MegaCam Observations of Globular Clusters in the Core of the Virgo Cluster

The Origin of Globular Cluster Systems — A fundamental question exists regarding the origin of globular cluster systems (GCSs): were the GCSs of giant ellipticals established at birth, or have they simply evolved from otherwise normal systems through interactions and mergers? Harris (1986) suggested that the structural similarity of GCSs in different environments argued for a common, early origin. At the other extreme, Ashman and Zepf (1992) assume that ellipticals form by mergers of spirals and that a substantial fraction of the GCS forms during the merger event. Recent observations of GCS colour (i.e. metallicity) distributions have invigorated this debate. A particularly striking observation is that the metallicity distributions of many giant ellipticals are bimodal (e.g. Fig. 1a). One obvious way to generate this bimodality is through two bursts of star formation: one when the initial GCS forms (metal-poor) and another later on during the merger (metal-rich).

In a recent paper, Côté, Marzke, and West (1998) have shown that the bimodal metallicity distributions of GCSs also arise naturally if a substantial fraction of a galaxy’s GCs are agglomerated during the tidal stripping and merging of cluster members (see Fig. 1a). This model admits at least two direct tests:

1. A fundamental requirement of the CMW model is the existence of a spatially-extended population of accreted and intergalactic globular clusters surrounding giant ellipticals such as M87 and M49. There is already indirect evidence for such a population in the GC counts of Harris (1986; see also West et al. 1995). Fig. 1b shows that at large projected radii, the M87 GCS follows the radial distribution of cluster mass, and is much more extended than the stellar halo. Recent discoveries of intergalactic stars (Ferguson et al. 1998) and planetary nebulae (Ciardullo et al. 1997) demonstrate that the detritus of mergers is spread widely through clusters, and almost demands that a population of intergalactic globulars should be present, as well.

2. The accreted globulars should be metal-poor because they originate mostly in low mass galaxies. Thus the ratio of metal-rich to metal-poor clusters should decrease with radius in the vicinity of a galaxy, and flatten out at a very small number at large radii.

Proposal — To test the aforementioned predictions, we propose a multicolor imaging survey of the Virgo cluster core, both to search for the population of intergalactic globular clusters predicted by the Côté et al. theory, and to test their metallicity distribution.

The expected surface density of these objects is around 180 per MegaCam field at $\theta = 44'$ from M87 (based on $\mu_B \approx 31$ mag arcsec$^{-2}$ from Ferguson et al. 1998, specific frequency $S_N = 5$, and $m - M = 31$). Imaging in BVI provides discrimination against foreground stars (Fig. 2a); the expected numbers of contaminating stars and (misclassified!) galaxies is relatively small (Fig. 2b). 30 min in each filter (1.5 hr total per field) will provide adequate photometric accuracy; we wish to survey an area encompassing at least NGC 4486 and NGC 4472 (say 30 deg²). To survey an area of this size would require ~45 hours total integration time, or approximately 6 nights. The data will be extremely valuable for other projects - for example, studies of low luminosity dwarfs and low surface brightness galaxies in the Virgo cluster.

We note that our proposed survey could piggyback off of a more general survey of the Virgo cluster, provided that such a survey reaches required depths of $V \simeq 24 - 25$, as this is the characteristic brightness of globular clusters at the distance of Virgo.

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Fig. 1.— (a) The metallicity distribution for the M87 GCS: filled triangles – observed (Santiago and Elson 1996); open squares and solid line – simulations (Côté et al. 1997) for different values of the luminosity function parameter $\alpha$. The dashed lines show the division of the GCS into metal-rich and metal-poor components. (b) Surface density of halo light and globulars for M87. Open circles – GCs (Harris 1996); filled squares – halo light; open triangles – residuals between observed GCs and predictions of metal-rich GCs from halo light (dashed line). The data demonstrates that the residual GCs fall off in a manner consistent with that expected for a population of tidally-stripped IGCs.

Fig. 2.— (a) Separation of Galactic globular clusters (filled squares, Harris 1996), and subdwarfs (small circles, Ryan 1989) in the $(B - V)_0$ vs. $(V - I)_0$ diagram. The box contains most of the Galactic globulars. (b) Distribution of stars and mis-classified galaxies ($V < 22.5$) for the CNOC 0223 field (~40% of Megacam area) in the color-color diagram. These are the dominant contaminants of globular clusters. The box defines the locus of Galactic GCs as in Fig 2a.