Revealing the outskirts of Milky Way analogs

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WHY MILKY WAY ANALOGS?

The high fraction of massive bulgeless galaxies in the nearby Universe, like the Milky Way, challenges the ΛCDM model.

To test the robustness of ΛCDM, the BEARD (Méndez-Abreu et al. in prep.) project uses multi-facility observations to study the formation of Milky Way analogs. Among other scientific objectives, BEARD aims at unveiling the merger history of bulgeless disc galaxies to explain how they survive in a ΛCDM Universe.

BEARD — Bulgeless Evolution And the Rise of Disks

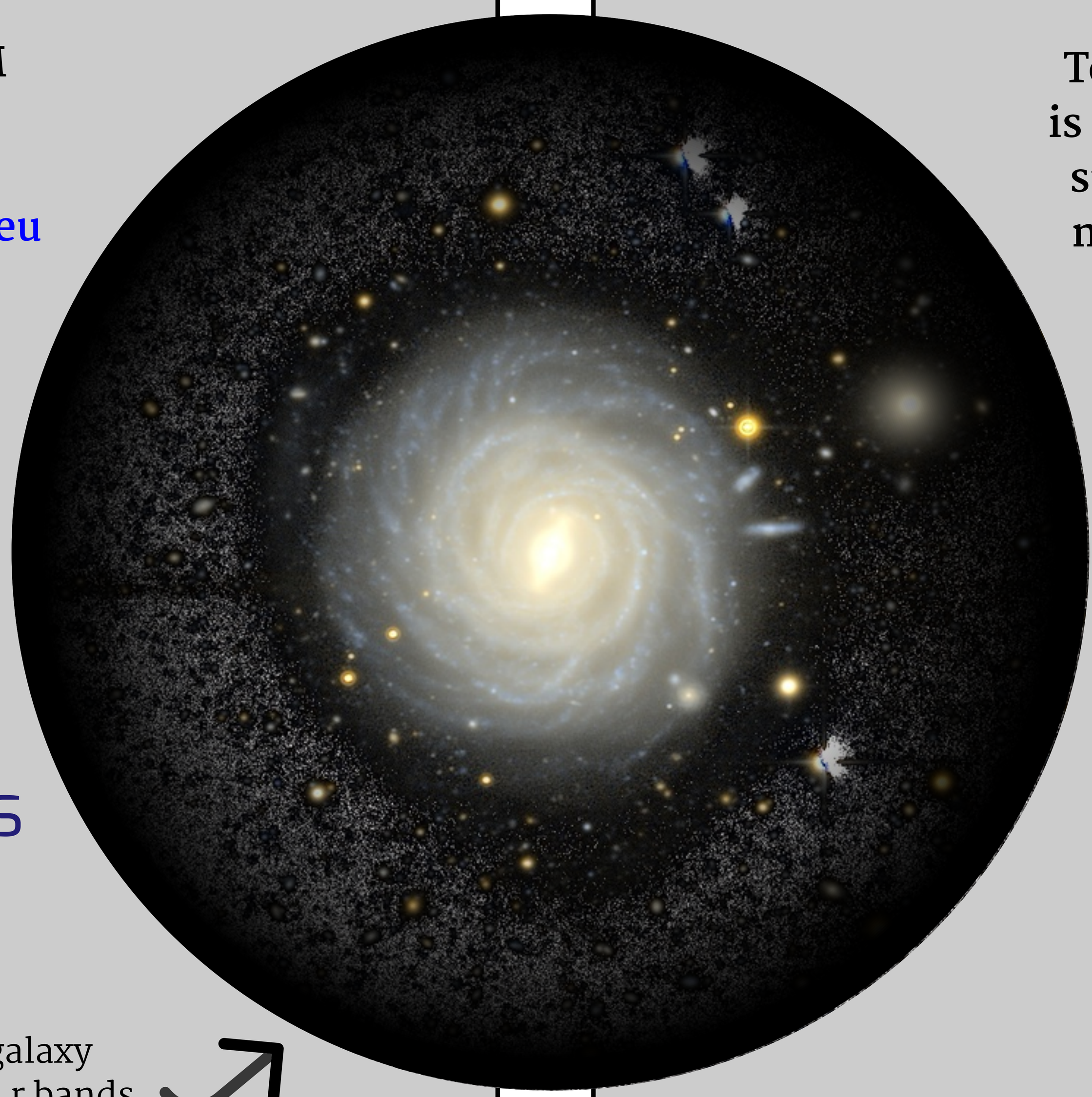


Fig 1. Color image of the galaxy NGC521 using the SDSS g and r bands.

RESEARCH FOCUS AND SAMPLE OVERVIEW

To understand the merger history of giant spiral galaxies, it is essential to study (i) their outer features like tidal tails and streams, which indicate past mergers, and (ii) the accreted mass fraction in their stellar halos, providing insights into past events and environment.

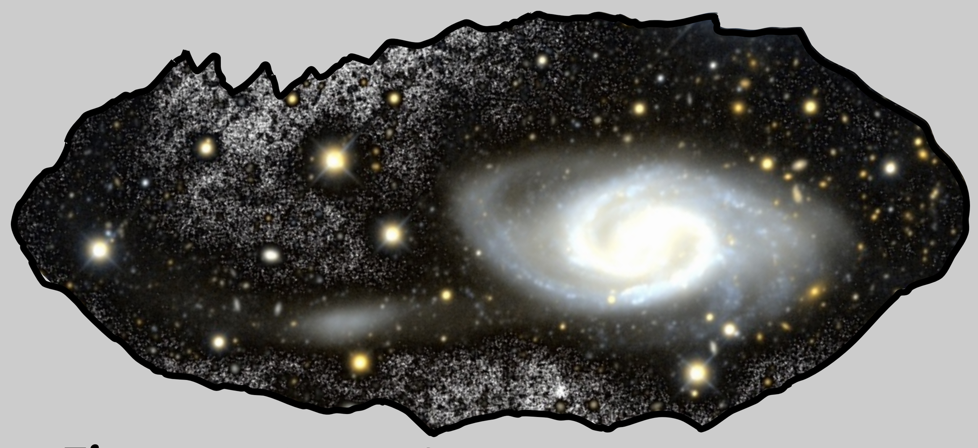


Fig 2. Color image of the BEARD galaxy NGC2543 using the SDSS g and r bands.

Our sample includes ~50 Milky Way analogs observed with deep photometry from the Isaac Newton Telescope (ORM), reaching surface brightness depths of 28–31 mag/arcsec² (3 σ, 10 x 10 arcsec²) , allowing us to detect faint features essential for understanding their mass assembly.

CONSTRUCTION OF THE EXTENDED PSF

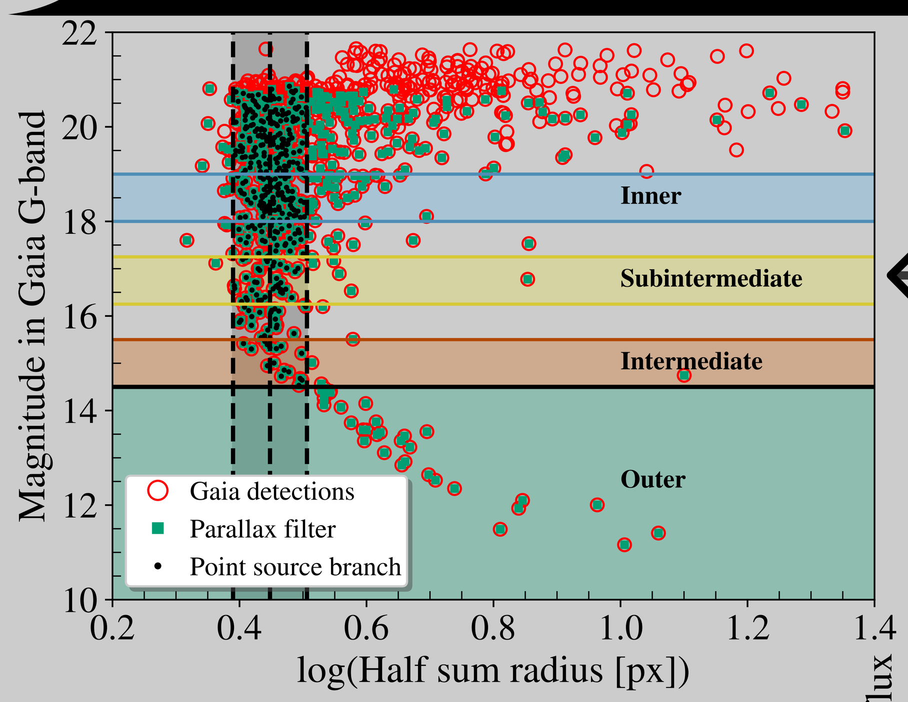


Fig 3. Diagram of the magnitudes and half sum radii of the stars in the NGC3810 field.

An extended PSF needs to be built to make corrections for each field of the sample.

Hence the need of cataloging and selecting stars, using the Gaia DR3 catalogue.

For the internal parts it is essential to select stars that are not saturated, and that are as point-like as possible.

At least 4 magnitude ranges are needed, built from stars, as we move outward from the PSF center [1],[2],[3]

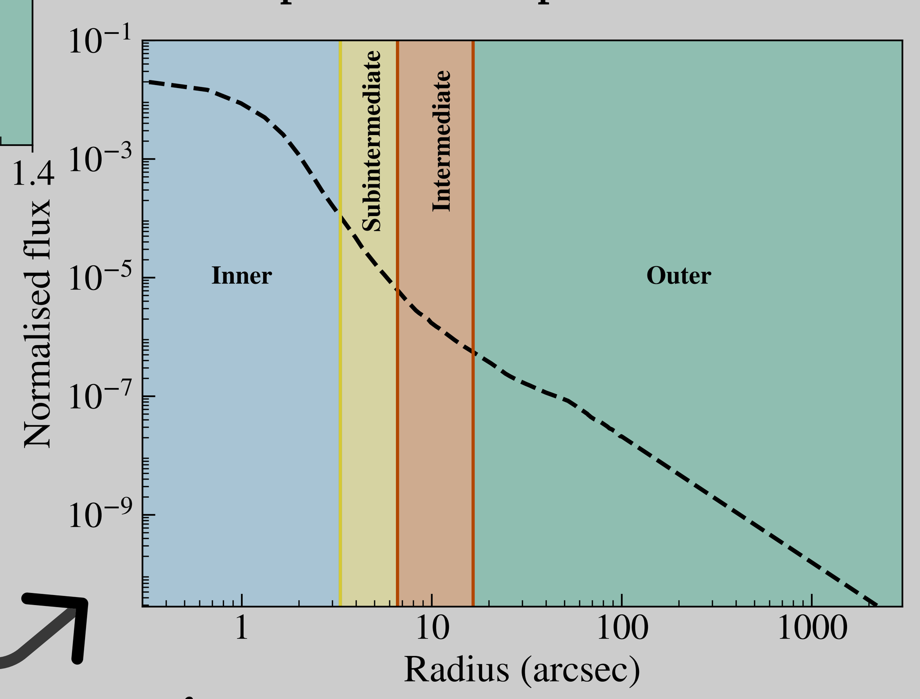
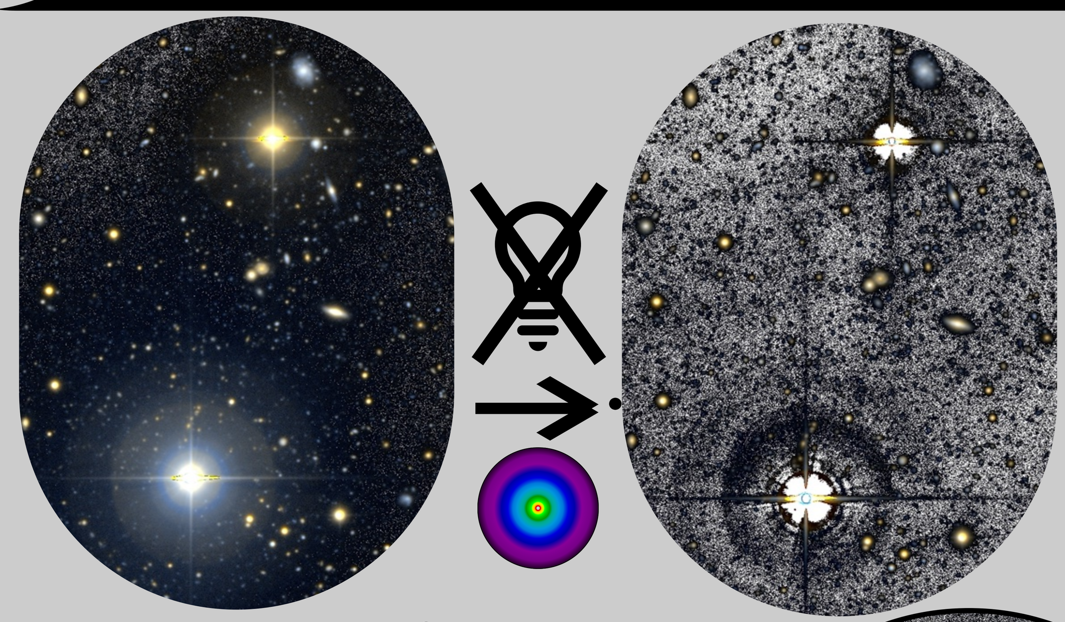


Fig 4. Extended PSF of the NGC3810 field, separated by its components.

SCATTERED LIGHT AND DECONVOLUTION



Once the PSF has been modeled, it can first be used to subtract the scattered light from stars. This will reveal low-brightness structures that lie beneath it. And it will reduce the contaminant light around the galaxy.

But the outer parts of the galaxy are also contaminated by light from its core. This effect is removed using the extended PSF and a deconvolution algorithm.

The methodology to carry out these corrections will be available in Golini et al. in prep, Ruiz-Cejudo et al. in prep and de la Rosa et al. in prep.

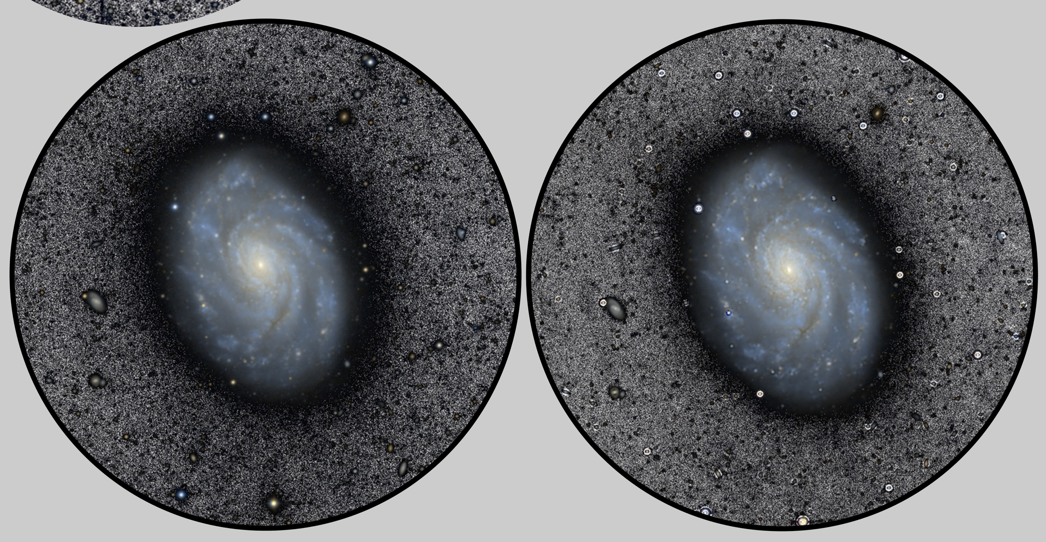


Fig 5. Color images of the galaxy NGC3810. Original image on the left, corrected image on the right.

SURFACE BRIGHTNESS AND MASS PROFILES

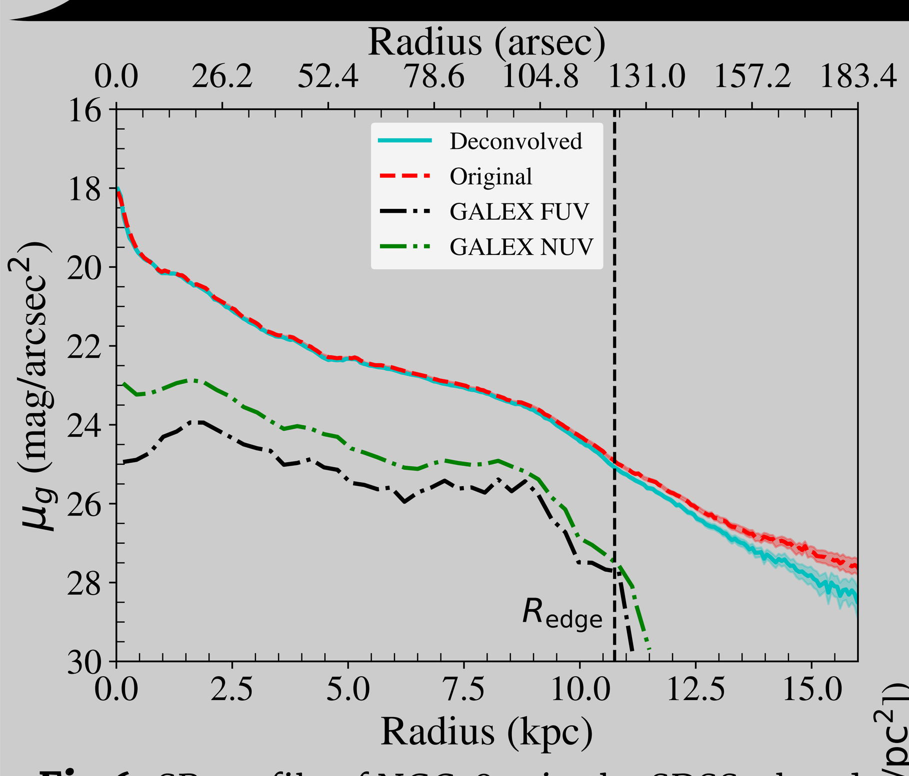


Fig 6. SB profile of NGC3810 in the SDSS g band.

The edge is defined as the outer zone in which there is a significant decrease in star formation, which can be seen more clearly with the help of UV-GALEX data.

Through surface brightness profiles and colors the mass profiles can be measured [6]. The above procedures ensure a degree of correction to the halo mass, if any.

After corrections, the surface brightness profiles are studied, with noticeable deconvolution effects starting from the edge.

For edge detection, the physical definition given in the works [4] and [5] has been used.

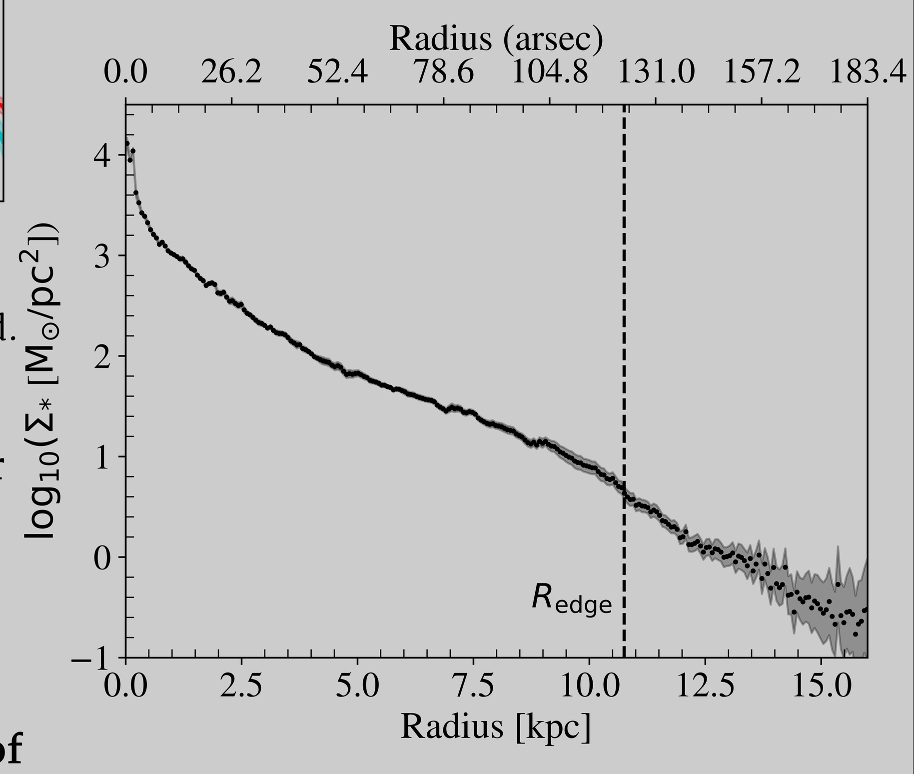


Fig 7. Stellar mass density profile of NGC3810.

WHAT IS NEXT?

With all the methodology designed, the following steps are:

1. To perform mass profile measurements on all galaxies in the sample.
2. To analyze the low-brightness structures around them that may have appeared after reducing the scattered light around the galaxy.
3. To compare the results obtained with what has been observed in simulations.

The tools for carrying out these analyses have already been designed, and they only need to be refined and fine-tuned to analyse the entire sample. Stay tuned for the results!

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MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES — Financiado por la Unión Europea NextGenerationEU — Plan de Recuperación, Transformación y Resiliencia — AGENCIA ESTATAL DE INVESTIGACIÓN

Acknowledgements: This project is possible thanks to financial support from the Spanish Ministry of Science and Innovation (MICINN) to the coBEARD project (PID2021-128131NB-I00).
J.M.A. acknowledges the support of the Viera y Clavijo Senior program funded by ACIISI and ULL and the support of the Agencia Estatal de Investigación del Ministerio de Ciencia e Innovación (MCIN/AEI/10.13039/501100011033) under grant nos. PID2021-128131NB-I00 and CNS2022-135482 and the European Regional Development Fund (ERDF) 'A way of making Europe' and the 'NextGenerationEU/PRTR'.