The Globular Cluster System of NGC 1395: combining optical and near infrared photometry

Introduction: In the framework of our BAGGs collaboration, we are involved in obtaining deep optical and NIR photometry, as well as deep MOS spectroscopy, of GC systems belonging to massive early-type galaxies. Combined with different SSP models, these data will help us to refine the age-metallicity degeneracy and will allow us to measure several color indices less sensitive to the effect of horizontal branch stars. By combining kinematics and color-metallicity measurements of GC systems in a self-consistent manner, we recover the evolutionary histories of the galaxies and shed light in the assembly history of the halos of the galaxies in the Hosts in the Objects in Probing the Evolution of Galaxies (HOST) observing campaign. We observed the GC system of the giant elliptical galaxy NGC 1395 (D = 34.3 Mpc, z = 0.020 mag), one of the dominant galaxies of the Eridanus group. This galaxy harbours thousands of GCs and show different GCs subpopulations in their optical color distributions (Escober+2013). Here we are presenting our final results, based on deep and high quality NIR photometric data in two different photometric bands (J and KS) obtained with GEMINI/Flamingos2 instrument which were combined with high quality optical photometry from previous GEMINI-GMOS runs.

Optical Data: We worked on images in the $g'$ ($g' = (g' - i' = 0.72)$, $r'(r' = (r' - i' = 0.70))$, $i'$ ($i' = (i' - z'' = 0.12)$) and $z''$ ($z'' = (i' - z'' = 0.12)$) bands obtained in three separate epochs with a total exposure time of 16,360 sec per field. These correspond to four science fields in the region of the elliptical galaxy NGC 1395, plus an additional comparison field. In this poster we present the results obtained from two fields. The complete optical photometric analysis is presented in Escober+2013.

NIR Data: Within the BAGGs collaboration, we also obtained NIR images of two of the optical fields through GEMINI/Flamingos2 in the J and KS bands (Program G2013B-Q-28). The exposure times were 330 sec on source $+ 1800$ sec on sky in both fields for the J band, and in the KS band, 320 sec on source $+ 1200$ sec on sky for the field containing the galaxy and 277 sec on source $+ 1104$ sec on sky for the other field. The NIR photometry was calibrated using 2MASS objects present in our fields.

Figure 1: ESO red image of NGC 1395 showing the 1130 000 optical GC candidates (red squares). The 733 red GC candidates (J/Ks band) detected in the J and KS images are shown as green squares. The number of GC candidates is 1243. North is up and east to the left.

Figure 2: Photometric errors of the Daophot photometry in the J (upper panel) and KS (lower panel) bands. The mean error for objects with $J < 24$ mag is 0.1 mag.

Figure 3: Histograms and density color distribution for different band combinations and for objects with $J < 24$ mag. The density distribution was built using Gaussian kernels with the bandwidth 0.05 mag. To avoid overpopulation, we shifted some histograms in a way that the absolute values indicated in the Figure look larger.

Figure 4: Color-color diagrams of our optical and NIR photometric sample are shown in left panels. The plots include ~300 objects with $g' < 24$ mag, detected and successfully measured in $g'$, $r'$ and $i'$, $J$ and KS bands. The lines show the Yorke+ Evolutionary Population Synthesis models (YEPS) for 8, 10 and 12 Gyr (violet, green and cyan lines, respectively). In order to match the photometry and the GSP models, an $-0.15$ and $-0.27$ mag offsets were applied to modelled J and KS magnitudes. In the right panels we show density graphs of the same diagrams. The yellow circular elliptical symbols show the kernel size in each case.

Figure 5: Color-color diagrams of the optical and NIR photometric sample are shown in left panels. The plots include ~300 objects with $g' < 24$ mag, detected and successfully measured in $g'$, $r'$ and $i'$, $J$ and KS bands. The lines show the Yorke+ Evolutionary Population Synthesis models (YEPS) for 8, 10 and 12 Gyr (violet, green and cyan lines, respectively). In order to match the photometry and the GSP models, an $-0.15$ and $-0.27$ mag offsets were applied to modelled J and KS magnitudes. In the right panels we show density graphs of the same diagrams. The yellow circular elliptical symbols show the kernel size in each case.

Figure 6: Summary and Conclusions: The appearance of the color distribution strongly depends on which bands are combined. All the optical, optical-IR and most of the purely NIR color distributions show evidence of the presence of subpopulations. Some of them, like $(g'-r')$, $(g'-i')$, $(g'-z''')$, $(r'-i')$ and $(r'-z''')$, look strongly bimodal with possible substructure. As previously noticed by others authors (e.g. Chen+2013), in particular cases of colors involving only NIR bands, the situation is not so clear. However, thanks to our deep and clean photometry, it is possible to detect different kinds of substructures in all of them. YEPS models (Chung+2013) show a nice agreement with our observations. The color-color diagrams show signs of different degrees of non-linearity. This is in good agreement with previous studies (Blakeslee+2012, Forte+2013, Castellani+2014, Pforr+2018). Interestingly, most of the smoothed diagrams suggest that at least two main subpopulations in color are present. The combination $(J-Ks)$ vs $(g'-J)$ resulted to be one of the most clearly non-linear cases. It is possible to see a "break" similar to that expected in the $(H-J)$ vs $(g'-J)$ diagram of Castellani+2014. This break produces a clear intermediate peak in the $(J-Ks)$ color distribution.