PROCEEDINGS OF SCIENCE

The Outer Cluster System of NGC 1399: Preliminary Results

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We present preliminary results of our dynamical study of the outer globular cluster system of NGC 1399, the central galaxy in the Fornax cluster. About 160 new radial velocities for globular clusters at projected galactocentric distances between 8′ and 18′ indicate that the constant velocity dispersion of $\sim 276\,\mathrm{km\,s^{-1}}$ (for all clusters) already found for the inner region can be traced out to 80 kpc. We find that the kinematical properties of the blue (metal-poor) and the red (metal-rich) globular cluster subpopulations appear to be different: While the velocity distribution of the red clusters is symmetric with respect to the systemic velocity of NGC 1399, the blue clusters show a somewhat asymmetric distribution, with more velocities above the systemic velocity.

Baryons in Dark Matter Halos
5-9 October 2004
Novigrad, Croatia

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Published by SISSA http://pos.sissa.it/

PoS(BDMH2004)065

1. Introduction

NGC 1399, the central giant elliptical in the Fornax Cluster has long since been known to host a very populous and extended globular cluster system (GCS). In the Southern hemisphere it is the prime target when using globular clusters as probes for the gravitational potential of the host galaxy. Recent wide-field photometry in the Washington system (Dirsch et al. 2003) provided the database to select GC candidates for the kinematical and dynamical study of the NGC 1399 GCS presented by Richtler et al. (2004) and Dirsch et al. (2004). They used the VLT with FORS2/MXU to obtain a sample of 470 GC velocities in a radial range of $2' < R < 9'$ (11 to 50 kpc in a distance of 19 Mpc), the largest sample of GC velocities measured until then. Briefly, their main findings are: For the entire sample, they find a radially constant velocity dispersion of $\sigma = 325 \pm 11\,\mathrm{km\,s^{-1}}$. Omitting the extreme velocities, i.e. taking into account only the clusters within the velocity interval $800 < v < 2080\,\mathrm{km\,s^{-1}}$ (see Fig. 1), they find $\sigma_{\mathrm{all}} = 276 \pm 11\,\mathrm{km\,s^{-1}}$. Inspecting blue (metal-poor) and red (metal-rich) clusters separately, the corresponding dispersions read: $\sigma_{\mathrm{blue}} = 291 \pm 14\,\mathrm{km\,s^{-1}}$ and $\sigma_{\mathrm{red}} = 255 \pm 13\,\mathrm{km\,s^{-1}}$. Using a dynamical model on the basis of the spherical Jeans equation, they derive – under the assumption of isotropy – a radially constant circular velocity of $v_{\mathrm{circ}} = 415 \pm 30\,\mathrm{km\,s^{-1}}$ out to a radius of 50 kpc.

It is of great interest to extend this study to larger galactocentric distances, in order to address the several key questions that can put constraints on galaxy formation scenarios: Out to what radius can the constant circular velocity be followed? Does the outer GCS rotate? Can one detect substructure in the dark matter distribution of the Fornax cluster (e.g. Ikebe et al. 1996)? Here we present the first preliminary results from a study measuring cluster velocities at projected galactocentric radii of up to 100 kpc.

2. The Data Set

The data have been obtained with FORS2 and the Mask Exchange Unit (MXU) at the Very Large Telescope of the European Southern Observatory at Cerro Paranal, Chile. The observing period was December 2/3, 2002 (ESO program ID 70.B-0174). Twelve masks in 7 different fields have been observed. The spectral resolution provided by the grism 600B is about 3Å. The data structure and the reduction procedure are identical to those in our previous study of the inner cluster system (Richtler et al. 2004, Dirsch et al. 2004). The data are not yet completely reduced. So far, we have determined 160 new GC velocities with typical uncertainties of $30\,\mathrm{km\,s^{-1}}$. For 139 of these objects, colours are available from the Washington photometry of Dirsch et al. (2003).

3. Results

Figure 1 shows a plot of the new radial velocities versus galactocentric distance together with the older data. Indicated are the systemic velocity and the boundaries within which we determine the velocity dispersion to be consistent with the previous selection. The outermost data point has a projected radial distance of 18′, corresponding to 100 kpc. Given that more velocities will soon follow, the velocity dispersions reported here might still change somewhat in the future.

A peculiarity is apparent in the velocity distribution of the outer clusters shown in Fig. 2. While the red clusters show a reasonably symmetric distribution, the outer blue clusters exhibit an

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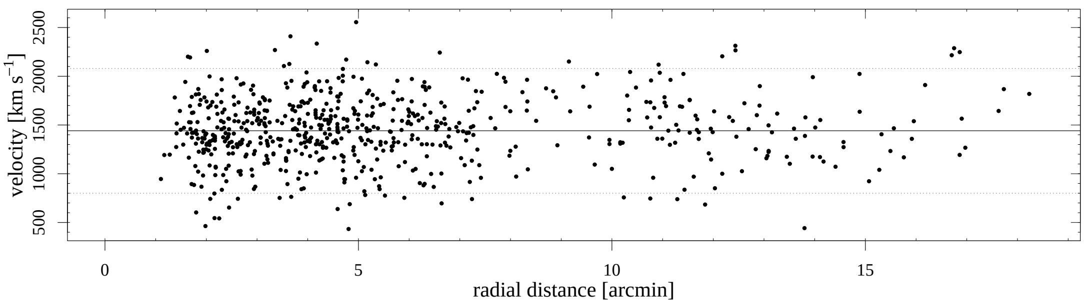

Figure 1: Radial velocity versus projected galactocentric radius for the combined sample. The solid line at 1441 km s^{-1} indicates the systemic velocity of NGC 1399. The dotted lines at 800 and 2080 km s^{-1} show the velocity selection we adopted from Richtler et al. (2004).

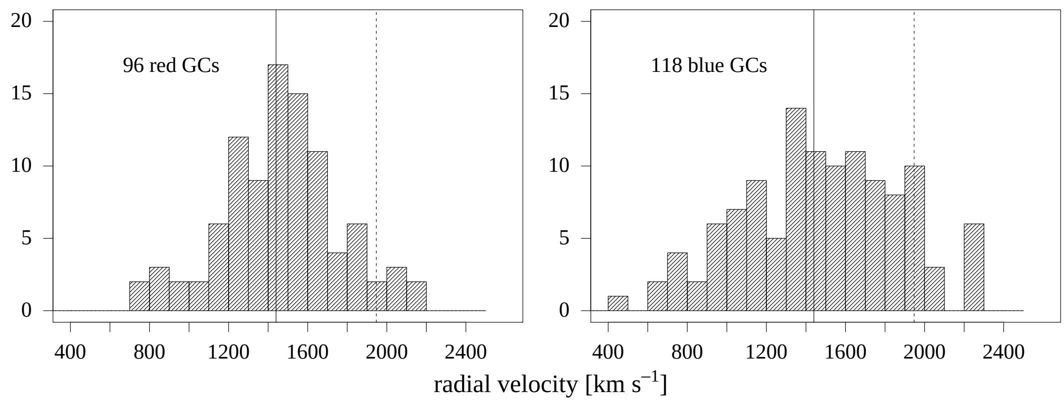

Figure 2: Histograms of the velocity distribution for the outer ($R > 5.5'$) red and blue clusters. The solid line marks the systemic velocity of NGC 1399. The dotted line at 1950 km s^{-1} indicates the systemic velocity of NGC 1404.

asymmetry, with a preference for higher velocities. A peak at 1800 km s^{-1} was already found for the blue clusters at smaller radii in the sample of Richtler et al. (2004). These findings are interesting in the context of the simulations presented by Bekki et al. (2003) who considered an interaction between the nearby elliptical NGC 1404 and NGC 1399, an idea first brought forward by Kissler–Patig et al. (1997). In the scenario of Bekki et al., where NGC 1404 is on a bound orbit around the Fornax cluster centre (i.e. around NGC 1399), the low specific frequency (the total number of clusters normalised to the host galaxy's luminosity) of NGC 1404 is explained by the tidal stripping of NGC 1404 clusters which subsequently form an additional GC population around NGC 1399. This mostly affects the blue clusters in NGC 1404 due to their shallower number density profile. If true, this would complicate the use of the blue clusters as tracers for the gravitational potential of NGC 1399. However, more velocities are needed to arrive at safer conclusions.

The projected velocity dispersions derived for the total, the blue, and the red sample are shown in Fig. 3. The horizontal dotted lines indicate the mean value of the respective dispersions and are in excellent agreement with the previously derived values for the inner region. Apparent dissimilarities, for instance the slight rise of the velocity dispersion of the blue (and the total) sample may be due to differences in the binning. The highest velocity dispersion values (at 10′) are probably not

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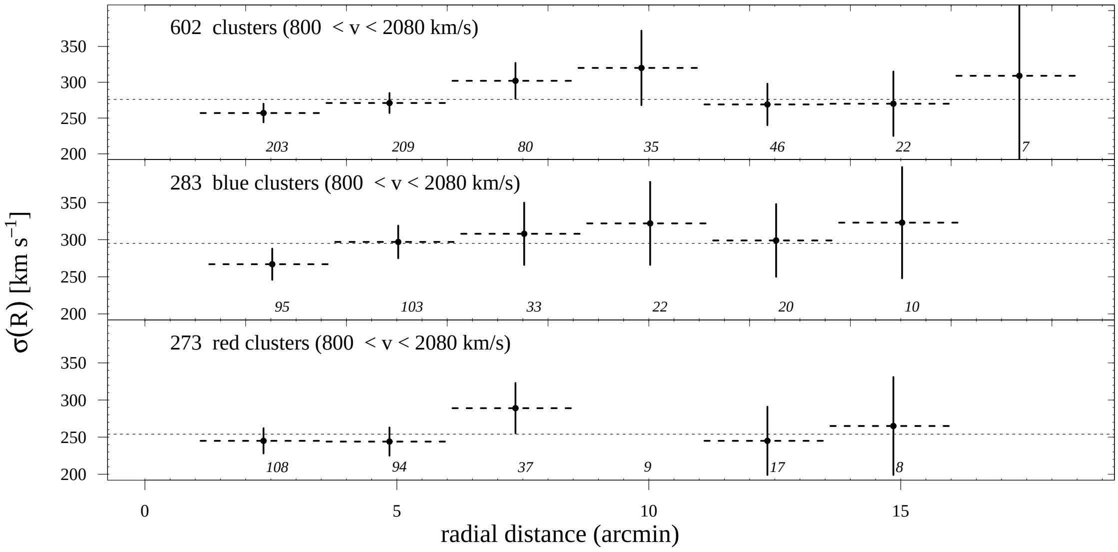

Figure 3: Velocity dispersion as function of projected radius. The upper panel shows the values for all selected clusters. The results for blue and red clusters are shown in the middle and bottom panel, respectively. In all panels, the dotted line indicates the mean of the corresponding dispersion measurements. The number of clusters entering the dispersion measurements for a given bin of 2.5′ width is indicated as well.

reliable since they trace a radial interval where, as a comparison with Fig. 1 shows, the distribution of velocities is highly asymmetric.

At present, the global picture is that of a constant velocity dispersion over the full radial range. The total sample has a velocity dispersion of $276\,\mathrm{km\,s^{-1}}$. The dispersion for the red clusters is $254\,\mathrm{km\,s^{-1}}$ and for the blue clusters $295\,\mathrm{km\,s^{-1}}$. It also seems that the difference between the blue and the red clusters found for the inner region, remains in the outer region. This is remarkable since the number density profiles of both populations are indistinguishable for radii beyond 8′ (Dirsch et al. 2003). In case of isotropy, the blue clusters should assume the same velocity dispersion as the red clusters beyond this radius. Summarising, the present data support the presence of an isothermal dark halo which extends to at least 80 kpc.

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