Scaling relations of anti-truncated stellar discs in galaxies across the Hubble Sequence

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Abstract

The characteristic photometric parameters of anti-truncated (Type-III) discs in S0 galaxies follow strong scaling relations. We have investigated whether similar scaling relations are satisfied by Type-III galaxies of other morphological types.

Using published data in the R and 3.6 μm bands, we have found tight scaling relations in both bands involving the scale-lengths of the inner and outer discs (h_i,h_o), their central surface brightnesses ($\mu_{0,i}$,$\mu_{0,o}$) and the break radius (R_{brkIII}) in Type-III galaxies from S0 to Scd.

The trends are independent of the morphological type and the presence of bars within errors. This study has been published in Eliche-Moral et al. (2015, [2]).

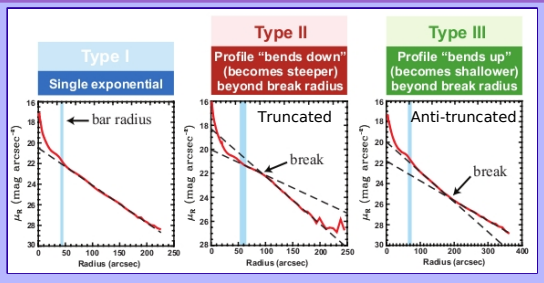
1 - Type-III stellar disc profiles

Anti-truncated or Type-III galaxies are those in which the surface brightness of the disc presents an up-bending profile beyond a given radius, called the **break radius** (see **Figure 1**, taken from [4]).

The origin of anti-truncated discs is poorly understood, but they seem unrelated to bars ([4; 5; 7; 12]). Diverse mechanisms have been proposed to explain their formation, mostly related to gravitational interactions and mergers ([1; 8; 11; 13; 14]). Other scenarios include different star formation thresholds, ram-pressure stripping, gas infall, simple fading or initial conditions of the dark matter halos ([3; 6; 9; 10; 11]).

Borlaff et al. (2014) have found that **the structures of the inner and outer discs and the location of the break in Type-III S0 galaxies are strongly coupled** ([1], **see poster SP16.1 by Borlaff et al.**).

Figure 1: Types of discs according to the shape of their surface brightness profiles.



2 - Aims and data

We have investigated whether the Type-III discs of spirals obey scaling relations that are as tight as those observed in anti-truncated S0s by Borlaff et al. (2014). The same analysis has been performed for barred and unbarred Type-III galaxies to find out whether bars and anti-truncations are structurally related or not.

We have used the data published in the R band by Erwin et al. (2008) and Gutiérrez et al. (2011) and in the 3.6 μm Spitzer band by Laine et al. (2014) ([4; 5; 7]). The R-band data contain the photometric parameters of the surface brightness profiles derived for 16 Type-III barred galaxies and for 24 unbarred ones (40 S0-Sbc's in total). The 3.6 μm dataset comprises the parameters of 62 Type-III (barred and unbarred) galaxies, with types S0-Scd. Depths reach μ_{lim}~25.5 – 27.5 mag arcsec^{-2}, in Vega.

3 – Results

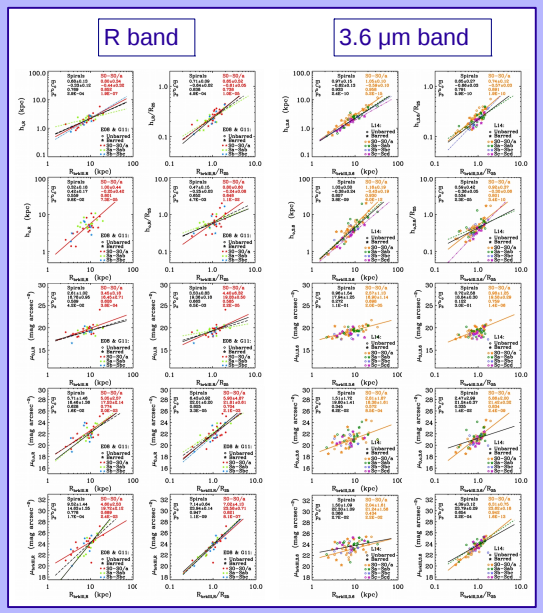


Figure 2: Trends of the photometric parameters of the break and the inner and outer discs with R_{brkIII} and R_{brkIII}/R_{25} in the R and 3.6 μm bands for Type-III galaxies with different morphological types (from S0 to Scd).

The linear fits performed to each galaxy type are over-plotted only if they are significant according to the Spearman rank correlation test.

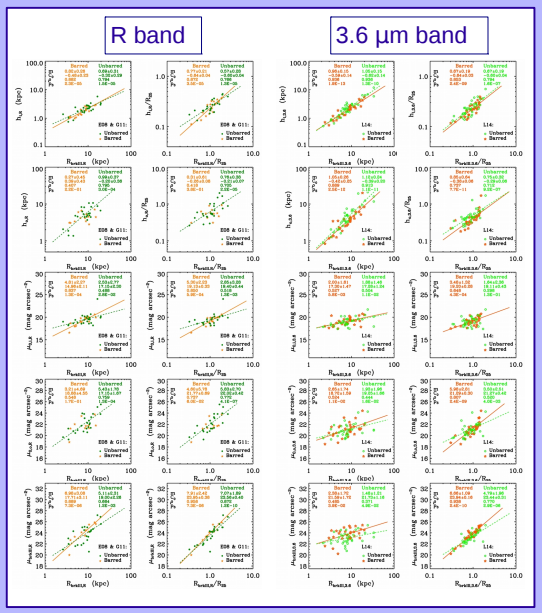


Figure 3: The same as Fig. 2, but analysing the scaling relations followed by barred and unbarred Type-III galaxies separately (compare with Fig. 2).

Figure 4: Scaling relations between the parameters of the inner and outer discs of local anti-truncated S0–Sbc galaxies in the 3.6 μm band.

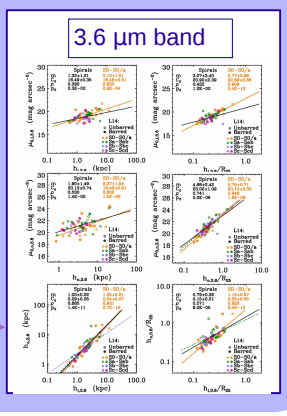
We have found that (see **Figs. 2-4**):

1) **the anti-truncated discs of all galaxy types from Sa to Scd obey tight scaling relations in R and 3.6 μm, as observed in S0s;**

2) the trends are clearly linear when the characteristic scale-lengths are plotted on a logarithmic scale;

3) some correlations (those involving $\mu_{0,i}$, $\mu_{0,o}$, or μ_{brkIII}) significantly improve when the scale-lengths are normalized to the optical radius of the galaxy, R_{25};

4) **the scaling relations found in Type-III discs seem independent of the morphological type and the presence of bars within the observational uncertainties,** but larger samples are required to confirm this robustly.



4 - Conclusions

The tight structural coupling implied by these scaling relations imposes strong constraints on the mechanisms proposed to explain the formation of anti-truncated stellar discs in galaxies across the whole Hubble Sequence.

References

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