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Globular clusters as tracers of galaxy assembly

Abstract

Globular clusters (GCs) are dense star clusters found in all types of galaxies. Due to their old ages, they are regarded as fossil records of galaxy assembly that still contain the chemical and dynamical information of their birthplace. To use them to their full potential, spectroscopy is required to study their kinematics and stellar populations.

We present a novel spectroscopic sample of 722 GCs in 32 galaxies in the Fornax cluster obtained from MUSE data of the Fornax3D survey, enabling a direct comparison with the stellar main body.

The GCs trace the rotation of the galaxy spheroid as well as the enclosed mass, validating their potential as bright kinematic tracers. Further, we find a non-linear colour-metallicity relation that challenges the often used division of GCs solely based on their colour and has implications for merger histories as traced by GCs.

Fahrion+ 2020a, A&A, 637, A26
Fahrion+ 2020b, A&A, 637, A27

Globular clusters from MUSE data

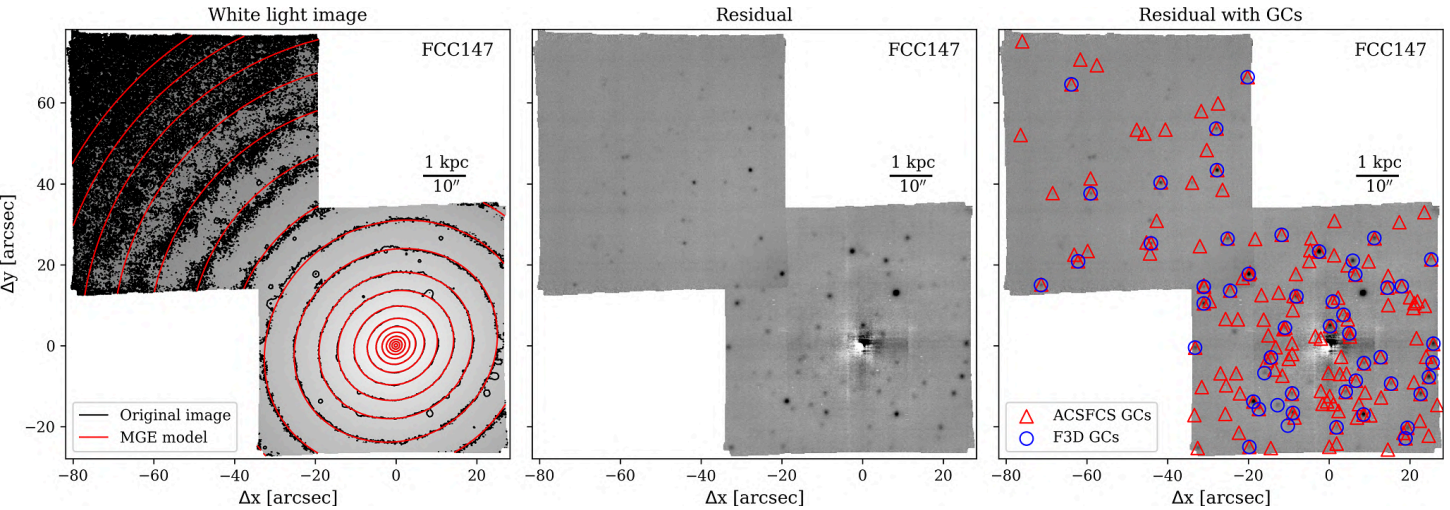


Fig.: Illustration of how GC positions are determined from the collapsed MUSE data (integrated along spectral axis).

I. Finding GCs in MUSE data

Galaxies are outshining the GCs, so the first step is to build a model of the galaxy to subtract. In the residual, GCs can be picked up and cross-referenced with photometric catalogues.

II. Fitting spectra

When extracting the spectra, it is important to remove the galaxy background. The cleaned GC spectra is fit with pPXF (Cappellari & Emsellem 2004), a full spectrum fitting method to get velocities and stellar population properties (age and metallicity).

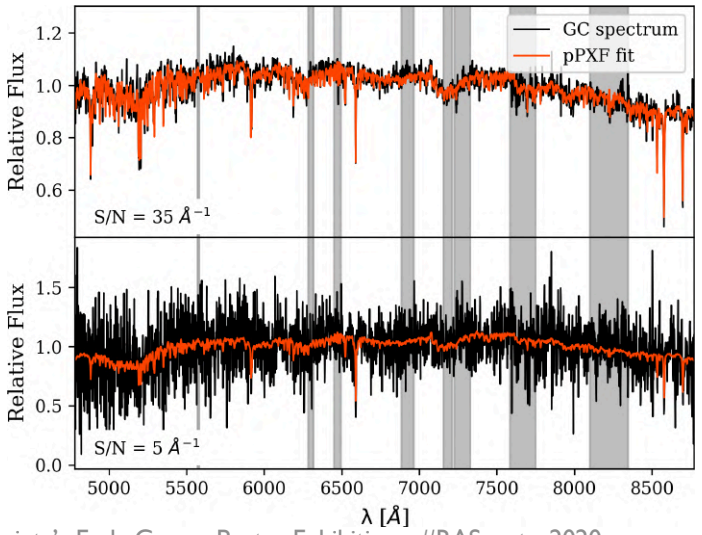


Fig.: Two example GC spectra with pPXF fit in red.

MUSE data

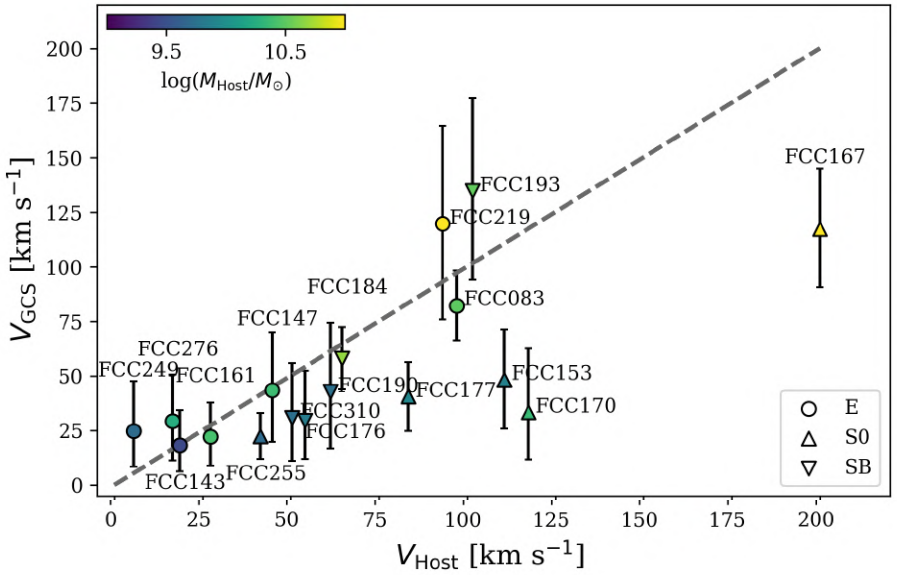
We use MUSE data from the Fornax 3D project, a survey that targets massive galaxies in the Fornax cluster with MUSE (Sarzi+ 2018). MUSE is an integral-field spectrograph at the Very Large Telescope in Chile. Each pixel contains a spectrum in the optical, resulting in 90'000 spectra per pointing.

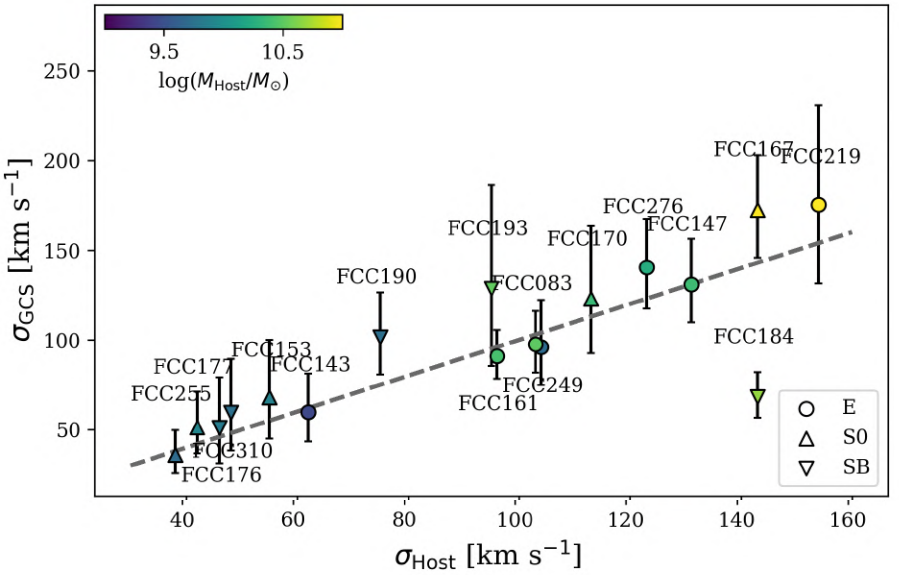
Globular cluster system kinematics

III. Kinematic modelling

For each galaxy with sufficient numbers of GCs, we model the rotation velocity and velocity dispersion of the GC system and directly compare it to the stellar light.

Fig.: GC system rotation velocity (left) and velocity dispersion (right) compared to the stellar body of the Fornax 3D galaxies.





Rotating GC systems

Some galaxies have GC systems that clearly rotate, but in general the GCs follow the rotation of the galaxy spheroid and not, e.g., the disk as seen in the edge-on S0 galaxies.

GC tracing mass

The GCs closely follow the velocity dispersion also seen in the stars, showing that they trace the enclosed mass.

A non-linear colour-metallicity relation

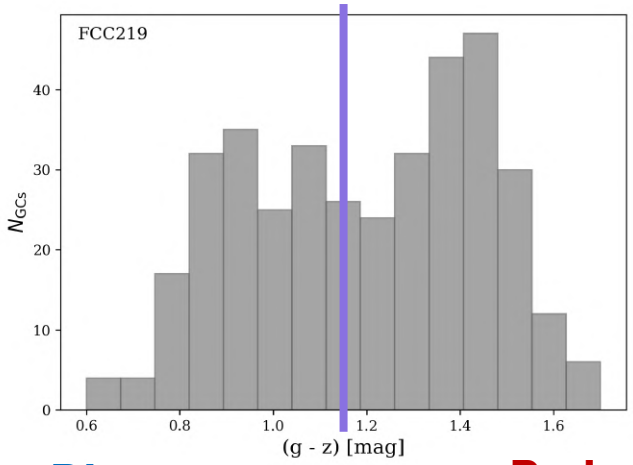


Fig.: GC colour distribution of FCC219.

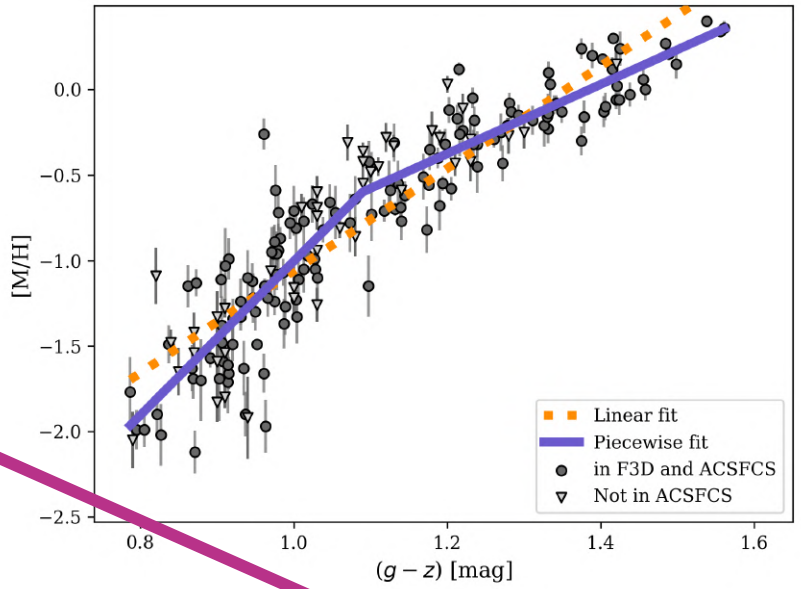


Fig.: Spectroscopic GC colour-metallicity relation.

IV. Metallicities

We combine the full sample of GC metallicities to study their relation with photometric colours.

Bimodal colour distributions

Photometric surveys of GC systems have shown many galaxies have bimodal GC colour distributions with a red and blue population. These have been interpreted as a metal-rich, in-situ born and a metal-poor, accreted population, linking GC populations to a two-stage formation of galaxies.

Colour-metallicity relation

We find a non-linear colour-metallicity relation that has implications for the interpretation of colour distributions because their shape is not preserved in metallicity. This challenges the simple division of GC origins into in-situ and accreted based on a single colour cut.

Fig.: Predicted GC metallicity distribution.

In-situ/ massive halo