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Surface Brightness Fluctuations: a theoretical point of view

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Abstract. We present new theoretical evaluations of optical and near-IR Surface Brightness Fluctuations (SBF) magnitudes for single-burst stellar populations in the age range $t = 5 - 15$ Gyr and metallicity from $Z_{\odot}/200$ to $2Z_{\odot}$. Our theoretical predictions can be successfully used to derive reliable distance evaluations. They also appear to be a new and valuable tool to trace the properties of unresolved stellar populations.

1. Introduction

The SBF method is commonly used to derive accurate extragalactic distances (Tonry et al. 2001). The basic idea arises from the evidence that the spatial distribution of the light of nearby galaxies is “bumpy”, while in more distant ones it appears quite smooth. On CCD images of galaxies the level of bumpiness was quantified by Tonry & Schneider (1988) by defining the apparent SBF magnitudes $\bar{m} = -2.5\ log\bar{f}$, where $\bar{f}$ is the ratio of the pixel to pixel flux variance to the average pixel flux. This value depends on the *number* and *kind* of unresolved stars actually “located” inside the pixels. Thus, if the absolute SBF magnitudes are evaluated by using a stellar population synthesis code (as we do), two major information on distant galaxies can be inferred: *i) the distance* and *ii) the stellar population properties.*

2. SBF magnitudes as distance indicator

On the basis of the stellar population synthesis code developed at the Teramo Observatory (Brocato et al. 2000), we computed new absolute SBF magnitudes (UBVRIJHK + HST bands). These predictions are compared to SBF measurements of objects with SBF-independent distance estimations. For a metal poor ($Z \leq 0.01$), old ($t = 15$ Gyr) population, our models agree with available data of galactic globular clusters (Cantiello et al. 2002). To test models of metal rich populations, we select a sample of galaxies from the Tonry et al. (2001) database of $\bar{I}$ measurements. Fig. 1 shows the very good agreement between present models and some observed galaxies with distances derived by Cepheids

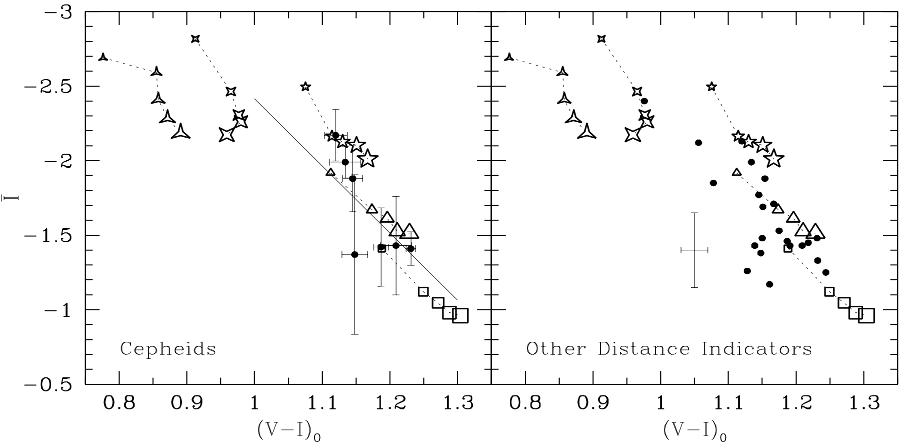

Figure 1. The comparison between data and new theoretical SBF models (Z = 0.0001, 0.001, 0.01: three, four, and five pointed stars respectively, Z = 0.02 triangles, Z = 0.04 squares; symbols with increasing size means increasing age: 5, 9, 11, 13, 15 Gyr). The empirical relation from Tonry et al. is plotted as a solid line.

or other distance indicators. This supports the reliability of our models and suggests the use of theoretical SBF magnitudes as *primary* indicators.

3. SBF magnitudes as stellar population tracers

The SBF signal is very sensitive to the most luminous stars in a stellar population. As a consequence all the evolutionary phases have to be properly considered in modeling SBF. The adopted population synthesis code is optimized to reproduce the details of the Color-Magnitude Diagram of star clusters. Thus, it is particularly reliable in providing theoretical SBF magnitudes and colors which can be used to infer the properties (like age and metallicity) of the stellar population dominating the integrated light of distant galaxies.

In particular, the $\bar{I}-\bar{K}$ SBF color discloses a sizeable separation (i.e. larger than typical uncertainties) between populations with different chemical compositions and ages. This allows the evaluation of metallicity and age of the studied stellar population. When used together with the integrated color $(V-I)$, the resulting two color diagram become a remarkable tool to investigate unresolved galaxies because it does not depend on their distances and appears to be very efficient in removing the problem of the age-metallicity degeneration (Cantiello et al. 2002).

References

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