Massive galaxies: improved photometry and consequences

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Better photometry of SDSS massive galaxies
- Stellar Mass Function/Variable IMF
- Dark matter fraction

Selection bias in SMBH samples having dynamically measured masses
Better photometry of the brightest SDSS galaxies ....

- Dependence on sky
- Dependence on fitted model/truncation
- Dependence on ICL

Bernardi et al. 2013 -- 2017
It is more than semantics …..

1) SDSS 1% of sky level is \( \sim 26 \) mag/arcsec\(^2\)

Individual SDSS galaxy profiles CANNOT be dominated by ICL

Stacking analysis of LRGs and BCGs

Tal & van Dokkum 2011
It is more than semantics ....

1) SDSS 1% of sky level is ~ 26 mag/arcsec²

Individual SDSS galaxy profiles CANNOT be dominated by ICL

Stacking analysis of LRGs and BCGs

Tal & van Dokkum 2011
Bernardi et al. 2017b

$Z \sim 0.19$

$M_r \sim -23.6$

$R_{hl} \sim 13$ kpc

$n_{Ser(Bulge)} \sim 5$

$n_{Ser} \sim 5.5$
Bernardi et al. 2017b

$Z \sim 0.3$

$M_r \sim -23.5$

$R_{hl} \sim 18$ kpc

$n_{Ser(Bulge)} \sim 5$

$n_{Ser} \sim 7$
It is more than semantics .....  
2) SDSS sky is biased more for Centrals than for Satellites
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PyMorph sky in excellent agreement with Blanton et al. (2011)

Fischer et al. 2017
It is more than semantics .....  

3) Centrals and Satellites are similar when (the correct!) PyMorph SerExp luminosities are used

Departure from deV related more to mass (accretion) than environment

Mass scale $2 \times 10^{11} \, M_{\odot}$ is where other scaling relations change (Bernardi et al. 2011)

NOTE: x-axis uses PyMorph SerExp mag
M* Function

\[ M^* = L \times \left( \frac{M^*}{L} \right) \]

Bernardi et al. 2013
M* Function
Dependence on L (same M*/L)

Bernardi et al. 2013
M* Function
Dependence on M*/L (same L)

Bernardi et al. 2017a
Confirmed by other groups

(see also Thanjavur et al. 2016
D’Souza et al. 2015)
Confirmed by other groups

Huang et al. 2017
(see also Thanjavur et al. 2016
D’Souza et al. 2015)

Bernardi et al. 2017a

Huang et al. 2017
(see also Thanjavur et al. 2016
D’Souza et al. 2015)
Required feedback at large $M^*$ is reduced, in better agreement with models

Naab & Ostriker 2017 (see also Cattaneo et al. 2017)
• impacts HOD/SHAM $M^* - M_{\text{halo}}$ relations (Shankar et al. 2014)
• reduces required feedback at high $M$
M* Function
Dependence on M*/L (same L)

Bernardi et al. 2017a
M* Function
Dependence on M*/L (same L)

M*/L depends on SFHistory, Dust, and IMF

Standard to assume IMF is same for all galaxies
Evidence for variable IMF

Conroy & van Dokkum 2012
IMF correlates with other properties

Conroy & van Dokkum 2012
Variable IMF using ~800 MaNGA galaxies
$M^*$ after accounting for variable IMF $\sim M^*$ dynamical

Bernardi et al. 2017c

\[ M^*_{\text{dyn + gas}} = k(n, t_a) \frac{R_e \sigma_a^2}{G}, \text{ where } t_a = \frac{\theta_a}{\theta_c} \]

\[ \left\langle \log_{10} \frac{M^*_{\text{JAM}}}{M_*} \right\rangle = a + b \log_{10} \frac{\sigma_e}{\text{km s}^{-1}} + 0.25 \]

\[ (a, b, \Delta_{\text{int}}) = (-1.086, 0.457, 0.082) \]
Measuring $\sigma$ at $z>0.5$ is expensive:

To estimate $M_{\text{dyn}}/M^*$(IMF-corr) without $\sigma$, use the FP (combination of effective radius $R_e$ and surface $M^*$ density) as proxy $\sigma$

Bernardi et al. 2017c
$\phi(M^*)$ with variable IMF

Bernardi et al. 2017c

FP-based estimate works well
Strictly speaking, \( M_{\text{dyn}} \) assumes \( \sigma \) inside SDSS fiber dominated by stars.

Expected if Halo Model estimates of DM-M* relation are OK

(Implications for MOND ... )
Welcome to the UPenn SDSS PhotDec Catalog!

Meert, Vikram & Bernardi (2015, 2016)

!! THIS IS A PAID COMMERCIAL ANNOUNCEMENT !!

STELLAR MASSES HAVE BEEN ADDED TO THE 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/
Outline

- Better photometry of SDSS massive galaxies
  - Stellar Mass Function/Variable IMF
  - Dark matter fraction

- Selection bias in SMBH samples having dynamically measured masses
Bias in SMBH samples

Bernardi et al. 2007
Bias confirmed, present in more recent samples

Van den Bosch et al. 2015
There is a well-known selection effect but often ignored: black hole dynamical mass estimates are only possible if (some multiple of) the black hole’s sphere of influence is resolved

\[ R_{\text{inf}} = \frac{G M_{\text{BH}}}{\sigma^2} \propto \sigma^a \]

There is a well-known selection effect but often ignored: black hole dynamical mass estimates are only possible if (some multiple of) the black hole’s sphere of influence $R_{\text{eff}} = \frac{GM_{\text{BH}}}{s^2}$ is resolved.
Discrepancy between dynamical and AGN measured $M_{\text{BH}}$
Due to selection bias!

Implications

• Black hole masses, abundances have been overestimated
• Accounting for this brings BH scaling relations into better agreement with those for AGN
• Smaller MBH $\rightarrow$ smaller AGN feedback $\rightarrow$ consistent with higher $M^*$?
• Predicted PTA gravity wave signal 3x smaller
Conclusions

• Sky-subtraction + Sersic/SerExp fits suggest more objects at $M_* > 10^{11} \, M_{\odot}$ than previous work:
  – impacts HOD/SHAM $M^*$-$M_{\text{halo}}$ relations
  – reduces required feedback at high $M^*$

• Bias in SMBH samples having dynamically measured masses