Galactic haloes — what are they and how do we detect them?

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Introduction

- Most galactic stars exist in the bulge and disc areas of spiral galaxies, and in the bulge of ellipticals.
- Older, diffuse stars make up the stellar halo, a region beyond the bulge and disc
- Haloes can make up 5% of a galaxy's mass[6],[7].
- Haloes are very faint: they can be detected at 26-29 mag arcsec^{-2} surface brightness
- Next Generation Virgo Survey penetrates to 29 mag arcsec^{-2}.
- Previous work in this area has employed 1D axisymmetric, azimuthally averaged light profiles to detect haloes[1],[4].
- The Sérsic profile is used to characterize galaxies[2].
- Sérsics can be used for bulges, discs and haloes.
- For discs, n equals 1, which generates the exponential profile.
- b_n is empirically derived and approximated[3].

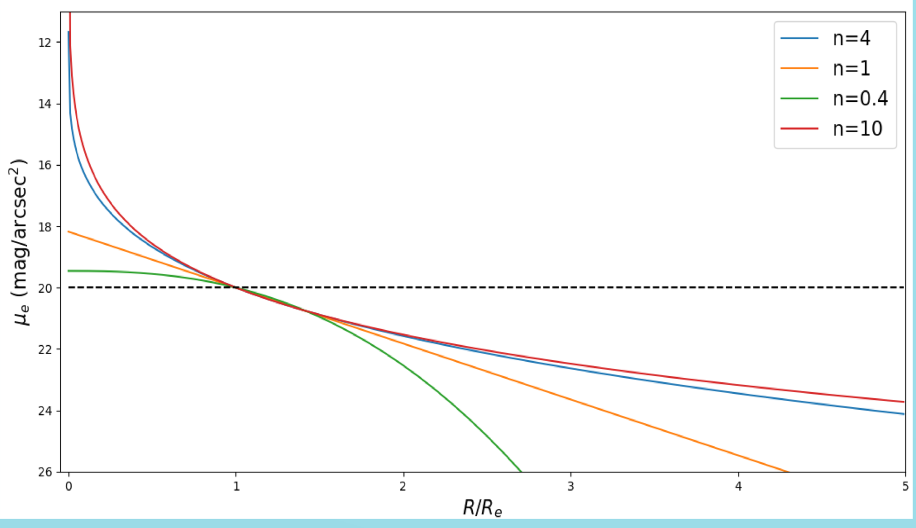

Fig 1: Surface brightness profiles for the various Sérsic functions, including the exponential.

$$\mu(\mathrm{R}) = \mu_e + 1.086\mathrm{b_n}\left[\left(\frac{\mathrm{R}}{\mathrm{R_e}}\right)^{1/n} - 1\right] \qquad (1)$$

$$\mathrm{b_n} = 2\mathrm{n} - \frac{1}{3} + \frac{4}{405\mathrm{n}} + \frac{46}{25515\mathrm{n}^2} + \frac{131}{1148175\mathrm{n}^3} - \frac{2194697}{30690717750\mathrm{n}^4} \qquad (2)$$

$\mu(R)$ - Surface brightness at radius R (mag arcsec^{-2})
n - Sérsic index
R_e - Effective radius (arcsec)
μ_e - Effective surface brightness (mag arcsec^{-2})

Methods

The 2-dimensional fitting software *GALFIT* was employed to extract component models from input images in the *i*-band[5].

Fig 2: Input image of VCC0725

Fig 3: Sample masking image

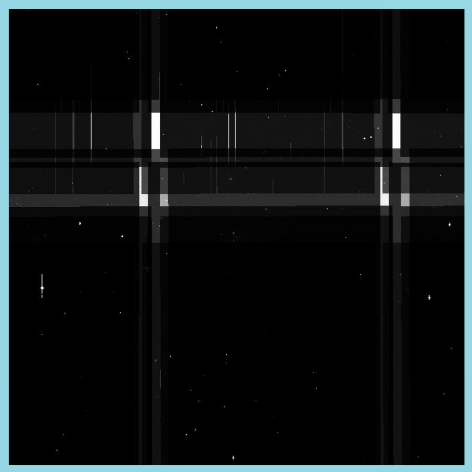

Fig 4: Sample sigma image

GALFIT requires an input image, a masking image, and a sigma image.

Together with the parameters for the Sérsic profile, *GALFIT* uses the Levenberg-Marquardt method (a χ^2 minimization regime) to build a component model of the data.

Fig 5: Data, model, and residual map of 2-component fit

After a proof-of-concept trial, 100 galaxies were modelled using a bulge and disc component, in a novel bulk fitting implementation.

The 100 galaxies were examined and those that did not fit the criteria for bulk 3-component fitting were discard, namely:

1. Minimal angular extent of the galaxy
2. Substantial amounts of bright objects in the field
3. The ellipticity of the imaged galaxy; is our view edge-on?
4. Non-elliptical features (which make bulk fitting impossible)

Results

The proof-of-concept trial was completed using a single Sérsic profile on 10 ellipticals.

Since the fit involves a single Sérsic function, the Sérsic parameters μ_e and R_e in Equation (1) correspond directly with the galactic half-light radius and surface brightness, and can be compared with previous results characterizing the galaxy as a whole.

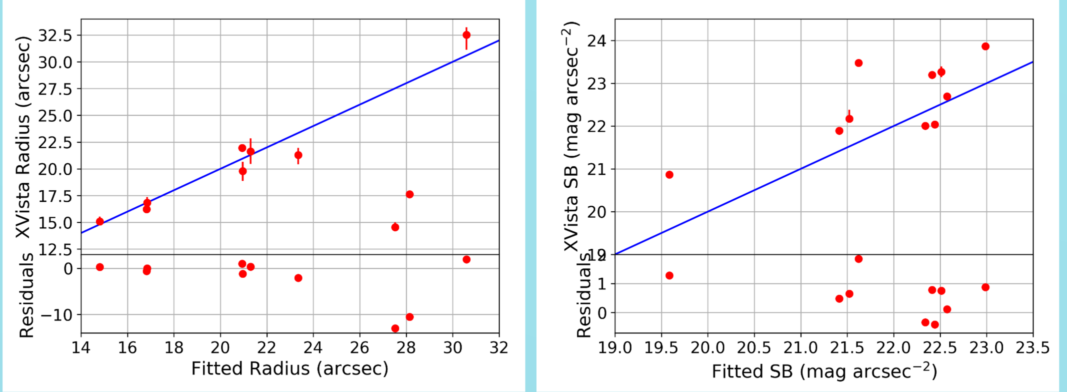

Fig 6: Comparison of 1-Component radius and surface brightness to half-light parameters

We compare with McKinnon's results obtained via *XVISTA*.

We note that there is significant brightening in the modelled surface brightnesses, possibly due to the 1-component overcompensating.

A bulk fitting regime for a 2-component model is implemented and tested on 100 candidate galaxies of varying morphologies.

We compare 2-component models with McKinnon's decompositions.

Relatively strong correlation can be observed in the radii population.

Amongst the surface brightnesses, we now note a dimming effect, in contrast to the 1-component models.

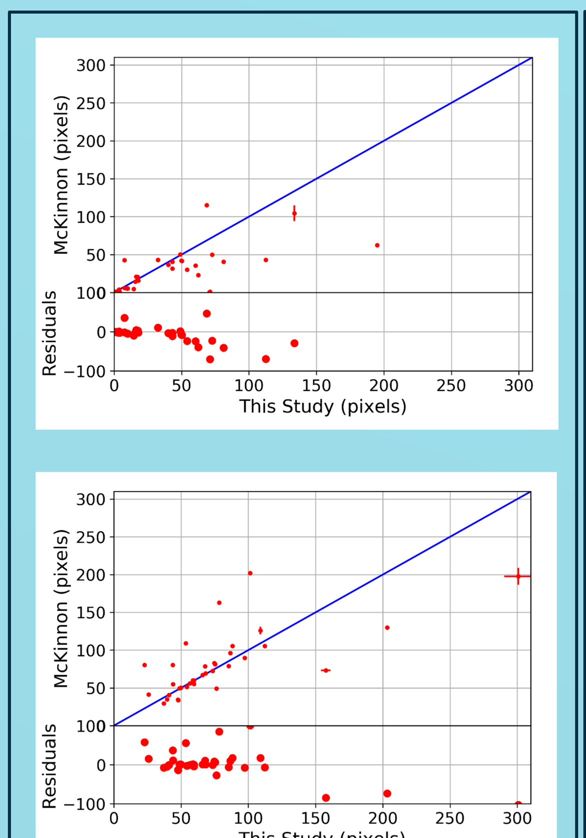

Fig 7: Radius comparison of bulge (top) and disc (bottom) components

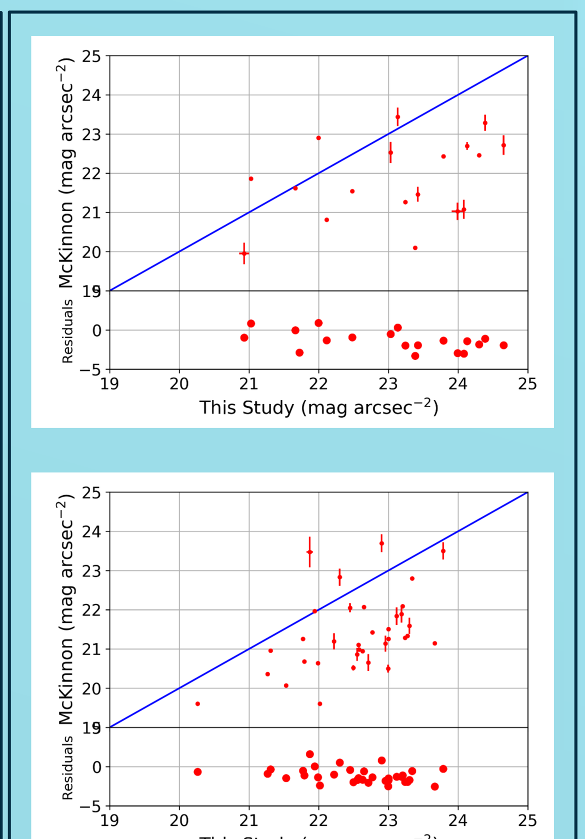

Fig 8: Surface brightness comparison of bulge (top) and disc (bottom) components

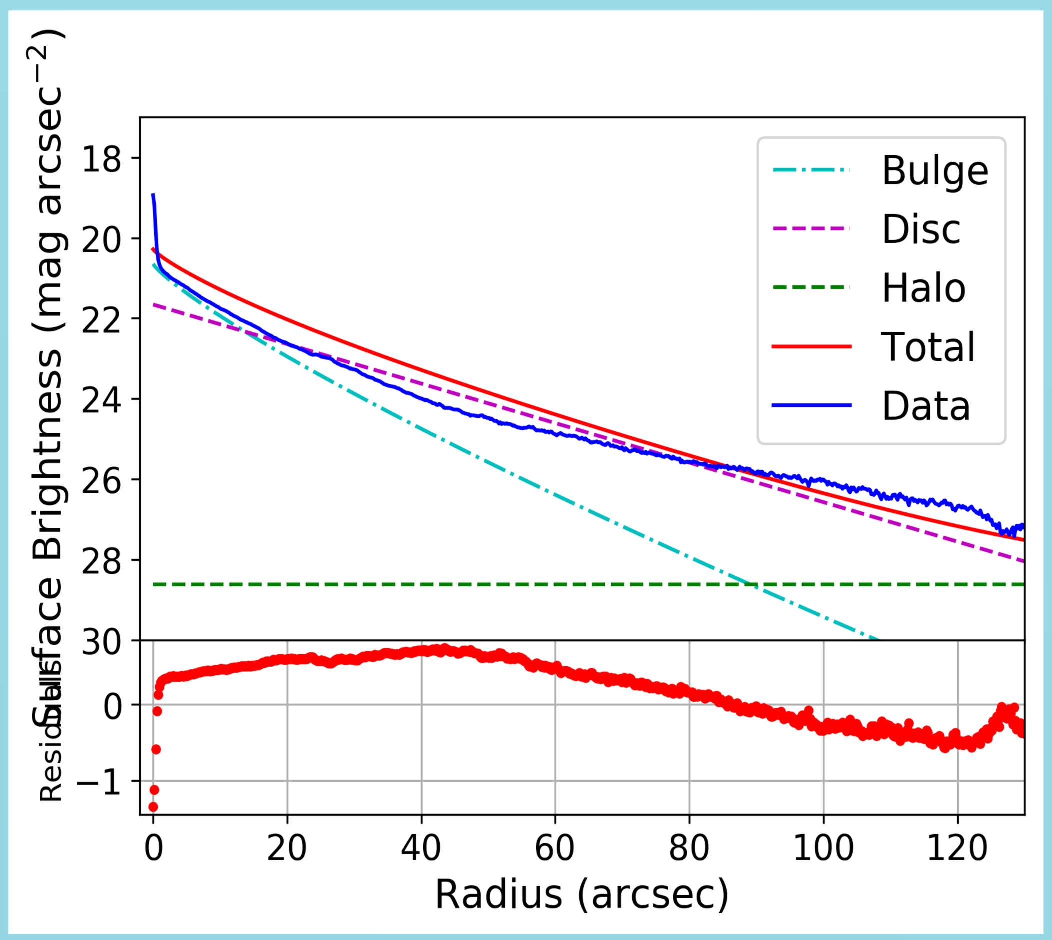

Fig 9: Light Profiles of bulge, disc and halo components of VCC1355

We impose a bulk fitting regime for a 3-component model on the remaining 36 galaxies.

22 of these yield a complete model, as *GALFIT* was unable to produce models for 14.

6 of the 22 were models with acceptable residual levels.

2 of the 6 were further manually examined, by forcing component parameters to remain fixed or within a certain range.

The constrained models displayed moderate improvements.

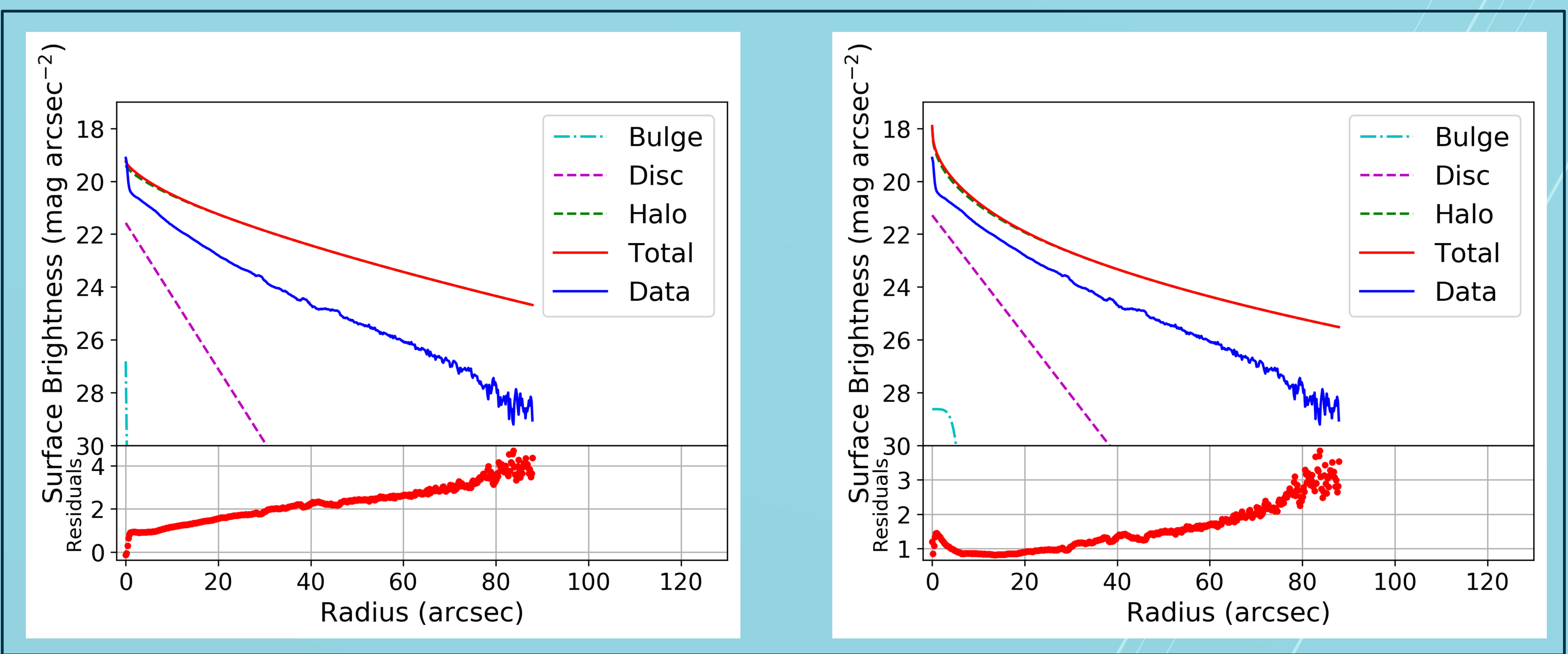

Fig 10: Unconstrained (left) and manually constrained (right) light profile models for VCC1075

Conclusion

- This research aimed to extract the light components of stellar haloes in NGVS galaxies.
- A bulk-fitting regime was implemented to standardize the software approach and increase sample size.
- The detection of faint halo structure proved troublesome, with 6 of 100 candidates displaying adequate 3-component models.
- The validity of the generated models is suspect.
- The search for stellar haloes is best described as a *quality* vs *quantity* problem.
- A generalized bulk approach may not be appropriate for the study of stellar haloes until the photometry can reach greater sensitivity.
- Future research will require significant human time investment to ensure adequate *quantity* of *quality* models.

References

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