Discovering the Dark Side of Centaurus A's Globular Cluster System

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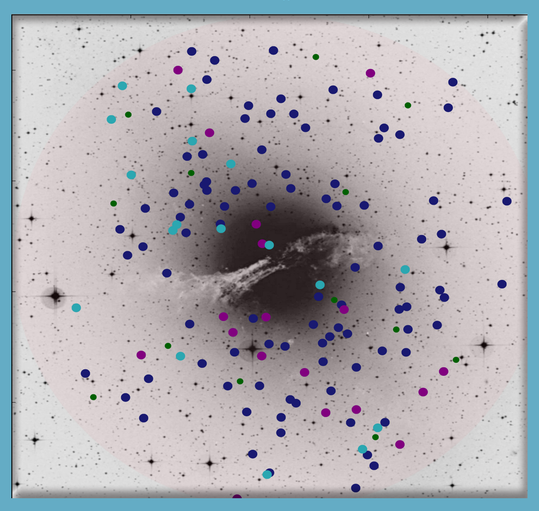
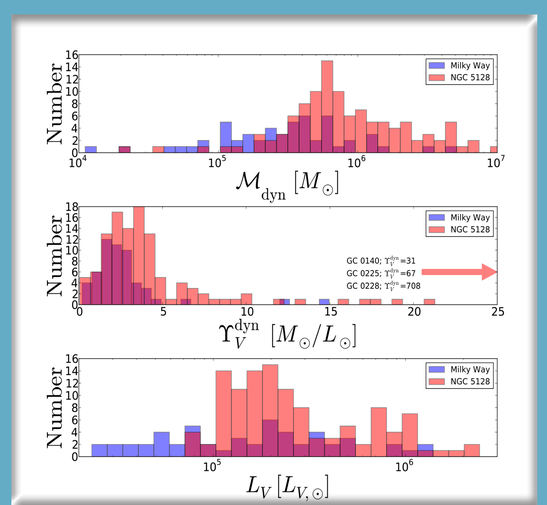
The Sample

Dynamical masses, M_{dyn} for **116 globular clusters (GCs) around NGC5128** were estimated based on VLT/FLAMES + UVES spectra.

Both **"classical" GCs and the high-luminosity tail of the globular cluster luminosity funtion** (GCLF) are represented, with luminosities in the range $-11.0 < M_V < -7.4$ mag.

The "**penalized pixel fitting**" (ppxf[1]) routine was used to measure **velocity dispersions**, σ, from Mg*b* and Fe5270 absorption features. M_{dyn} and **dynamical mass-to-light ratios**, Υ_{dyn}, were estimated by combining σ with half-light radii, r_h, and luminosities.





The "Low-Υ_{dyn}" Sequence

High-mass ($M_{dyn} > 2\times10^6\ M_{sun}$) GCs with **low-intermediate mass-to-light ratios** ($\Upsilon_{dyn} < 10\ M_{sun}L_{sun}^{-1}$) represent the "low-$\Upsilon_{dyn}$" sequence. These GCs follow an **empirical scaling relation of the form $\Upsilon_{dyn} \alpha M_{dyn}^{0.33+\backslash-0.04}$** and are consistent with simply being **very bright, "classical" GCs**. Factors such as rotation or intermediate-mass black holes are able to account for any abnormal $\Upsilon_{dyn} > 5\ M_{sun}L_{sun}^{-1}$.

The "High-Υ_{dyn}" Sequence

Faint ($M_V > -8.5$ mag) objects with **elevated mass-to-light ratios** ($\Upsilon_{dyn} > 6\ M_{sun}L_{sun}^{-1}$) form the "high-$\Upsilon_{dyn}$" sequence. These objects follow a **scaling relation much steeper than the low-Υ_{dyn} branch with $\Upsilon_{dyn} \alpha M_{dyn}^{0.91+\backslash-0.04}$** and are **incompatible with being GCs** as they are classically known.

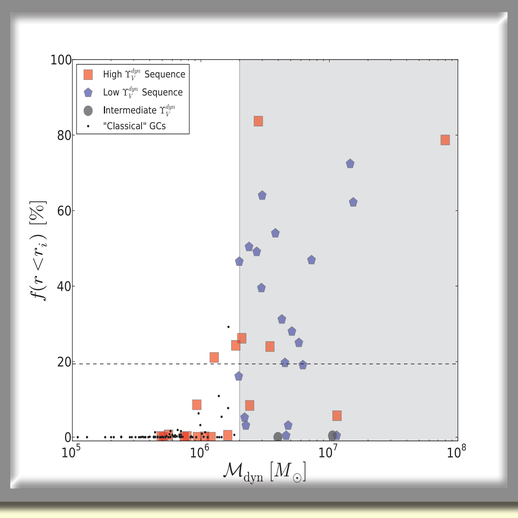
Dark Matter??

The extreme Υ_{dyn} shown by the objects on the high-Υ_{dyn} sequence become very difficult to explain if dark matter is not to be invoked. This is contrary to the accepted paradigm that GCs are devoid of DM[2,3,4], even though it cannot be ruled out[5,6].

"...but what about black holes?"

Central intermediate-mass black holes (IMBHs) can influence the dynamics of GCs[9]. **Masses** and **spheres of influence**[10], r_i, of **potential IMBHs** were thus estimated.

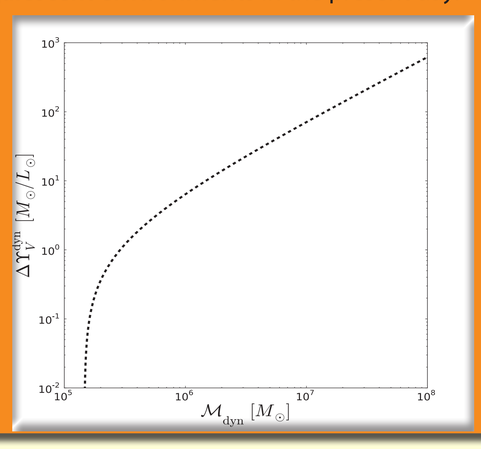
An IMBH is **likely to dynamically affect** a large fraction of stars in **low-Υ_{dyn} sequence GCs.** Conversely, almost all **high-Υ_{dyn} sequence objects** would be **relatively unaffected, ruling out central IMBHs** as the cause of their **extreme Υ_{dyn}**.



"Okay fine. Maybe there is Dark Matter. So what?"

If **DM is the driver of the high-Υ_{dyn} sequence**, then NGC5128 may host a **population of increasingly DM dominated compact stellar systems** with sizes and luminosities **representative of "classical" GCs** found in the Local Group.

If **cosmological in origin**, these may represent the **smallest primordial DM halos** that have **survived** being accreted onto more massive structures **up to z=0**. If they have **undergone stripping** in NGC5128's environment, **losing up to 80-90% of their original DM**[11], then there may have been a **population of stellar systems of $100 < \Upsilon_{dyn}/M_{sun}L_{sun}^{-1} < 1000$ around NGC5128** in the recent past. This finding would imply the **potential presence** of such structures **in more quiescent environments** in the present day.



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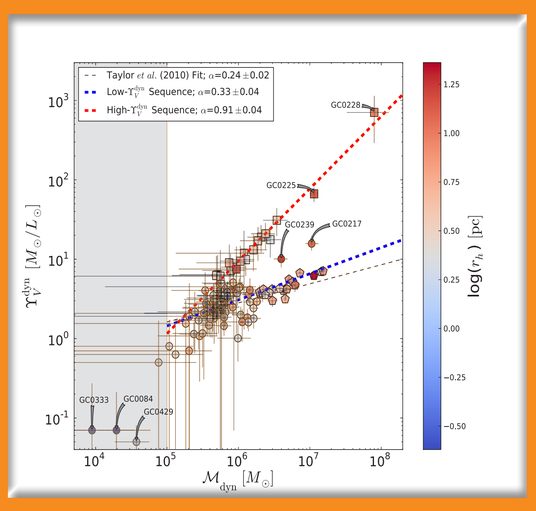
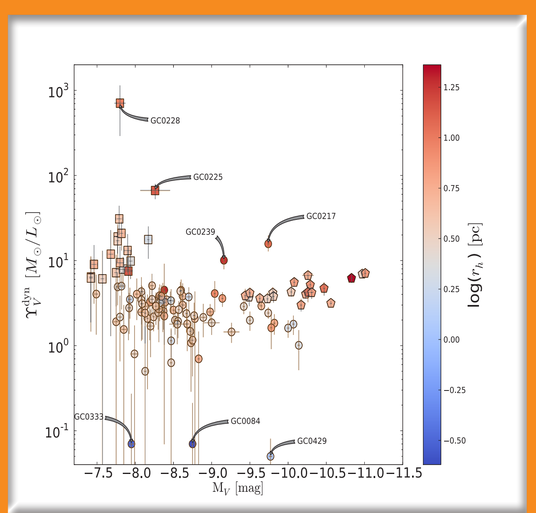
The "Chopstick" Diagram

Plotting Υ_{dyn} as a function of M_{dyn} reveals four interesting groups:

1. Three **young, massive open cluster candidates**, the first discovered around NGC5128
2. A cloud of **"classical" GCs** with **unremarkable M_{dyn}, r_h, or Υ_{dyn}**
3. A sequence of **high-mass** ($M_{dyn} > 2\times10^6\ M_{sun}$) GCs with **low to intermediate mass-to-light ratios** ($\Upsilon_{dyn} < 10\ M_{sun}L_{sun}^{-1}$)
4. A sequence of **low-luminosity** ($M_V > -8.5$ mag) objects with **high to extreme mass-to-light ratios** ($\Upsilon_{dyn} > 6\ M_{sun}L_{sun}^{-1}$)
5. The latter groups are well fit by **two distinct power-laws**, forming the red- and blue-dashed line "chopsticks".



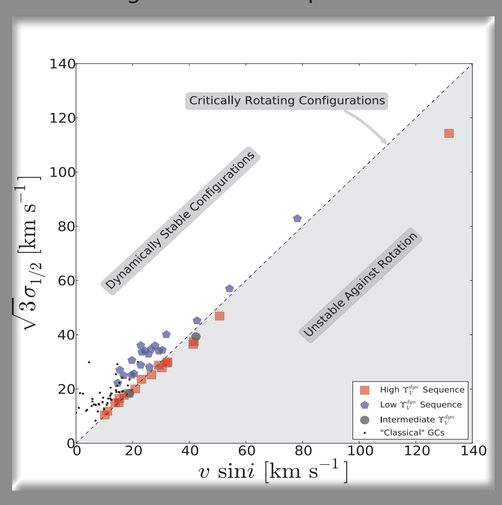


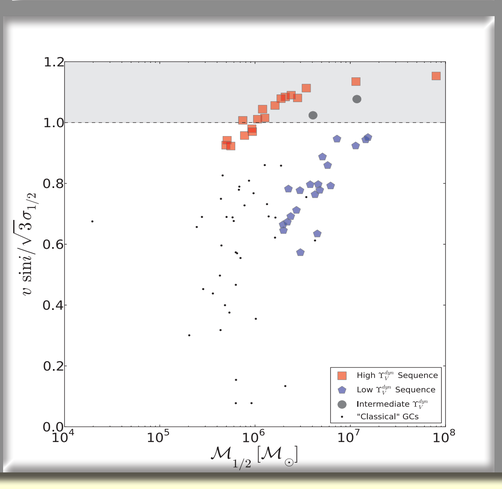
"...but what about rotation?"

Can **rotation** potentially **mimic larger σ** that would lead to **higher M_{dyn}/Υ_{dyn}**? If so, then **average stellar orbital velocities** sufficient to account for the **"extra" mass** are needed to explain our Υ_{dyn} values with respect to Υ_{dyn} of Local Group GCs.

All "classical" and low-Υ_{dyn} GCs could possibly be **rotating fast enough** to boost the M_{dyn} estimates, and would be **dynamically stable**. However, **the average stellar velocities** of the **high-Υ_{dyn} objects is not fast enough** to explain the "extra" mass, and would **not be dynamically stable** even if they were.

Both sequences and most of the "classical" GCs also **show mild trends** of **increasing rotational support** with M_{dyn}, consistent with recent findings for Local Group GCs[7,8].

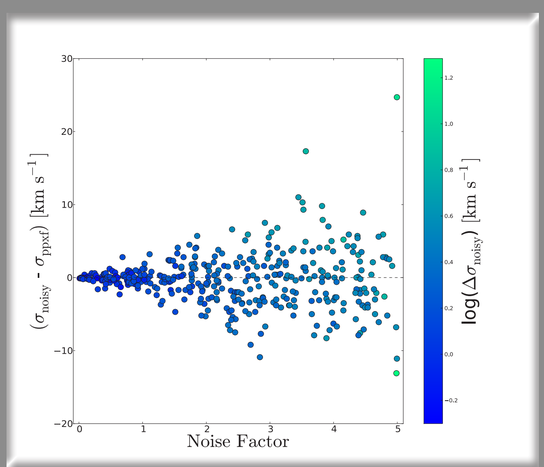


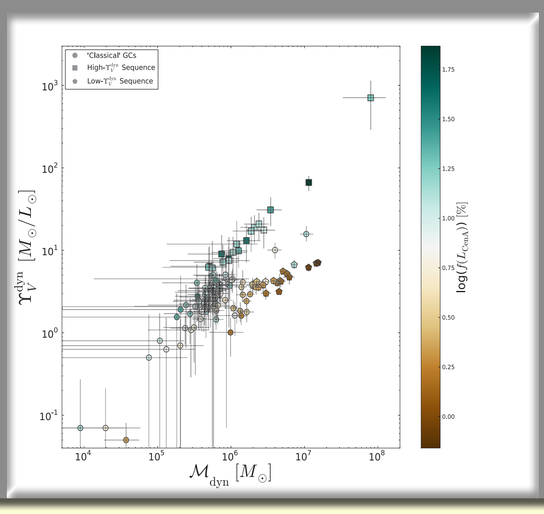


"...but what about analysis/ observational biases?"

Noise tests reveal that **low-S/N spectra are not the cause of the high-Υ_{dyn} sequence.** The variation about our adopted σ of those measured from **degraded spectra** shows that **uncertainty due to noisy spectra does not result in systematically increasing σ.**

Likewise, the **lack of a trend** in the fractional contribution of **diffuse galaxy light** to the flux entering the FLAMES fibres **excludes contamination** from being the cause of elevated Υ_{dyn}.





References
1. Cappellari & Emsellem (2004); 2. Moore (2011); 3. Conroy et al. (2011); 4. Sollima et al. (2012); 5. Peebles (1984); 6. Saitoh, et al. (2006); 7. Kacharov et al. (2014); 8. Fabricius et al. (2014); 9. Mieske et al. (2013); 10. Merritt (2004); 11. Smith et al. (2013)