 215, 22.
- Mei, S., Blakeslee, J., Cotˆ e, P., et al. 2007, ApJ, 655, 144.
- Worthey, G., Faber, S.M., Gonzalez, J.J., & Burstein, D., 1994, ApJS, 94,687.
- Worthey, G., & Ottaviani, D. L. 1997, ApJS, 11, 2.

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