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Dynamical Studies of the M87 Globular Cluster System: The Use of the CFHT MOS

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Abstract. We describe and celebrate the use of the MOS instrument at the Canada-France-Hawaii Telescope in a multi-object spectroscopic study of the rich globular cluster system (GCS) of the giant elliptical galaxy M87.

1. Introduction

The dynamical study of globular cluster systems (GCSs) has a long and important history, both within and outside the Milky Way. As the oldest identifiable stellar constituents of galaxies, globular clusters serve not only as conspicuous dynamical test particles but also provide insights into the chemical enrichment history of the parent galaxy. They provide the promise, therefore, of distinguishing between various models of galaxy formation and interaction history. The importance of this has been underscored by recent discoveries in extragalactic studies: in particular, the finding that the GCSs of many giant elliptical galaxies are bimodal in their color distributions, a circumstance that may be telling us of a formation via a major merger event.

2. The Particular Importance and Interest of M87

M87 represents both an obvious and a problematic target for multi-object spectroscopic work – obvious in the sense that it possesses a particularly rich GCS within reach of MOS instrumentation on 4-metre class telescopes, but problematic in the sense that its special location in the core of the Virgo cluster, and its well-known apparent superabundance of globular clusters, make it arguably unrepresentative of 'typical' elliptical galaxies. The former consideration, that of the richness of the GCS, is of particular importance given the desiderata identified by Merritt and others: some *hundreds* of tracer velocities will be required if dynamical models are to be subjected to any but the most superficial of tests of uniqueness and acceptability. Moreover, the study of this fascinating galaxy would seem certain to provide profound food for thought, even if it should turn out to be unique or even bizarre in its properties.

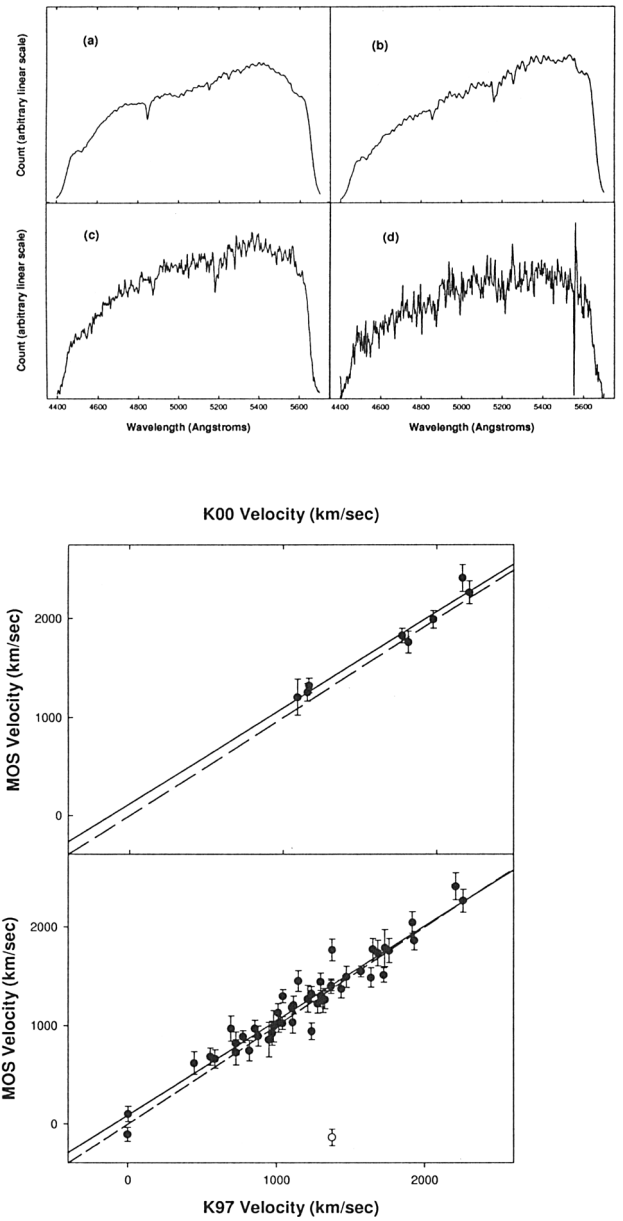

Figure 1. Top: high signal-to-noise spectra of two Galactic globular clusters (NGCs 6205 and 6356), objects which serve as templates in the determination of velocities for targets in the M87 field, two of which are also shown (at R=19.46 and 20.98 mag). Bottom: a comparison of MOS-derived velocities in the M87 GCS with those determined at the Keck telescope by J. Cohen and her collaborators.

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3. The Continuing Importance of 4-Metre Multi-Spectroscopic Instrumentation

In a companion paper in this volume, Terry Bridges describes the success we have enjoyed in our MOS analyses of the GCS of M87 and that of NGC4472, another luminous giant elliptical galaxy in the Virgo cluster. (The M87 study will soon be appearing in the Astrophysical Journal in a pair of companion papers; see Terry's discussion for detailed references.) In this short contribution, however, I would like to emphasize the fact that, even as we enter the era of the 8-metre telescopes, well-equipped 4-metre reflectors still have a very important role to play. Indeed, for galaxies at Virgo-like distances, highly-efficient multi-object spectroscopic instruments like the MOS at the Canada-France-Hawaii Telescope represent *the almost ideal tool for the needed observations.*

There are two reasons for this happy circumstance. The first stems from the physical scale and consequent angular extent over which the target GCS extends. The 10 arcmin square direct imaging field of the CFHT MOS, for instance, samples about 45 kpc in the M87 rest frame. Of course, this allows an enormous multiplex gain, since hundreds of potential targets lie within each pointing. Second, and just as important, is the fact that a large fraction of the globular clusters at Virgo-like distances are luminous enough ($V \leq 22$ mag) that integration times of a few hours yield spectral signal-to-noise ratios which are perfectly adequate for cross-correlation velocity determinations of the requisite precision.

These points are made clear in the attached figures. The lower one demonstrates that our velocity precision is comparable to that attained by Judy Cohen and her collaborators using the LRIS instrument at the Keck Telescope, while in the upper one we show some representative spectra. The spectra also show the effects of using a carefully chosen pre-filter to allow the stacking of several tiers of spectra per frame without any overlaps. This strategy permitted us to target as many as one hundred objects per pointing.

On the other hand, it must be conceded that observations with 4-metre telescopes will not tell the whole story. Eventually, it will be essential to obtain signal-to-noise ratios considerably higher than that required for velocities if we are to unscramble the degenerate effects of age and metallicity in the spectra of extragalactic globular clusters: only then will we understand the full chronology of mergers and interactions (or other responsible phenomena) which led to the present complex GCS properties. This remains a job for the 8-metre class telescopes. For dynamical studies, however, superb instruments like the CFHT MOS are uniquely optimized for the efficient acquisition of rich samples of test particle velocities and the strict testing of theoretical dynamical models in the context of galaxy formation and interaction history.

Acknowledgments. It is a real pleasure to acknowledge the team effort which this work represents. Elsewhere in this volume, Terry Bridges will describe the mix of observational effort and analytic modelling which the research encompasses, the combined endeavour of Pat Côté, Dean McLaughlin, Terry, myself, Doug Geisler, Dave Merritt, Jim Hesser, Gretchen Harris, and Myung Gyoon Lee. Nor would it have been possible without the support of the CFHT personnel—and the TACs!