Clues on Elliptical galaxy formation from SDSS galaxy profiles

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Better photometry of the SDSS brightest galaxies ....

- Dependence on fitting model
- Dependence on sky

Bernardi et al. 2013
Dependence on sky

Meert, Vikram & MB 2014
Sky subtraction problems also affect $n_{\text{Ser}}$

Bernardi et al. 2014a

Simard et al. (2011)

$Z \sim 0.25$

$Z \sim 0.06$
Welcome to the UPenn SDSS PhotDec Catalog!

The UPenn SDSS PhotDec Catalog provides 2-d galaxy profile fits in several visible bands using SDSS data. Additional data collected from other sources is provided to facilitate analysis. The catalog is constructed and maintained by Mariangela Bernardi, Alan Meert and Vinu Vikram. To learn more about the catalog visit the other sections.

Explore the Catalog

About the Catalog

PLOTS!!! Radius vs. Magnitude | Sersic vs. Radius | Sersic vs. Magnitude

View the Galaxies

Classify the Galaxies

Download the Catalog Data

http://shalaowai.physics.upenn.edu/~ameert/fit_catalog/
$M_{serexp} = -23.228$
$m_{serexp} = 16.389$
$B/T_{serexp} = 0.72$
$r_{serexp} = 5.63$
$r_{halo,serexp} = 4.23$
$r_{bulge,serexp} = 2.78$
$r_{disk,serexp} = 5.96$
$p_{bulge,serexp} = -74.88$
$p_{disk,serexp} = -63.33$
$b_{bulge,serexp} = 0.87$
$b_{disk,serexp} = 0.73$

$z = 0.16$
$P_{ser}(Ell) = 0.82$
$P_{ser}(Spiral) = 0.04$
$P(Ell) = 0.81$
$P(S0) = 0.09$
$P(Sab) = 0.06$
$P(Scd) = 0.04$
$M_{Petro} = -22.941$
$m_{Petro} = 16.676$
$r_{Petro} = 2.79$

FLAGS:
Good Total Magnitudes and Sizes
Two-Component Galaxies
No Flags
Measurements in close agreement with other photometry of nearby clusters

Kravtsov et al. 2014

Kravtsov et al.
Meert, Vikram & MB
Simard et al.
Luminosity Function
Bernardi et al. 2013

\[
\log_{10} \Phi(M_r) \text{ [Mpc}^{-3} \text{ dex}^{-1}] \\
M_r \text{ [mag]}
\]
M* Function
Bernardi et al. 2013

![Graph showing the M* Function with data points and curves representing different studies and models.](image)
• impacts HOD/SHAM $M^*-M_{\text{halo}}$ relations
• reduces required feedback at high $M$
The assembling of massive galaxies and the growth of sizes ..... At fixed stellar mass, high-z sizes are smaller by \((1+z)^{-1}\) or more (e.g. Trujillo et al. 2007; Cimatti et al. 2008; van Dokkum et al. 2008; Saglia et al. 2011; Bruce et al. 2012; Fan et al. 2013)

Inside-out growth scenario (minor mergers) is plausible, in which the compact high z galaxies make up the centers of normal nearby Es.

SDSS 
\(z \sim 0.1\)

5 kpc @ \(z \sim 0 \rightarrow 0.9\) kpc @ \(z \sim 2\)
Two scales are important: $3 \times 10^{10}$ and $2 \times 10^{11} M_{\text{Sun}}$

Bernardi et al. 2011b
The two mass scales are important also for the bulge and disk M*-R relation

Bernardi et al. 2014a
Capellari et al. (2013)
Minor vs Major dry mergers

Using the Sersic profile

Hilz et al. (2013)
Minor vs Major dry mergers

Hilz et al. (2013)

Effective radius evolution

Velocity dispersion evolution

$n_{\text{Ser}}$ shows largest change

$n_{\text{Ser}}$ evolution
The two mass scales: $3 \times 10^{10} & 2 \times 10^{11} \ M_{\text{sun}}$

Bernardi et al. 2014b

Also in $n_{\text{Ser}}$!!
Analysing $n_{\text{Ser}}$

At fixed $M_*$ larger $n_{\text{Ser}}$ have smaller $\sigma$
But we should look at B/T
The high mass scale: $2 \times 10^{11} \, M_{\text{sun}}$

Bernardi et al. 2014b

A break for a disk component and increased evidence of minor dry mergers
Minor dry mergers

Bulge component

Evidence of a disk
At fixed $M_*$ larger $n_{\text{Ser}}$ have higher SSFR.
How did the compact high-z galaxies evolve?

Evolution of $n_{\text{Ser}}$, $\sigma$ and $M_*$
Evolution of $R_e$, $n_{\text{Ser}}$, and $M_*$
Evolution of $R_\text{e}$, $n_\text{Ser}$, $\sigma$ and $M_*$

$M^* = 2 \times 10^{11}$

$n_{\text{Ser}} = 8$

$n_{\text{Ser}} = 5$
van der Wel et al. 2014

Bernardi et al. 2014b
In addition larger \( n_{\text{Ser}} \) have higher SSFR ....
Dependence on Halo Mass
(using the Yang et al. catalog)

Bernardi et al. 2014b

• Not completely trivial
• Yang et al. have no scatter in $L_{\text{tot}}$ vs $M_{\text{halo}}$ and very low scatter in $L_{\text{cen}}$ vs $M_{\text{halo}}$ especially at low $M_{\text{halo}}$
• Simply using our new $L_{\text{tot}}$ gives spurious results, so
  – We rank order in our new $L_{\text{tot}}$ and assign $M_{\text{halo}}$ accordingly; this will alter $V_{\text{halo}}$-$M_{\text{halo}}$ relation
• We also account for fact that new Ls sometime mean another object in group is brightest; we define ‘central’ to be brightest
Analysing $n_{\text{Ser}} - M_\ast - M_{\text{halo}}$

ONLY CHANGE L

CHANGE L AND RE-SORT $L_{\text{tot}}$
At fixed $M_*$ centrals in larger $M_{\text{halo}}$ have smaller $n_{\text{Ser}}$. 

Analysing $n_{\text{Ser}} - M_* - M_{\text{halo}}$
Central vs Satellites

Small difference in SSFR

Bernardi et al. 2014b
Conclusions from our fitting profiles:

- Sky-subtraction + Sersic/SerExp fits suggest more objects at \( M_* > 2 \times 10^{11} \) than previous work:
  - impacts HOD/SHAM \( M_* - M_{\text{halo}} \) relations
  - reduces required feedback at high \( M \)
  - alleviates tension between \( \rho_* \) and SFR(z)

- Two mass scales are important: \( 3 \times 10^{10} \) and \( 2 \times 10^{11} \): \( M_* > 2 \times 10^{11} \) special even more pronounced in \( n - M_* \)
  - Difference between total and bulge dramatic at \( M_* < 2 \times 10^{11} \) (suggestive of fast/slow rotator dichotomy)

- Sersic \( n > 6 \) at \( M_* > 2 \times 10^{11} \) suggestive of minor dry mergers
  - \( n - \sigma \) at fixed \( M_* \) particularly useful
  - At fixed \( M_* \) smaller \( \sigma \) have larger \( n \); larger SSFR have larger \( n \); smaller \( M_{\text{halo}} \) have larger \( n \)
  - Evolution of compact high-z galaxies \( \Rightarrow \) high \( n_{\text{Ser}} \) galaxies at \( z \sim 0 \)? Evidence of minor mergers?