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Simulating CCD images of elliptical galaxies

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Abstract. We introduce a procedure developed by the "Teramo Stellar Populations Tools" group (Teramo-SPoT), specifically optimized to obtain realistic simulations of CCD images of elliptical galaxies.

Particular attention is devoted to include the Surface Brightness Fluctuation (SBF) signal observed in ellipticals and to simulate the Globular Cluster (GC) system in the galaxy, and the distribution of background galaxies present in real CCD frames. In addition to the physical properties of the simulated objects - galaxy distance and brightness profile, luminosity function of GC and background galaxies, etc. - the tool presented allows the user to set some of the main instrumental properties - FoV, zero point magnitude, exposure time, etc.

The light coming from distant galaxies includes a specific SBF signal, essentially correlated with the properties of the host stellar system (Tonry & Schneider 1988). The existence of these luminosity fluctuations is due to the statistical correlation between adjacent galaxy regions (pixels). Since its introduction, the SBF method has been used as a reliable distance indicator for elliptical galaxies (e.g. Tonry et al. 2001) and, more recently, as a tracer of stellar population properties (e.g. Cantiello et al. 2003, 2005; Raimondo et al. 2005, R05).

In order to derive SBF magnitudes from CCD images of elliptical galaxies, very high quality CCD data are required. We have developed a tool to simulate CCD images of elliptical galaxies including the SBF signal and other properties of the galaxy - surface brightness profile, distance, color profiles, contamination of background galaxies, etc.

Due to its statistical nature, a reliable simulation of the SBF signal needs: i) to accurately reproduce the details of the statistics governing the stellar SBF signal, and ii) to take into account the presence of any other source of fluctuations. To include SBF signal in the simulations we use the Teramo-SPoT Single-burst Stellar Populations (SSP) models (R05, visit also the SPoT website www.oa-teramo.inaf.it/SPoT). These models are provided by computing a number N_{sim} of independent SSP simulations for a large range of ages and chemical compositions. The latter property of SPoT SSP models is at the base of our simulations of realistic galaxies: we start with a galaxy having an analytic Sersic $r^{1/n}$ profile, then, for each pixel [i,j] at the radius $r*$ we substitute the analytic magnitude profile $\mu_{th}(r*)_{[i,j]}$ with the integrated magnitudes μ_{sim} as evaluated in one of the N_{sim} independent SSP simulations, having assumed $\langle\mu_{sim}\rangle = \mu_{th}(r*)$. In this

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way the poissonian correlation between adjacent pixels is introduced, preserving the galaxy brightness profile.

To be realistic, the simulation must also include the presence of GC and background galaxies - which, in addition, can strongly affect the fluctuations signal derived from the CCD. These sources are indeed included into our simulations according to their typical luminosity functions, i.e., the total luminosity function is assumed to be the sum of a power law for galaxies, and a gaussian distribution for the GC component. The characteristic parameters of these functions can be arbitrarily set by the user. Once the luminosity functions are randomly populated all the background galaxies are randomly distributed in the frame, while the GC spatial distribution is additionally convolved with an inverse power law centered on the galaxy.

Finally, a uniform sky value is included, and the detector noise is added according to the readout-noise and gain values of the selected instrument.

After the galaxy profile - including SBF -, the GC system, the background galaxies, and the detector noise properties have been properly chosen, the simulation can be carried out. The panels of Figure 1 show the frames associated to some of the steps described above, the final frame simulated, and the luminosity functions of GC and background galaxies.

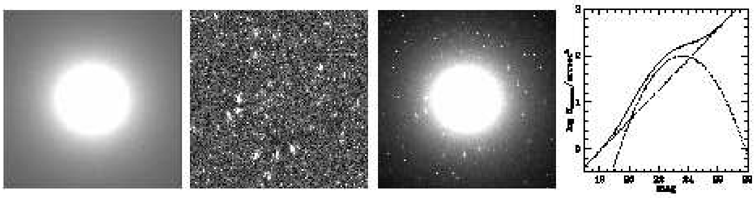

Figure 1. The first three panels of the figure (left to right) show the profile of the galaxy simulated, the frame of GC and background galaxies, and the sum of the previous two frames plus sky and noise, respectively. ACS camera properties are adopted for the instrumental characteristics. The last plot shows the luminosity functions adopted of the GC (short dashed line) and the background galaxies (long dashed line), and their sum (solid line).

The capabilities of the procedure here briefly described makes it useful to simulate astronomical data for a wide range of applications. As a specific case we mention the use of this tool to simulate realistic runs at defined telescopes with the aim of measuring SBF. For example, we have applied this technique to simulate ISAAC@VLT Ks-band, and ACS@HST F814W-band (reported Figure 1) images of given ellipticals in order to evaluate the proper exposure times required to reach a defined S/N ratio for objects at different distances.

References

Cantiello, M., Raimondo, G., Brocato, E., Capaccioli, M. 2003, AJ, 611, 670
Cantiello, M., et al. 2005, ApJ, 634, 239
Raimondo, G., et al. 2005, AJ, 130, 2625

Tonry, J. & Schneider, D.P. 1988, AJ, 96, 807
Tonry, J. et al. 2001, AJ, 546, 681