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Globular Clusters as Probes of the Virgo gE NGC 4472

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Abstract. We present radial velocities for 144 globular clusters (GCs) around the Virgo gE NGC 4472 (M49), and ages and metallicities from co-added spectra of 131 GCs. We confirm our earlier finding that the metal-poor GCs have a significantly higher velocity dispersion than the metal-rich GCs, and we find little or no rotation in the metal-rich GCs. The velocity dispersion profile is consistent with isotropic orbits for the GCs and the NGC 4472 mass distribution inferred from X-ray data. Our sample of GCs spans a metallicity range of $-1.6 \leq [Fe/H] \leq 0$ dex. The metal-poor and metal-rich GC populations are coeval within the errors, and all GCs older than 6 Gyr at 95% confidence. Our findings are consistent with a merger origin for NGC 4472, but other elliptical formation models cannot be ruled out.

1. Observations

GC spectra were obtained in two observing runs, one in 1994 with WHT/LDSS-2 (Sharples et al. 1998), and the second in 1998 with CFHT/MOS (Beasley et al. 2000; Zepf et al. 2000). GC candidates for both runs were chosen from Washington photometry (Geisler et al. 1996), with colour ($0.5 < C - T_1 < 2.2$) and magnitude ($19.5 < V < 22.5$) selection. Spectra were obtained over the wavelength range 3600−6000 Å, with a resolution of 3−6 Å, and a velocity precision of 50−100 km/sec. Exposure times were 3−3.5 hours per mask. We have a total sample of 144 confirmed GCs in NGC 4472, out to $\sim 7'$ radius ($\sim$ 30 kpc, 6 R_{eff}). See Sharples et al., and Beasley et al. for more details.

2. GC Kinematics and Dark Matter in NGC 4472 (Zepf. et al. 2000)

Figure 1 shows smoothed velocity and velocity dispersion profiles for the full GC sample, and for the metal-rich and metal-poor populations separately. We confirm our earlier result (Sharples et al. 1998) that the metal-poor GCs have a significantly higher velocity dispersion than the metal-rich GCs. There is little or no rotation in the metal-rich GCs, and modest rotation of ~ 100 km/sec in the metal-poor GCs. For the metal-rich GCs, $V/\sigma < 0.34$ at 99% confidence. This absence of rotation in the more centrally-concentrated metal-rich GCs seems to require significant outward angular momentum transport (from a merger?).

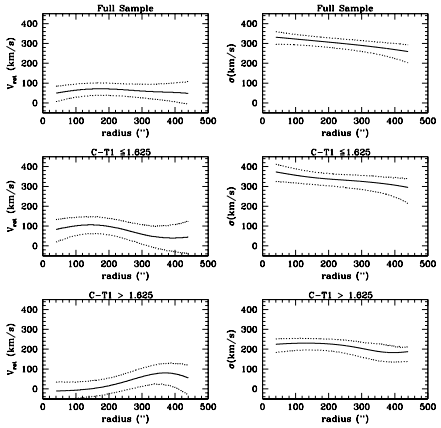

Figure 1. Smoothed rotation and velocity dispersion profiles for NGC 4472 GCs. **Top:** full dataset; **Middle:** metal-poor (blue) GCs; **Bottom:** metal-rich (red) GCs. Dotted lines show the 1σ uncertainties, determined from bootstrapping.

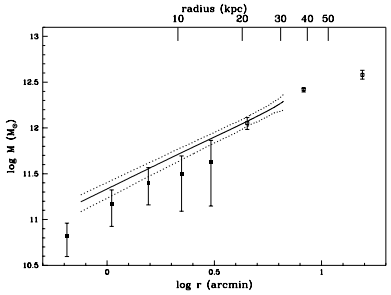

Figure 2. The mass of NGC 4472 as a function of radius. The solid line is the best fit to 144 GC radial velocities, and the dotted lines are the 1σ lower and upper limits. The points are masses inferred from ROSAT X-ray data (Irwin & Sarazin 1996).

We have used the deprojected GC velocity dispersion and density profiles together with the Jeans equation to derive the mass distribution of NGC 4472, with the assumption of isotropic GC orbits. **Figure 2** shows the resulting mass profile for NGC 4472, compared with that obtained from X-ray data (Irwin & Sarazin 1996). There is reasonable agreement between the two profiles, and we confirm the existence of a substantial dark matter halo in NGC 4472, with a M/L ratio > 50 at 30 kpc radius.

3. GC Ages and Abundances (Beasley et al. 2000)

To improve the S/N ratio for age and abundance analysis, we have co-added our GC spectra by colour into four bins with 30−35 GCs each. For each bin, we have measured age (Hβ, Hδ, Hγ) and metallicity (Mg$_2$, Fe5270/5335) sensitive indices, on the Lick system. **Figure 3** shows the predictions of Worthey (1994) models for the NGC 4472 GCs in the Mg$_2$, Hβ plane. Based on a Galactic GC

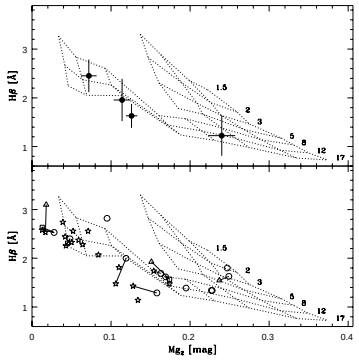

Figure 3. Predictions of Worthey (1994) models for NGC 4472 and Galactic GCs. **Top Panel:** co-added NGC 4472 GCs (filled circles). **Lower Panel:** Data for Galactic GCs. Open circles: Cohen et al. (1998); open stars: Brodie & Huchra (1990); triangles: our CFHT data; squares: our WHT data. Lines connect the same GCs between different datasets. Ages on the right side of the grid run from 1.5−17 Gyr.

calibration, the NGC 4472 GCs span a metallicity range $-1.6 \leq [Fe/H] \leq 0$ dex.

It is notoriously difficult to determine *absolute* GC ages, but within the errors all four bins are coeval; we can further say that all GCs are older than 6 Gyr at 95% confidence. Interestingly, the metal-rich GCs are 0.7 ± 7 Gyr younger than the metal-poor GCs. **Table 1** summarizes the ages and metallicities for our binned NGC 4472 data.

Table 1. Ages and abundances for binned NGC 4472 GCs.

Bin #	$\overline{C-T_1}$	[Fe/H] (dex)	Mean Age (Gyr)
1	1.30 ± 0.09	−1.29 ± 0.30	$10.7\ ^{+6}_{-5}$
2	1.44 ± 0.07	−0.91 ± 0.35	$15.3\ ^{+8}_{-5}$
3	1.61 ± 0.06	−0.84 ± 0.25	$18.5\ ^{+4}_{-5}$
4	1.91 ± 0.11	−0.27 ± 0.30	$11.3\ ^{+8}_{-9}$

References

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