Stellar Populations as Building Blocks of Galaxies
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News from bulges hosted by low surface brightness galaxies

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Abstract. We present new results on stellar populations of bulges in spiral galaxies, from optical and near-IR data (images and spectra). In particular, we analyze a sample of bulges hosted by low surface brightness galaxies (LSBs). Correlations between metallicity, scale lengths of disk and bulges, and HI content are reported, supporting the bulge secular evolution hypothesis, as well as systematics between the derived evolutionary parameters of the embedded stellar populations. Using spectra of moderate resolution, we also investigate the stellar histories of bulges using Lick/IDS indices and recent α-enhancement models. Results indicate that small bulges tend to be smaller and metal poor, compared to larger ones. However, all bulges appear to have been formed in the same time-scale. We present some ongoing studies and some prospects of our research.

1. Introduction

Low surface brightness galaxies (LSBs) are galaxies with disk central surface brightness $\mu_B(0)$ fainter than 22.0 mag arcsec^{-2}, historically close to the value established by Freeman (Freeman, K. 1970, ApJ, 160, 811) as the threshold for the disk brightness of spiral galaxies. Lately, Disney (Disney, M. 1976, Nature, 263, 573) showed that such a limit was only due to a selection effect in photographic plates as a consequence of the sky brightness. Since then, observational data and theoretical work has been produced not only to describe the most relevant features of these galaxies but also to analyze whether these features are consistent with models of galaxy formation and evolution. These works strongly indicate that LSB galaxies are unevolved systems with a low stellar formation rate (SFR), low metallicity, small stellar density, a relatively high gas fraction, and, from dynamical information, large amounts of dark matter. However, several challenging problems remain unanswered. In particular, and in spite of the evidence indicating that LSB galaxies are young when compared with spectrophotometric models, the spread in color is wide, implying that LSBs have probably gone through diverse evolutionary paths, including possible secular evolution to form bulges.

2. Goals

We explore possible evolutionary scenarios for a set of selected face-on spiral and LSB galaxies using a combination of optical and near-IR colors, as well as spectral information. In particular, we investigate the observables and structural parameters in the scope of the secular disk-to-bulge evolution, as estated for example, in Courteau et al. (Courteau *et al.* 1996, ApJ, 457, L73). All galaxies are part of the catalog published by Impey *et al.* (Impey *et al.* 1996, ApJS, 105, 209), from which we select 21 face-on LSBs (Galaz *et al.* 2002, AJ,

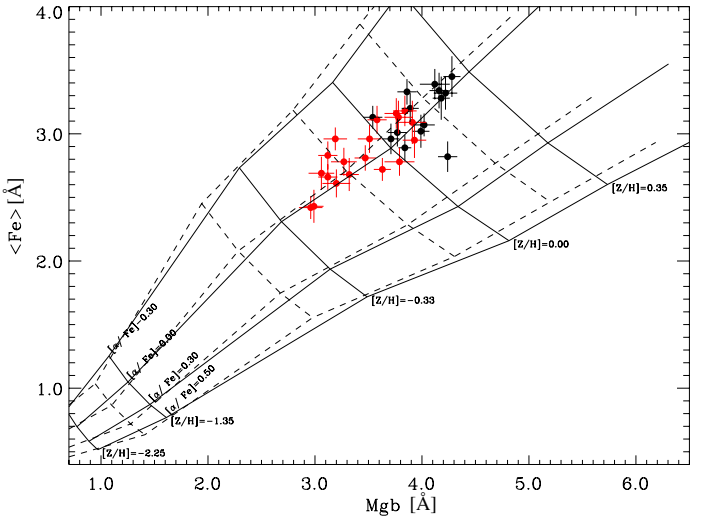

Figure 1. Distribution of Mgb-Fe for the LSB galaxies of this work (grey dots) and for control galaxies (black dots). The lines indicate models (Thomas *et al.* 2003, MNRAS, 339, 897) of constant ages and metallicity. Models are for fixed ages of 12 Gyr and 6 Gyr and different α-Fe enhancements.

124, 1360; — 2006, AJ, 131, 2035), to investigate the stellar content of bulges. The goal of this work is to determine what range of metallicity and age is consistent with bulge and disk formation scenarios by comparing observed B, R, J, and Ks magnitudes and colors with spectrophotometric models of galaxy evolution. We compare different metallicity indicators with the same obtained for HSB galaxies from the sample of Peletier and Balcells (Peletier & Balcells 1996, AJ, 111, 2238), including colors and spectral indices. Our results suggest that secular evolution is not ruled out to form, in an homogeneous scale of time, most of the observed bulges hosted by LSBs included in our sample.

3. Results

Long-slit spectra. The 21 bulges were observed with Magellan/LDSS3 during 2004 and 2005, with 8 Å resolution. A comparison between the observed spectra with synthetic ones, shows that all bulges can be fitted by a e-folding SFR with τ between 3 and 12 Gyr, but never younger.

Lick/IDS indices and α-enhancement models. We derived Lick/IDS spectral indices for all 21 galaxies, plus 14 galaxies from the sample of Peletier & Balcells (1996, P&B), re-observed and for which spectral indices were derived. Figure 1 shows results for the Lick indices <Fe> vs. Mgb, and compared to α-enhanced model by Thomas *et al.* (Thomas *et al.* 2003, MNRAS, 339, 897). These results suggest that bulges of LSBs are metal poor compared to those of high surface brightness galaxies (HSBs) from the sample of P&B, but were formed at quite similar time-scales (because all of them are around a constant value of α/Fe [= 0]).

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