A-ph

Galaxy structure from multiple tracers: III. Radial variations in M87's IMF

Lindsay Oldham[1*†] & Matthew Auger[2]
[1] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[2] Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK

November 17, 2017

ABSTRACT

We present the first constraints on stellar mass-to-light ratio gradients in an early-type galaxy (ETG) using multiple dynamical tracer populations to model the dark and luminous mass structure simultaneously. We combine the kinematics of the central starlight, two globular cluster populations and satellite galaxies in a Jeans analysis to obtain new constraints on M87's mass structure, employing a flexible mass model which allows for radial gradients in the stellar mass-to-light ratio. We find that, in the context of our model, a radially declining stellar-mass-to-light ratio is strongly favoured. Modelling the stellar mass-to-light ratio as following a power law, $\Upsilon_\star \sim R^{-\mu}$, we infer a power-law slope $\mu = -0.54 \pm 0.05$; equally, parameterising the stellar-mass-to-light ratio via a central mismatch parameter relative to a Salpeter IMF, α, and scale radius R_M, we find $\alpha > 1.48$ at 95% confidence and $R_M = 0.35 \pm 0.04$ kpc. We use stellar population modelling of high-resolution 11-band HST photometry to show that such a steep gradient cannot be achieved by variations in only the metallicity, age, dust extinction and star formation history if the stellar initial mass function (IMF) remains spatially constant. On the other hand, the stellar mass-to-light ratio gradient that we

- Одинакова ли IMF для звёзд, возникших в галактике, и приобретённых в результате мержингов?
- Две основные сложности оценки IMF:

учёт DM, и то, что в апертуру попадают звёзды на разных R.

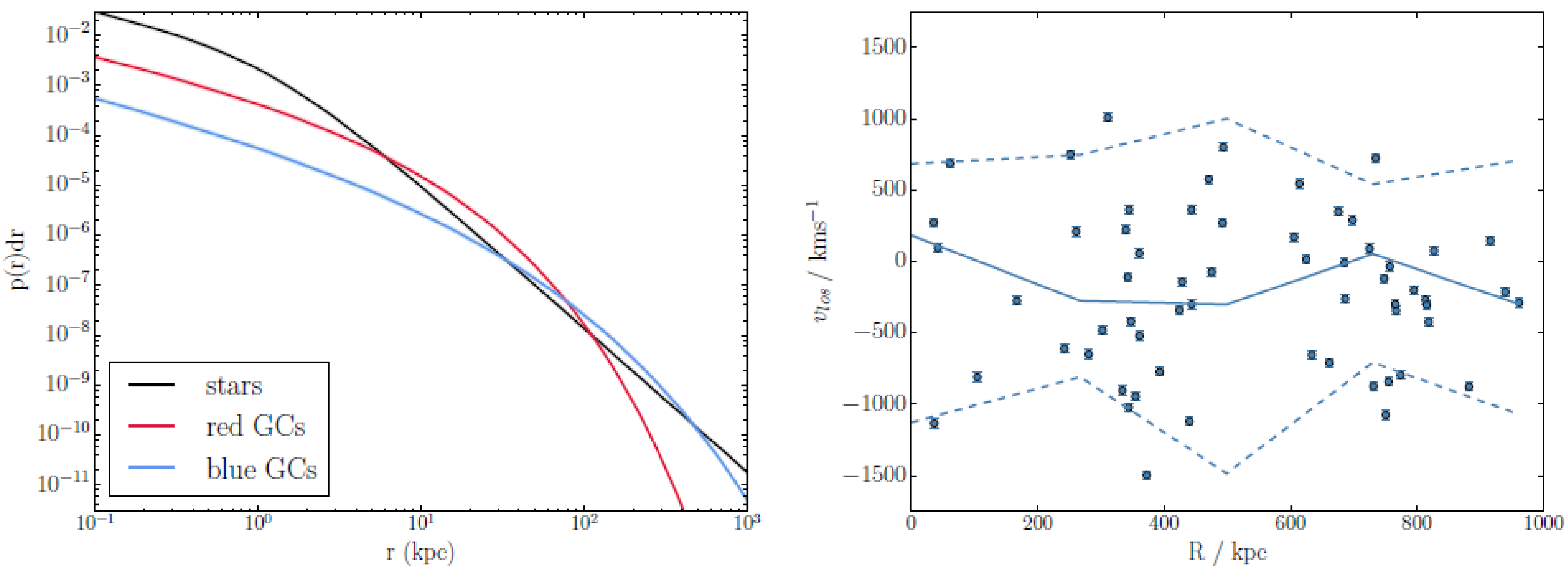

Figure 1. Left: Normalised probability distribution functions for the deprojected 3D luminosity profiles of the dynamical tracer populations as a function of radius. Uncertainties are included, but are small. The stellar profile is modelled with a Nuker profile as in Equation 1; each globular cluster population follows a Sérsic profile in radius. Right: Line-of-sight velocity distribution of satellite galaxies as a function of projected radius, with the running median (solid line) and 3σ tracks (dashed lines) shown.

$$\Sigma_\star(R) = \Upsilon_\star(R) I_\star(R) \tag{4}$$

for projected radius R. To assess the sensitivity of our inference to the assumed form of $\Upsilon_\star(R)$, we consider two profiles. Firstly, we consider a **power-law (PL) profile** in which

$$\log \Upsilon_\star(R) = \log \Upsilon_{\star,1} + \mu \log R, \tag{5}$$

with power-law index μ, and $\Upsilon_{\star,1}$ representing the stellar mass-to-light ratio at a projected distance of 1 kpc from

In reality, however, there exists some covariance between M_{BH} and $\Upsilon_\star(R)$ that is important to explore; we therefore consider a second **Salpeter-to-Chabrier (SC) model** in which $\Upsilon_\star$ tends to a finite value centrally and becomes Chabrier-like at large radii:

$$\Upsilon_\star(R) = \alpha_s \Upsilon_{\star,s} + \frac{\Upsilon_{\star,ch} - \alpha_s \Upsilon_{\star,s}}{R^2 + R_M^2} R^2 \tag{6}$$

for stellar mass-to-light ratios assuming Salpeter and Chabrier IMFs $\Upsilon_{\star,s}$, $\Upsilon_{\star,ch}$ inferred from photometry (see Section 7), mismatch parameter relative to a Salpeter IMF

We model the photometry following the methods of Auger et al. (2009); Oldham et al. (2017). We use the composite BC03 stellar population models (Bruzual & Charlot 2003) to compute apparent magnitudes in the 11 filters on a grid of stellar age T, metallicity Z, dust extinction τ_V and time constant τ of an exponentially decaying star formation history, and construct a spline interpolation model

- The novel result from this modelling is that we can rule out a stellar mass-to-light ratio that is constant with radius with >99% confidence. We nd an IMF mismatch parameter. Stellar M/L is a declining function of radius and becomes Chabrier-like by a radius of roughly 3 kpc.

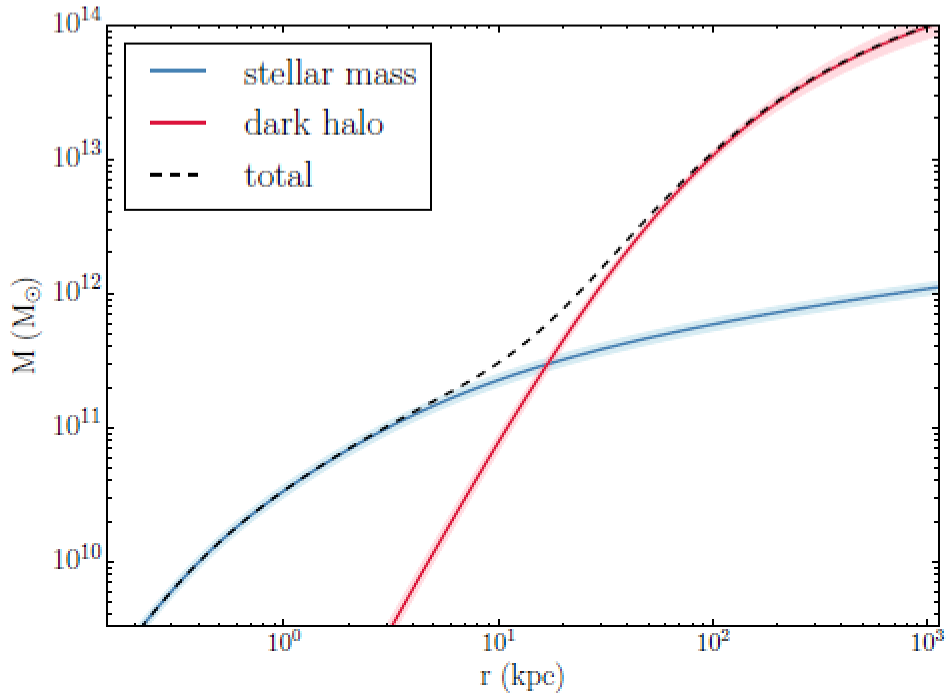

Figure 2. Inference on the dark, stellar and total mass profile in the anisotropic model. At radii $\leqslant$ 10 kpc $\sim R_e$, the stellar mass dominates, whereas beyond this, the dark halo becomes the main contributor to the potential. Our kinematic data extend from $\sim$ 10 pc to 1 Mpc, which is the radius range spanned in this Figure. Note that we include systematic uncertainties as described in Section 5.

Самые главные выводы

(ii) Multi-band, high-resolution photometry indicates that such a strong stellar mass-to-light ratio gradient cannot be achieved by varying only the metallicity, age, dust extinction and star formation history of the stellar population if the IMF remains fixed. On the other hand, the stellar mass-to-light ratio gradient that we infer is consistent with M87 having an IMF which is Salpeter-like in the central ~ 0.5 kpc and becomes Chabrier-like at ~ 3 kpc.

(iv) Taken together, M87's dark matter core and radially-varying IMF can be explained coherently if the galaxy formed its central stellar populations in un-Milky-Way-like physical conditions – leading to the stellar mass in this region having a bottom-heavy IMF – and subsequently accreted material from more Milky-Way-like systems at larger radii, in a process which both ingrained a stellar-mass-to-light ratio gradient and dynamically heated the halo to create a dark matter core.