

Galaxy Scaling Relations with the SAMI Survey

... and beyond!

Francesco D'Eugenio, Matthew Colless, SAMI Team

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September 20, 2016



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... and beyond!

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The Virial Theorem

1 The Fundamental Plane

$$\log L = a \log \sigma + b \log R + c$$

2 The Virial Mass Estimator

$$M_{\rm dyn} \propto \sigma^2 \, {
m R}$$

The Virial Theorem:

$$\sigma^2 = \alpha \frac{\mathrm{G\,M}}{\mathrm{R}}$$



$$\begin{array}{l} \alpha = \alpha(\sigma) \\ \text{and/or} \\ M/L =: \Upsilon = \Upsilon(\sigma) \end{array}$$



The Fundamental Plane 1 / 6

- 1 fitting algorithm
- 2 aperture size and shape for σ
- 3 magnitude
- 4 effective radius
- 5 sample selection (morphology, redshift, ...)
- \rightarrow assess the methods using the observed RMS and MAD about the plane





The Fundamental Plane 1 / 6

- 1 fitting algorithm
- 2 aperture size and shape for σ
- 3 magnitude
- 4 effective radius
- 5 sample selection (morphology, redshift, ...)



 \rightarrow assess the methods using the observed RMS and MAD about the plane





The Fundamental Plane 2 / 6

Comparing the effect of:

- morphology
- photometry

- aperture size/shape
- spectral resolution
- spatial resolution

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The Fundamental Plane 3 / 6

Warp in the FP: using an effective M/L to correct for the warp Best fit, 1σ (68%) and 2.6 σ (99%) - y₀) [kpc] 12.0 $a = 0.8256 \pm 0.0077$ 11.5 $b = 0.8555 \pm 0.0059$ $\varepsilon_z = 0.0848 \pm 0.0014$ $a (\log \sigma - x_0) [\text{km s}^{-1}] + b (\log \text{R}_e (\text{Sersic}))$ $\langle (z-\overline{z})^2 \rangle = 0.11$ $median(|z-\overline{z}|) = 0.076$ 11.0 $\langle (z-\overline{z})^2 \rangle_{\text{all}} = 0.15$ $median(|z-\overline{z}|)_{all} = 0.082$ $N = 7404 N_{good} = 6990 N_{bad} = 4$ 10.5 $(x_0 = 2.23)$ $(u_0 = 0, 45)$ RMS \approx 0.11 dex 10.0 9.5 9.0 9.0 9.5 10.0 10.5 11.0 11.5 12.0

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 $\log L \left[L_{\odot} \right]$

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Warp in the FP: using an effective M/L to correct for the warp



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A (1) > A (2) > A

8/23



The Fundamental Plane 5 / 6

Warp in the FP: using an effective M/L to correct for the warp



SAMI Scaling Relations

RMS -= 0.02 dex

Really the: "Fundamental Buckled Paraboloid with Jagged Ends"

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The Fundamental Plane 6 / 6





Summary (so far)

1 Single fibre is sufficient for cosmology applications

 \downarrow ... but photometry/aperture effects may appear for larger sample sizes (Hector?)

- 2 for Cosmology: use ${\rm L}$ or I; for galaxies: use ${\rm M}^*$
- 3 Morphology & Warp are the main sources of scatter in the FP

4 . . . 5 . . .





Virial Mass estimator

Dynamical (Virial) vs Stellar Masses: SAMI ETGs



$$\begin{split} \mathrm{MGE} : \mbox{ log } \mathrm{M}_{\mathrm{Vir}} &= 2 \mbox{ log } \sigma + \mbox{ log } \mathrm{R}_e^{\mathrm{maj}} + \dots & \Delta(\log \ \mathrm{M}^*/\mathrm{M}_{\mathrm{Vir}}) \approx \\ \mathrm{S\acute{e}rsic} : \mbox{ log } \mathrm{M}_{\mathrm{Vir}} &= \beta(n) + 2 \mbox{ log } \sigma + \mbox{ log } \mathrm{R}_e^{\mathrm{maj}} + \dots & 0.4 \ \mathrm{dex} \end{split}$$

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Virial Mass estimator

Dynamical (Virial) vs Stellar Masses: SAMI ETGs



$$\begin{split} \mathrm{MGE}: \mbox{ log } \mathrm{M}_{\mathrm{Vir}} &= 2 \mbox{ log } \sigma + \mbox{ log } \mathrm{R}_e^{\mathrm{maj}} + \dots \end{split} \\ \mathrm{S\acute{e}rsic}: \mbox{ log } \mathrm{M}_{\mathrm{Vir}} &= \beta(n) + 2 \mbox{ log } \sigma + \mbox{ log } \mathrm{R}_e^{\mathrm{maj}} + \dots \end{split}$$

galaxy survey SAMI Scaling Relations

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Virial Mass estimator

Dynamical (Virial) vs Stellar Masses: ATLAS^{3D}



- SDSS magnitude: trend
- Alt magnitude: trend
- Spectroscopic M*: no trend

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Virial Mass estimator

Dynamical (Virial) vs Stellar Masses: ATLAS^{3D}



A trend with age? (Take 2)



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Origin of the bias



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Origin of the bias





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Summary and conclusions

- Single fibre is sufficient for cosmology applications ↓ ...but photometry/aperture effects may appear for larger sample sizes (Hector?)
- 2 for Cosmology: use $\rm L$ or I; for galaxies: use $\rm M^*$
- 3 Morphology & Warp are the main sources of scatter in the FP
- 4 The Virial mass estimator is still a useful tool
- 5 Use photometric stellar masses with care



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A (10) > A (10) > A



Summary and conclusions

- Single fibre is sufficient for cosmology applications ↓ ...but photometry/aperture effects may appear for larger sample sizes (Hector?)
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A (1) > A (1) > A



Future prospects

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Origin of the bias







Origin of the bias







Fitting a line in LATEX

Hi Brent, challenge accepted ...



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