NGC 2787. Credit: NASA

Spectroscopic Bulge–Disc Decomposition: a new method to study the evolution of lenticular galaxies

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Introduction

The Hubble Tuning Fork Diagram (figure 1) is thought to represent the sequence of evolution of galaxy morphology, going from young, star forming spiral galaxies to old, 'red and dead' ellipticals. Lenticular galaxies (S0s) are seen as a transitional phase between these two morphologies, and understanding their origins is a key stage in understanding galaxy evolution.

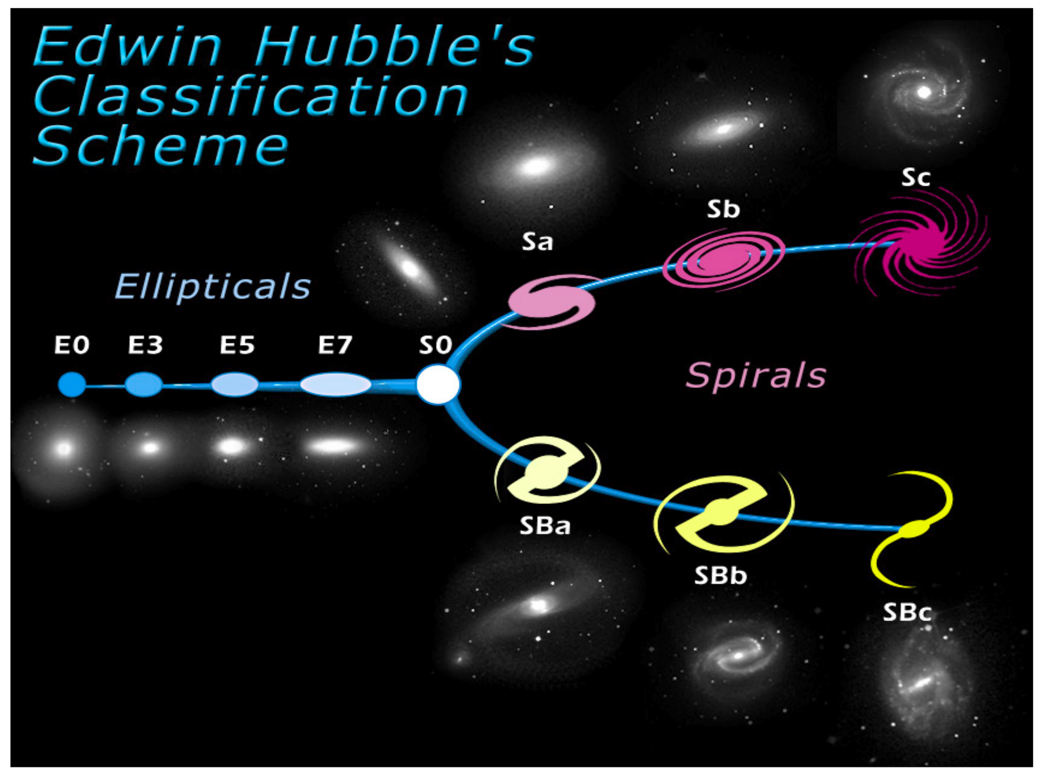

Figure 1. The Hubble Sequence of galaxy evolution (left) and NGC5866, an edge on lenticular galaxy with a dust lane. Credit: NASA

S0s are disc galaxies with a large central bulge, like spiral galaxies, but lack the bright young stars that define the spiral arms. Instead they contain older stellar populations like those found in ellipticals. We aim to study the formation of these galaxies by looking at the stellar populations of the bulges and discs. To do this we have developed a method for spectroscopic bulge-disc decomposition, where the light profile of the galaxy at each wavelength is separated into bulge and disc components. These are then recombined to produce two spectra representing purely the bulge and disc light, which can provide clues to the star formation histories of each component, and thus the galaxy's evolution.

Spectroscopic Bulge–Disc Decomposition

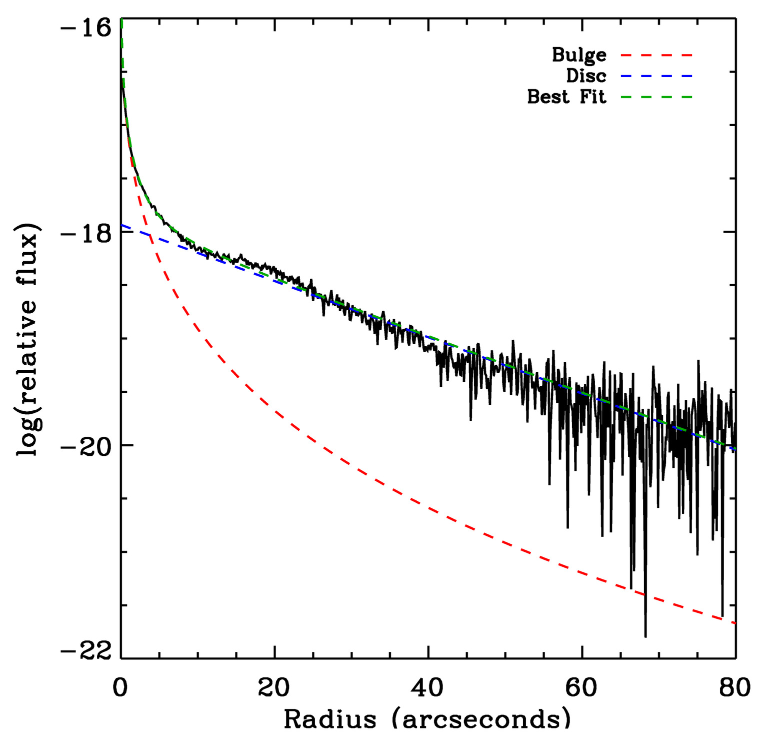

Figure 2. Light profile of NGC 1375 at 5195 Å, showing the best fit from bulge and disc models.

From a two-dimensional spectrum taken along the major axis of an S0 galaxy, the luminosity is plotted against the radius at each wavelength. The light profile is fitted with a de Vaucouleurs bulge[1] and an exponential disc[2] (see figure 2), from which model spectra can be produced like those in figure 3. The total luminosity of the bulge and disc at each wavelength is calculated by integration, and plotted against wavelength to give the decomposed bulge and disc spectra. The strength of spectral features within these spectra can be measured for clues to the relative ages and metallicities of the stellar populations present.

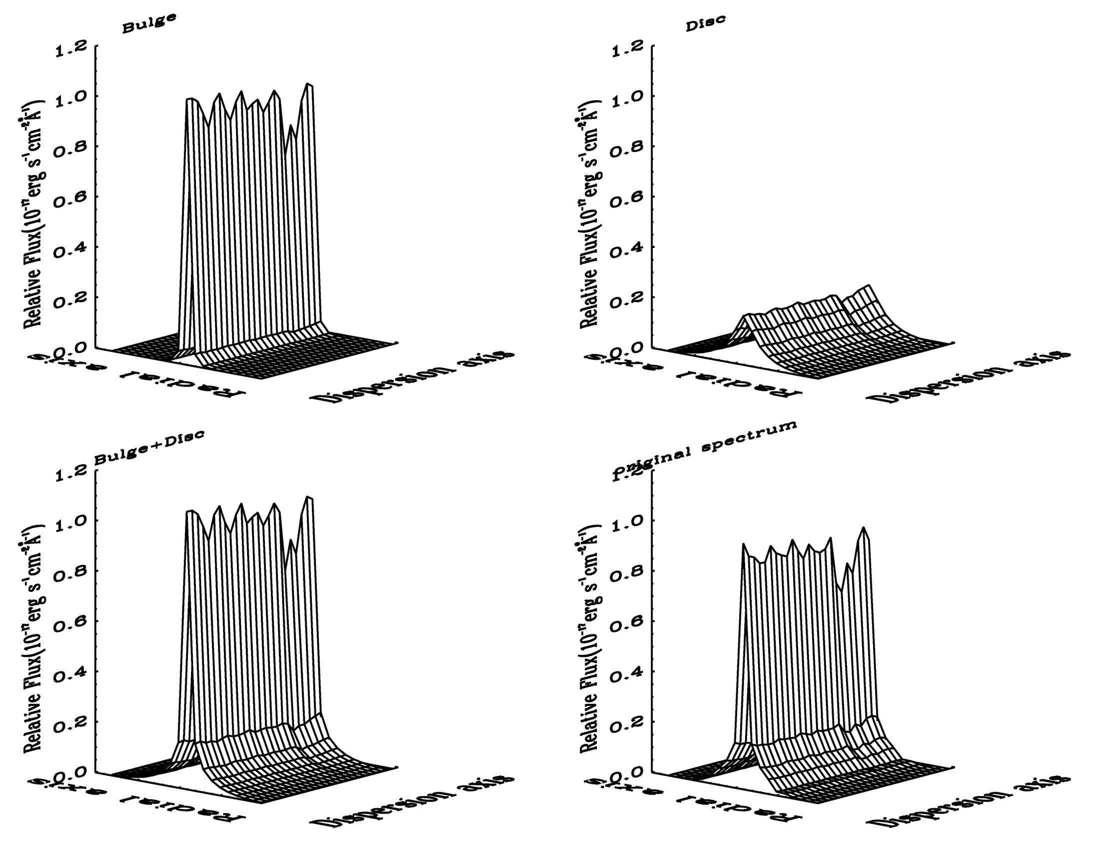

Figure 3. Section of the bulge, disc and composite models, with the original spectrum of NGC 1381 for comparison.

Initial Results

This technique has been applied to a test sample of nine S0 galaxies from the Fornax Cluster. Due to the simplicity of the model, only two of these could be fitted with both bulge and disc components, while a further three were fitted as pure discs (see figure 4).

Th initial results show that within the galaxies that could be decomposed, the bulges contain younger stellar populations with higher metallicities than the discs, which has also been found within these galaxies in Bedregal et al (2011). This suggests that star formation finished later in the bulge, and went on for a longer period of time. To investigate this further, the decomposed spectra can be studied for colour, age and metallicity gradients within the bulge and disc, which will indicate whether the most recent star formation occurred as a central, concentrated starburst, or happened throughout the bulge and disc.

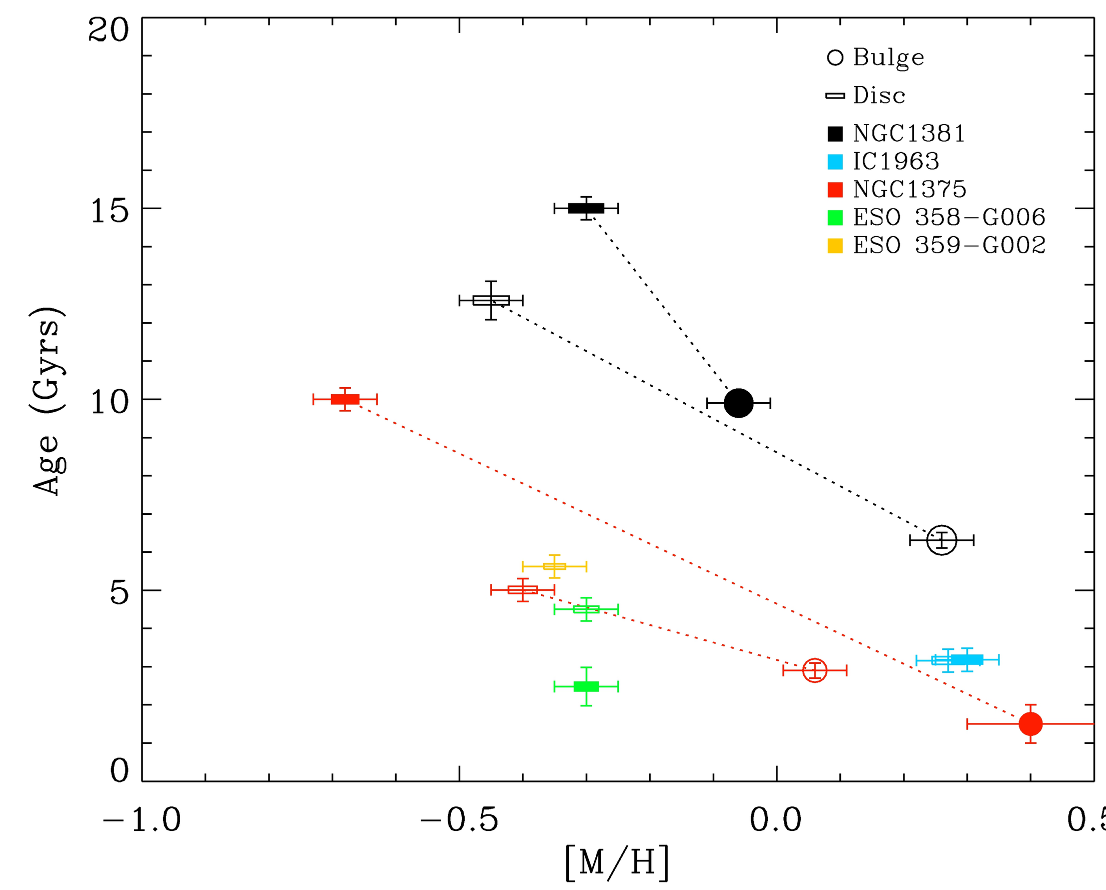

Figure 4. Relative ages and metallicities for the bulges and discs, measured from each half of the galaxy where possible for comparison. Dotted lines link up bulges and discs from the same galaxy.

References: 1. de Vouculeurs G., 1953, MNRAS, 113, 134, **2.** Freeman K. C., 1970, ApJ, 160, 811, **3.** Bedregal, A. et al, 2011, MNRAS, 415,2063