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Observations of internal dynamics of globular clusters

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Abstract. In preparation for the first simulation of a real globular cluster with a few 10^5 particles and several Gyr of evolution, which will be made possible by the advent of the new GRAPE-8, the MODEST community encharged our working group (WG-9) to provide all of the needed observational constrains. The selected clusters for this experiment were NGC 6121 (M 4) and NGC 6397. We present the status of the project.

Keywords. Galaxy: globular clusters: individual (NGC 6121, NGC 6397)

1. Cluster properties

The requested observational inputs are: cluster membership, internal proper motion, internal line of sight velocities, geometrical distance, mass function, mass segregation, anisotropy, binary fraction (and, possibly, binary properties), spatial distribution of stars, white dwarf (WD) counts, tidal tail distribution, and absolute proper motion and radial velocities (in order to characterize the orbit).

In Fig. 1 we show in a schematic way all the observational quantities that needs to be known in order to constrain MODEST simulations.

2. Instruments and techniques

To obtain these observational quantities, we started an extensive observational campaign in order to get high precision photometry and astrometry with both *HST* – from space – and with wide-field-imagers – from ground. In addition to this, for the third component of the motions (along the line of sight) we got time at the ESO VLT-FLAMES multi-fiber spectroscope.

Furthermore, our exquisite photometry from the tip of the red giant branch to the bottom of the WD cooling sequence allows: (*i*) to obtain local present day mass functions (down to the hydrogen burning limit) at different distances from the cluster center, and cleaned from contamination of foreground/background objects; (*ii*) to study the WDs down to the cooling sequence end, (*iii*) estimate the photometric binaries. Comparison of internal proper motions with line of sight velocities for thousands of stars provide geometric determination of the cluster distance with uncertainties of the order of a few percent (see Bedin 2003a for a short description of the method). The internal proper motions and radial velocities provide information on the stellar kinematics inside the cluster.

A project born inside MODEST to determine the spectroscopic binary fraction in M 4 has been recently approved, and observations are carried out in these days at VLT-FLAMES.

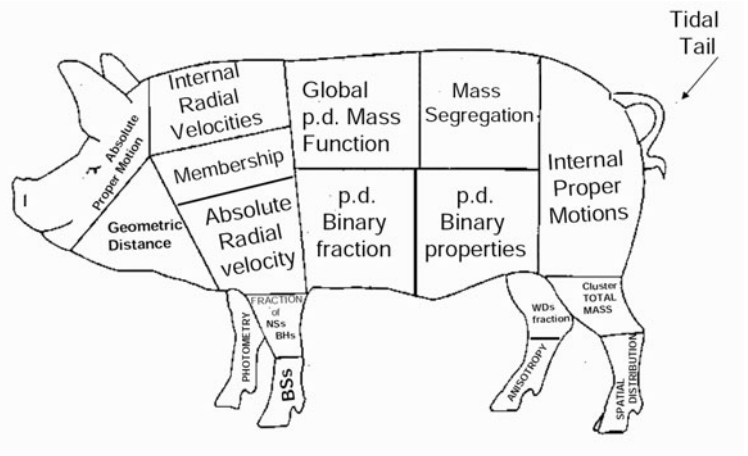

Figure 1. Typical Galactic globular cluster with indication of its main observational quantities and parameters useful to constrain MODEST simulations. (p.d.: present day.)

High-precision astrometry and photometry also allow to disentangle blends from real binaries, for which we can now provide an estimate on their (present day) number, and radial distribution.

In Table 1 we summarized the status of the project.

Table 1. Summary of the status of the project. *Notes*: '-': not yet available; *a*: Bedin *et al.* (2003b); *b*: Milone *et al.* (2006); *c*: Bedin *et al.* (2001); *d*: King *et al.* (1998); *e*: Anderson *et al.* (2006).

Observational quantities	Proposed	Acquired	Reduced	Published
absolute proper motions	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	M 4[a] /NGC 6397[b]
absolute radial velocity	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	–/NGC 6397[b]
internal proper motions	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	–/–
internal radial velocity	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	–/–
geometrical distance	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	–/–
orbital parameters	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	–/NGC 6397[b]
deep *HST* photometry	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	M 4[c] /NGC 6397[d]
wide field photometry	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	M 4[e] /NGC 6397[e]
membership	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	M 4[a,c,e] /NGC 6397[b,d,e]
p.d. mass function	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	M 4[c] /NGC 6397[d]
p.d. mass segregation	M 4/NGC 6397	M 4/NGC 6397	M 4/NGC 6397	–/–
p.d. binary fraction	M 4/–	M 4/–	–/–	–/–
p.d. binary properties	M 4/–	–/–	–/–	–/–

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