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Galactic bulges: the importance of early formation scenarios vs. secular evolution

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Abstract. We study the stellar content of three galactic bulges with the high resolution gratings (R=7000) of the WiFeS integral field unit in order to better understand their formation and evolution. In all cases we find that at least 50% of the stellar mass already existed 12 Gyrs ago, more than currently predicted by simulations. A younger component (age between ∼1 to ∼8 Gyrs) is also prominent and its present day distribution seems to be much more affected by morphological structures, especially bars, than the older one. This in-depth analysis supports the notion of increasing complexity in bulges which cannot be achieved by mergers alone, but requires a non-negligible contribution from secular evolution.

Keywords. galaxies: individual (NGC 5701, NGC 6753, NGC 7552), galaxies: bulges, galaxies: evolution, galaxies: kinematics and dynamics, galaxies: stellar content, techniques: spectroscopic

1. Introduction

Galactic bulges, considered as a deviation from the exponential profile in the centres of galaxies, hold crucial clues to refine our understanding of galaxy formation and evolution. Yet, the details of the interplay of collapse, mergers and secular processes are still not fully understood. The review by Kormendy & Kennicutt (2004) (and references therein) summarizes the two main bulge formation mechanisms: i) merger-driven and ii) secularly evolved. The advances in instrumentation, spectral libraries (e.g., MILES, Sánchez-Blázquez *et al.* 2006), and stellar population (SP) studies via full-spectral fitting techniques (e.g. `STECKMAP`: Ocvirk *et al.* 2006) now allow us to characterize the stellar content of galaxies on a spatially resolved basis, and test the different bulge formation mechanisms. To that end, we conducted a pilot study using the WiFeS integral field unit (and its high resolution mode; R=7000) to link the stellar kinematics and SP parameters (and their radial distribution). The three bulges analyzed are NGC 5701, NGC 6753 and NGC 7552 and their unsharp masks are shown in Fig. 1 along with their kinematics. The high quality of our data allows us to characterize the 2D distribution of different stellar populations (i.e. young, intermediate, and old, see Fig. 1, middle and bottom row).

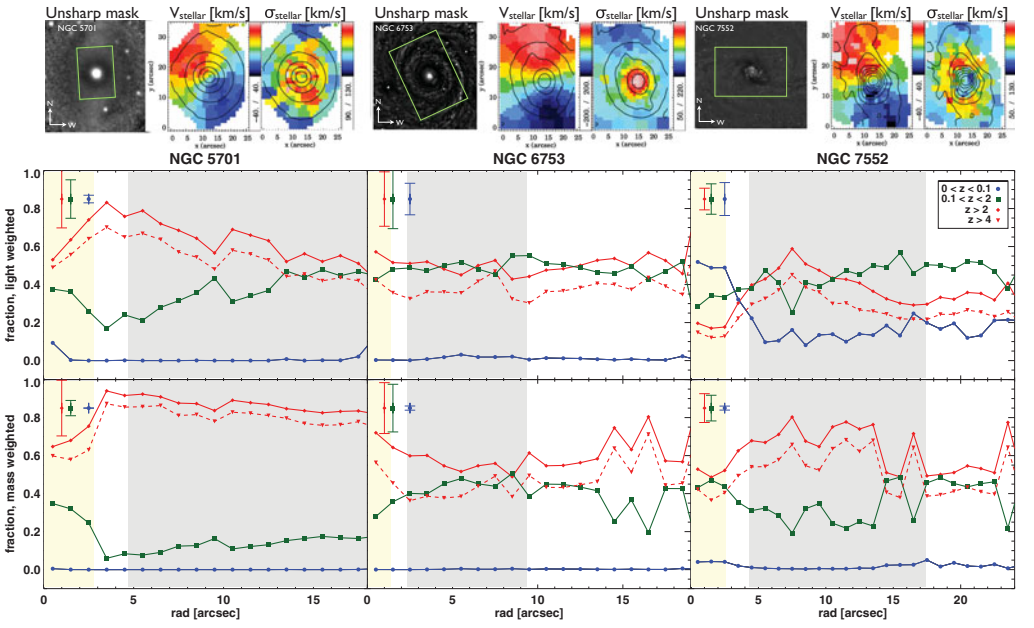

Figure 1. *Top row:* Unsharp masks (Spitzer image for NGC 5701, HST WFPC2 F814W filter for NGC 6753 and NGC 7552) with the WiFeS FoV (25×38 arcsec) in green, stellar velocity and stellar velocity dispersion map. *Below:* Fractions of young (blue dots), intermediate (green squares) and old SP (red rhombus) as a function of radius. Top left corner: corresponding uncertainties. *Middle row:* L-weighted and *Bottom row:* M-weighted results. Shaded regions show the central (< 0.3 kpc) and inner parts (0.5 kpc < r < 2 kpc).

2. Conclusions: Old bulge structures rejuvenated by bars

Our main conclusions are threefold (as illustrated in Fig. 1):

- The stellar velocity dispersion is higher in regions where the light of the old population is dominant
- The fraction of the mass of the old stellar population (existing already at z∼2) is 50-80% in the inner 2 kpc of all bulges, hinting towards high star formation (SF) during the collapse in the early cosmic web
- The barred galaxies (NGC 5701, NGC 7552) show a significant amount of light of the young SP and mass of the intermediate SP in the centres, likely indicating the influence of the bars driving necessary material towards the centre to fuel this second SF period.

These conclusions are based on a sample that cannot be regarded as representative. But as all our bulges show consistent features albeit their different nature (mass, morphology), it hints towards a common evolution. More details in Seidel *et al.* (2014, submitted).

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References

Kormendy J. & Kennicutt, Jr., R. C. 2004, *Annual Review of Astronomy & Astrophysics*, 42, 603-683

Sánchez-Blázquez, P., Peletier, R. F., Jiménez-Vicente, J., Cardiel, N., Cenarro, A. J., Falcón-Barroso, J., Gorgas, J., Selam, S., & Vazdekis, A. 2006, *MNRAS*, 371, 703-718

Ocvirk, P. , Pichon, C., Lançon, A., & Thiébaut, E. 2006, 365, 74-84

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