Bulge-Disc Decomposition of IFU Data

Evelyn Johnston (ESO, Chile)

evelyn.johnston@eso.org

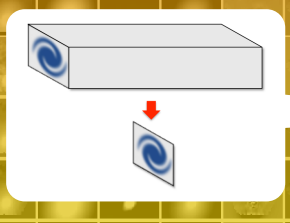
In collaboration with Boris Häußler, Alfonso Aragón-Salamanca, Michael Merrifield, Steven Bamford, Matthew Bershady, Kevin Bundy, Niv Drory, Hai Fu, David Law, Christian Nitschelm, Daniel Thomas, Alexandre Roman Lopes, David Wake, Renbin Yan

Abstract

With the availability of large IFU surveys of nearby galaxies, there is now the potential to extract spectral information from across the bulges and discs of galaxies in a systematic way. This information can address questions such as how these components built up with time, how galaxies evolve and whether their evolution depends on other properties of the galaxy such as its mass or environment. We present a new approach to fit the two-dimensional light profiles of galaxies as a function of wavelength to extract the spectral properties of these galaxies' discs and bulges.

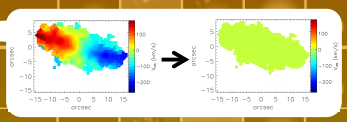
How to decompose a galaxy datacube

The decomposition is carried out with GALFITM (Häußler et al, 2013; see poster by B. Häußler), a modified version of GALFIT (Peng et al, 2002, 2010) that can fit multiwaveband images simultaneously. Ideally, one would run the IFU datacube through GALFITM directly to keep the full galaxy information for the fitting process. However, with the number of images involved, this approach is impossible in due to the required memory and CPU time. Instead, we have developed the following 5 step process.



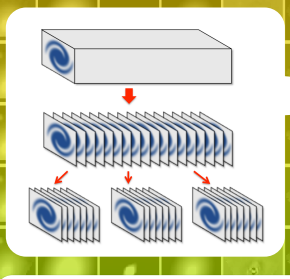
Measure and obliterate the kinematics

to obtain a homogeneous datacube, where each spaxel in each image slice measures the light at the same rest-frame wavelength and at the same position within any spectral feature at that wavelength



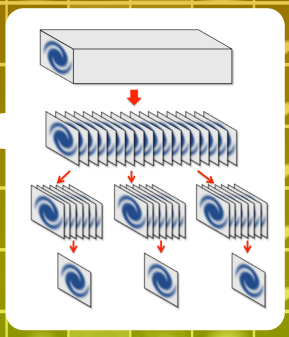
Fit a "broad-band" or white-light image

to determine the number of components required for a good fit



Fit binned, "narrow-band" images

to further refine the fit parameters and allow variations with wavelength



Fit individual image slices

best done in batches to reduce the required computing power

Construct decomposed bulge and disc spectra

either as one-dimensional integrated spectra (see Fig. 1) or datacubes

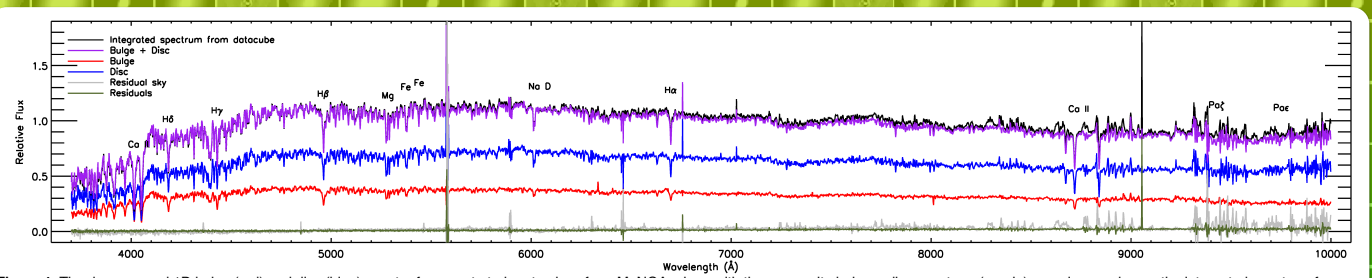


Figure 1: The decomposed 1D bulge (red) and disc (blue) spectra for a post-starburst galaxy from MaNGA, along with the composite bulge + disc spectrum (purple) superimposed upon the integrated spectrum from the original datacube (black). At the bottom, the residual sky component included in the fit is plotted (grey), along with the residuals after subtracting the best fit model from the original image at each wavelength (green).

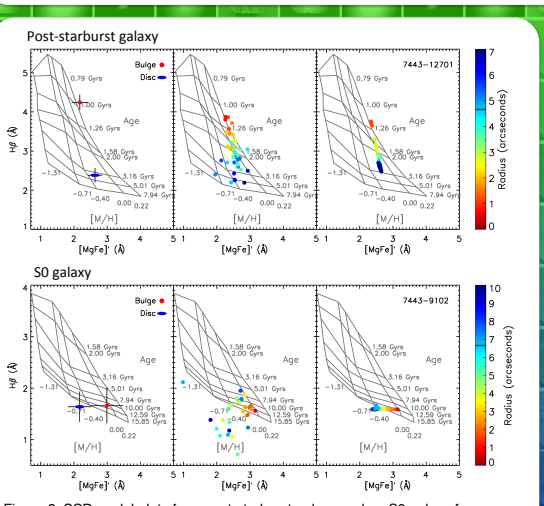


Figure 2: SSP model plots for a post-starburst galaxy and an S0 galaxy from MaNGA. L-r: results for the decomposed bulge and disc spectra, the radially binned MaNGA datacube before decomposition, and bulge + disc datacube after decomposition. The latter two plots are colour coded by distance from the centre of the galaxy.

Example Analysis

Figure 1 shows a clean separation of the bulge and disc spectra of a post-starburst galaxy from the MaNGA (Bundy et al, 2015) commissioning data set, alongside a comparison with the original integrated galaxy spectrum. One can see that the majority of the regions of poor fits and higher levels of noise correspond to regions of non-zero residual-sky background (also plotted) and poorly subtracted strong sky lines.

In order to demonstrate the potential of this method, Fig. 2 presents example stellar population analyses for the separated bulge and disc spectra from a post-starburst and an S0 galaxy in MaNGA. The plots show consistent results for each galaxy between decomposed, one-dimensional bulge and disc spectra, the radially binned MaNGA datacube after obliterating the kinematics but before decomposition, and the combined, radially binned decomposed bulge + disc datacube.

How can we use the decomposed spectra to better understand galaxy evolution?

- Measure star-formation histories within bulges and discs,
- Measure stellar population gradients within bulges and discs,
- Isolate spectra of faint structures, such as bars and rings,
- Isolate spectra of faint objects, such as globular clusters,
- And many more applications.

References: Bundy K. et al., 2015, ApJ, 798, 7; Häußler B. et al., 2013, MNRAS, 430, 330; Peng C. Y., Ho L. C., Impey C. D., Rix H.-W., 2002, AJ, 124, 266; Peng C. Y., Ho L. C., Impey C. D., Rix H.-W., 2010, AJ, 139, 2097

Background image: example decomposition of a binned MaNGA datacube. L-r: original image, disc model, bulge model, composite model, residuals.