RevMexAA (Serie de Conferencias), **17**, 177–178 (2003)

EARLY-TYPE GALAXIES IN THE NOAO FUNDAMENTAL PLANE SURVEY

M. J. Hudson,[1] J. R. Lucey,[2] J. J. Malecki,[1] S. A. W. Moore,[2] J. E. Nelan,[3] S. J. Quinney,[2] D. Schade,[4] R. J. Smith,[1,5] N. B. Suntzeff,[6] and G. A. Wegner[3]

RESUMEN

Reseñamos el sondeo NOAO del plano fundamental de los cúmulos de galaxias cercanos y luminosos en rayos X, y presentamos algunos resultados preliminares de los primeros datos obtenidos.

ABSTRACT

We review the NOAO Fundamental Plane Survey of nearby X-ray luminous galaxy clusters and present some preliminary results from early data.

Key Words: **GALAXIES : CLUSTERS : GENERAL — GALAXIES : ELLIPTICAL AND LENTICULAR, CD**

Galaxy Evolution: Theory and Observations (Cozumel, Quintana Roo, México, 8-12 April 2002)
Editors: Vladimir Avila-Reese, Claudio Firmani, Carlos S. Frenk & Christine Allen

1. INTRODUCTION

The NOAO Fundamental Plane Survey (NFPS) is an all-sky imaging and spectroscopic survey of nearby clusters. A prime goal of this survey is to resolve definitively the controversial issue of large-scale bulk-flows in cluster samples, using the Fundamental Plane as a distance indicator. A recent analysis (Hudson 2001) indicates that approximately 420 ± 180 km s^{-1} of the Local Group's 600 km s^{-1} peculiar velocity with respect to the Cosmic Microwave Background, is generated by structures on scales of ~ 100 h^{-1} Mpc. This contribution from large scales is marginally inconsistent (at 95% confidence) with the expectatations from the concordance ΛCDM model. Clearly better data are required. With ∼50 early-type members observed per cluster, the FP yields distances with random errors of $< 3\%$, allowing meaningful measurements of peculiar velocities out to distances well beyond $100\,h^{-1}$ Mpc. In addition to cosmic flows applications, the NFPS data will provide a wealth of data on galaxy morphology and spectroscopic parameters for nearby cluster galaxies.

The cluster sample consists of ∼100 clusters, selected by X-ray luminosity, to a depth of $z = 0.06$ and distributed over the whole sky. Clusters have been imaged in the B and R bands and color-magnitude relations are obtained. This data are used to select red-sequence cluster members (i.e. likely early-type galaxies) for spectroscopic follow-up. In addition, the images will be employed to measure morphological parameters (including bulge/disk decomposition from 2D profile fitting) for all bright galaxies in the field.

The spectroscopic program makes use of the Hydra multi-fiber spectrographs at the WIYN 3.5m and CTIO 4m telescopes. In each cluster, typically 40 to 70 galaxies (with $R < 17$ and 'red' relative to the cluster color–magnitude relation) are observed, over the 60 arcmin or 40 arcmin field of view of the instruments. Spectral resolution and signal-to-noise are sufficient to measure redshifts, internal velocity dispersions and a wide range of metal and Balmer-series absorption line indices over the spectral range 4000–6000 Å.

In this contribution, we present some early results from the NFPS relating to the properties of early-type galaxies.

2. RESULTS

2.1. *Red-Sequence*

The imaging data allow us to study the homogeneity of the early-type population, both within individual clusters and from cluster to cluster. For each cluster, we obtain a red-sequence by fitting the $B-R$ vs R color-magnitude relation with a constant slope and zero-point to galaxies with $R < 17$. Once the effects of galactic extinction and k-correction are accounted for, the variation in the zero-point of the red-sequence from cluster-to-cluster is less than 0.04 mags.

Within individual clusters, the red sequence can be used to probe substructure. A useful statistic is the locally-measured scatter in color around a locally-measured mean CMR. Clumps of red galaxies appear as regions of low scatter relative to a typical field population. Fig. 1 shows this technique applied to wide-field imaging data of Abell 400: the method

[1] Univ. of Waterloo
[2] Durham Univ.
[3] Dartmouth College
[4] Canadian Astronomical Data Centre
[5] Univ. Católica de Chile
[6] Cerro Tololo Inter-American Observatory

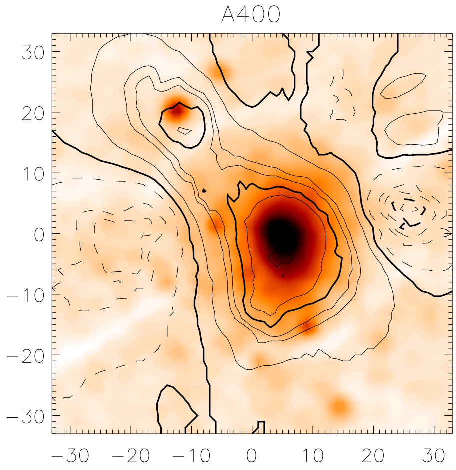

Fig. 1. Abell 400. The axis scales are in arcminutes. Contours show regions where the locally-measured scatter in color is lower than the field at the 50%, 68%, 90%, 95%, 99% (bold) and 99.9% confidence levels. Greyscale are X-ray images from Chandra.

identifies the two subclumps also detected in X-rays. This technique thus is a simple, empirical method for detecting the presence of clusters and substructure from imaging data alone.

2.2. *Metallicities and Ages*

Early results from the spectroscopic observations include a study of the linestrength versus velocity dispersion (σ) relationships. For example, it has long been known that the Mg*b* index at 5177 Å increases strongly with σ. This is likely due to a steady increase of metallicity with mass, as expected in galactic wind models, although age can also influence this index. Interestingly, in some clusters Mg*b* is systematically stronger – *at given* σ – for galaxies in the center of the cluster than for members further out. That is, galaxies near the cluster core may be more metal-rich, at given mass, than galaxies in the outskirts. An age interpretation (in the sense that outer members are younger) can be ruled out, due the lack of any radial trend in residuals from the H$\gamma - \sigma$ relation. This effect is found in NFPS data for a number of clusters so far (the case of Abell 3558 is shown here), and a similar effect has been noted for the Coma cluster in previous studies. However, initial indications are that such gradients are not ubiquitous in NFPS clusters. Since any existing cluster-centric gradient, in metallicity (or indeed in age) would probably be quickly erased by mixing in cluster mergers, it is possible that the presence of gradients might be correlated with other indicators of 'regularity' in clusters, such as cooling-flows, absence of substructure, etc.

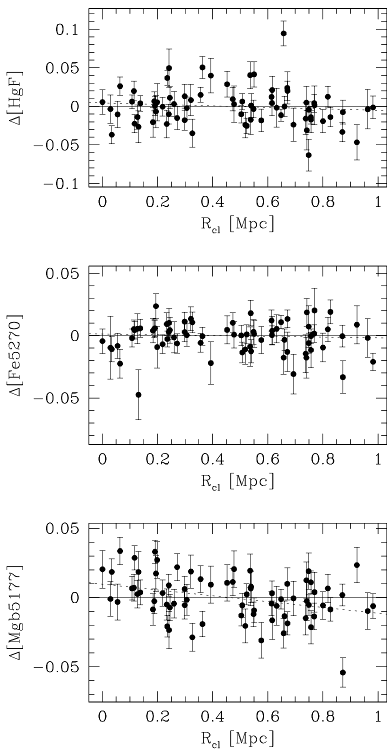

Fig. 2. Residuals from the Mg$b - \sigma$, Fe5270$-\sigma$ and H$\gamma_F - \sigma$, relations, plotted against cluster-centric distance $R_{\rm cl}$, for galaxies in the rich cluster Abell 3558. The significant ($> 3\sigma$) trend in the Mg*b* residuals suggests that centrally-located galaxies have higher metallicity, *at given mass* than members further out. Note that the Fe5270 line shows no strong trend. The lack of trend in HγF residuals strongly argues against an 'age-gradient' interpretation.

The final data sample will merge high S/N spectroscopic data with colors and morphological data from 2D fitting for approximately 100 clusters. This rich dataset will yield new insights into galaxy formation and evolution in the cluster environment.

REFERENCES

Hudson, M. J. 2001, in "Where's the Matter? Tracing Dark and Bright Matter with the New Generation of Large Scale Surveys", eds. Treyer & Tresse, 2001, Frontier Group.

Michael J. Hudson: Dept. of Physics, Univ. of Waterloo, 200 University Avenue West, Waterloo, ON N2L 1Z5 Canada (mjhudson@uwaterloo.ca).