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STUDYING THE STELLAR POPULATIONS IN DISTANT CLUSTER GALAXIES

M. SEROTE ROOS
Centro de Astronomia e Astrofísica da Universidade de Lisboa,
Observatório Astronómico de Lisboa, Portugal

I present preliminary results of a study of the stellar populations in three galaxy clusters, at redshifts z 0.64, 0.66 and 0.71. We are analysing the impact of environmental effects and dynamical interactions typical of clusters on the stellar populations of the cluster member galaxies. We use a method of population synthesis developed by Pelat (1997), with a stellar database.

1 Introduction

Clusters of galaxies occupy an important status in the actual scenario of astronomical research. The study of the properties of their galaxy populations at different epochs provides understanding on the role of environment in galaxy formation and evolution mechanisms. Such processes are still poorly known. Several works have shown that galaxies recently accreted into clusters suffer truncation - probably preceded by an intense burst - of star formation. Follows a period of passive evolution in luminosity. We intend to study the properties of the galaxies in terms of their stellar populations. The population synthesis analysis will give us an idea of the stellar content (or evolutionary stage) of the cluster galaxies at different radial distances from the cluster center. Also, the field galaxy sample, analyzed in the same way, shall provide the term of comparison in order to deduce the impact of environmental effects and dynamical interactions typical of clusters on the stellar populations.

2 The galaxy clusters

The clusters presented here have been detected in the optical, by running a new cluster detection algorithm (Lobo et al., 2000, A&A in press) on the ESO Imaging Survey (Renzini & da Costa, 1997) data set. Additional BVRI photometry helped selecting these systems as problable distant

($z \geq 0.5$) clusters (Lobo, this conference). Follow-up spectroscopy was next performed providing us with spectra FORS1 at VLT UT1 (2 nights) for three clusters, CL 2245-3954, CL 2249-3958 and CL 0048-2942. Observations were made in September 1999. The adopted instrumental setup was as follows: 4500-8600 Å wavelength range (equivalent to 3000-5700 Å/ 2250-4300 Å for a $z = 0.5/z = 1.0$ galaxy), providing a nominal resolution of 11 Å (FWHM), equivalent to $\sim$ 6 Å in the rest-frame wavelength for a $z = 0.7$ galaxy. Such a performance is comparable with standard mid-resolution observations of local galaxies. We are probing the blue/near-UV features of the galaxy spectral energy distribution, where the Balmer 4000 Å break is the most prominent feature in the spectra.

We have between 6 and 8 masks for each cluster, each with 19 slitlets, which gives us approximately 400 spectra in total. Many of these will be field galaxies, red stars, etc, but we expect to have many galaxy clusters among them.

We have applied, for 3 masks for each cluster a quick look reduction procedure (Thomas Szeifert, ESO) with the ESO/MIDAS package. This procedure calculates the slit positions on the CCD, detects the targets automatically (for the very faint ones it won't work so we need to identify them interactively), does a 1st order sky subtraction, extracts the sources and does the wavelength and flux calibration.

Figures 1, 2 and 3 show some of these spectra, along with the identification of the galaxy in the image of the cluster. The lines of CaII H and K can be clearly seen is every spectrum. These, together with the CNλ3831 and the G band, were used to calculate the redshift of the objects. Some of the spectra also show the Hβ line and the MgI blend at 5176 Å, depending on the redshift. Since these are preliminary reduced spectra some lines of the sky, as well as atmospheric features, are still quite visible in the plots. This will be properly corrected in a standard reduction procedure.

For CL 2245-3954 there are mainly two sets of galaxies, with z = 0.66 and 0.54. CL 2249-3958 shows the main bulk of galaxies around redshifts of the order of 0.55. Four galaxies have z = 0.71. CL 0048-2942 seems to have more dispersed values of z. Figure 3 shows sets of galaxies with z $\sim$ 0.49, 0.64 and 0.70.

3 The population synthesis

We will apply to these spectra (once properly reduced) a stellar population synthesis method with a stellar database.

We will use a synthetic population algorithm developed by D. Pelat (1997, MNRAS 284, 365). This algorithm uses a new mathematical method, GPG, which gives a unique solution, contrary to the other methods widely used for population synthesis. It works with the equivalent widths (EW) of all the absorption features found in the spectra and continuum values. If we consider a galaxy made up of a set of stars with different spectral types, luminosities and metallicities, this particular composition will carry its own signature in terms of equivalent widths of the absorption lines: we define the composition by matching this signature as closely as possible to the observed equivalent widths, using the least squares method and a stellar library. The internal reddening is also a free parameter given by the method in an indirect way.

The accuracy of the fit is estimated through means of a parameter, the *distance*, which is defined as the sum, for all absorption features, of the difference between the observed EW and the synthetic EW calculated through the combination of the different stars that compose the stellar population obtained. This value depends on the number of absorption features used and the smaller this *distance*, the better the fit. Also, residuals estimated over the continuum help us to verify the accuracy of the solution found.

The stellar library will be chosen in order to cover the space temperature/gravity as much as possible without being degenerate. In fact, we cannot include as many stellar types as we

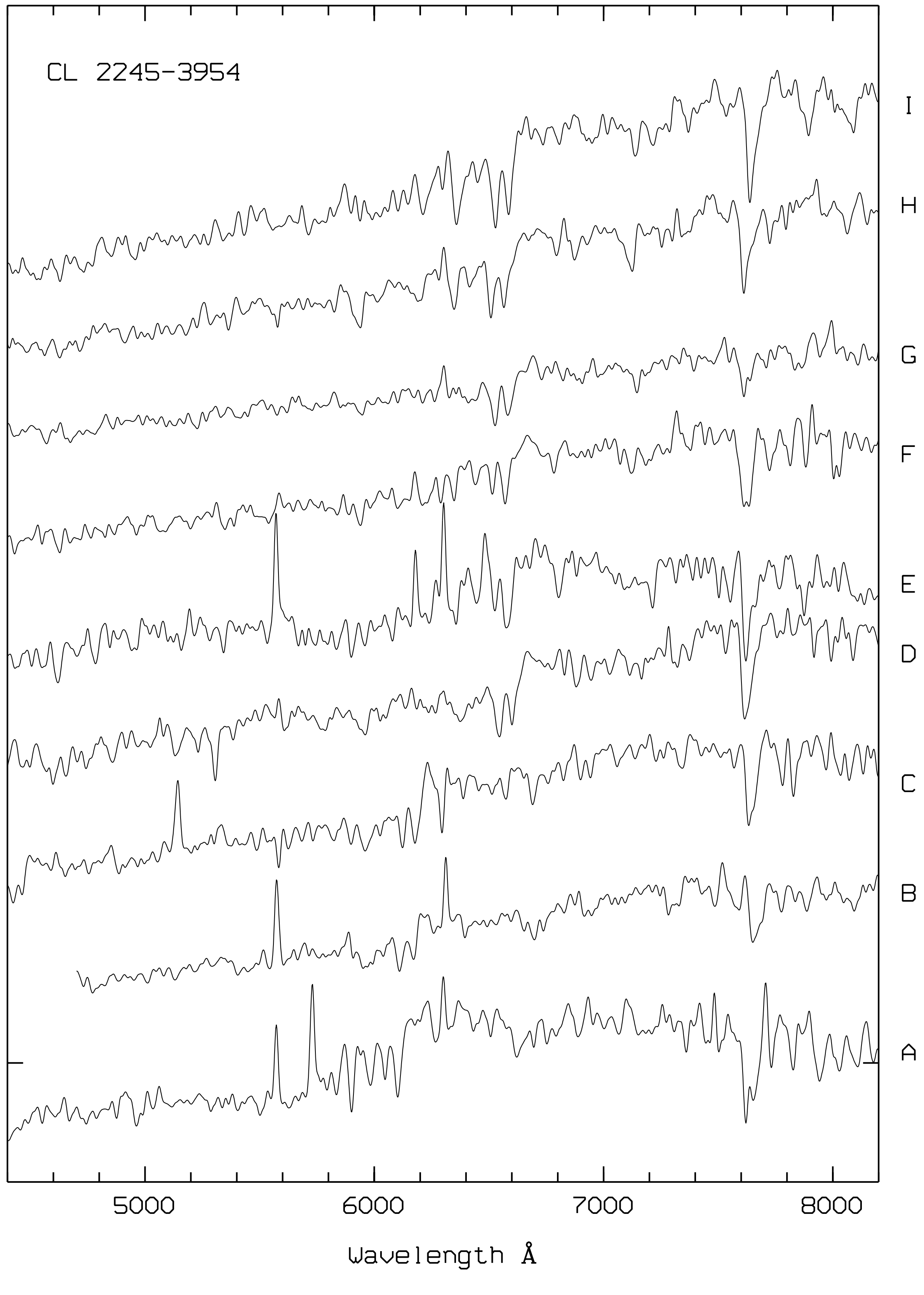

Figure 1: Spectra for CL 2245-3954, with z = 0.54 and 0.66

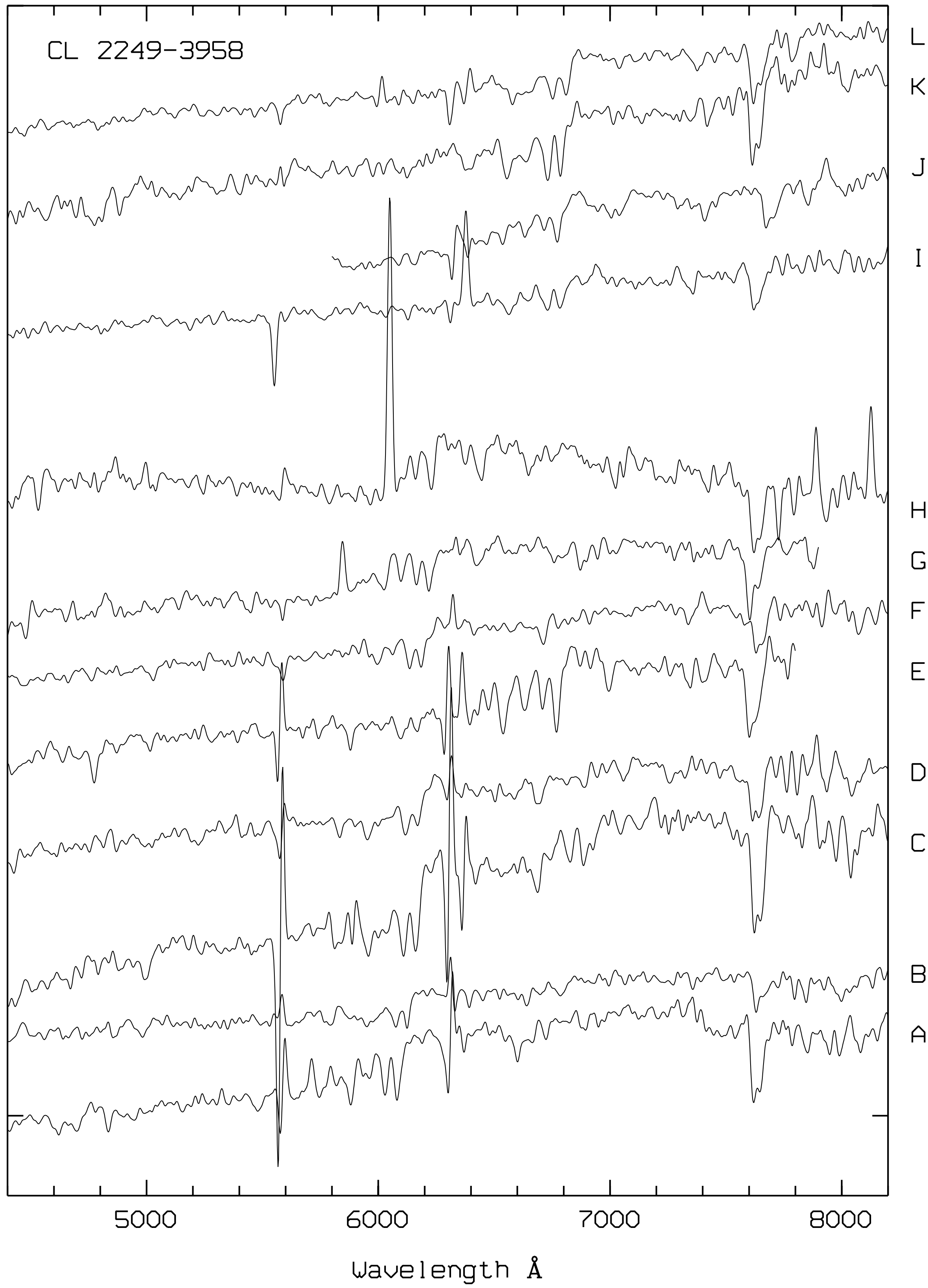

Figure 2: Spectra for CL 2249-3958, with z = 0.55 and 0.71

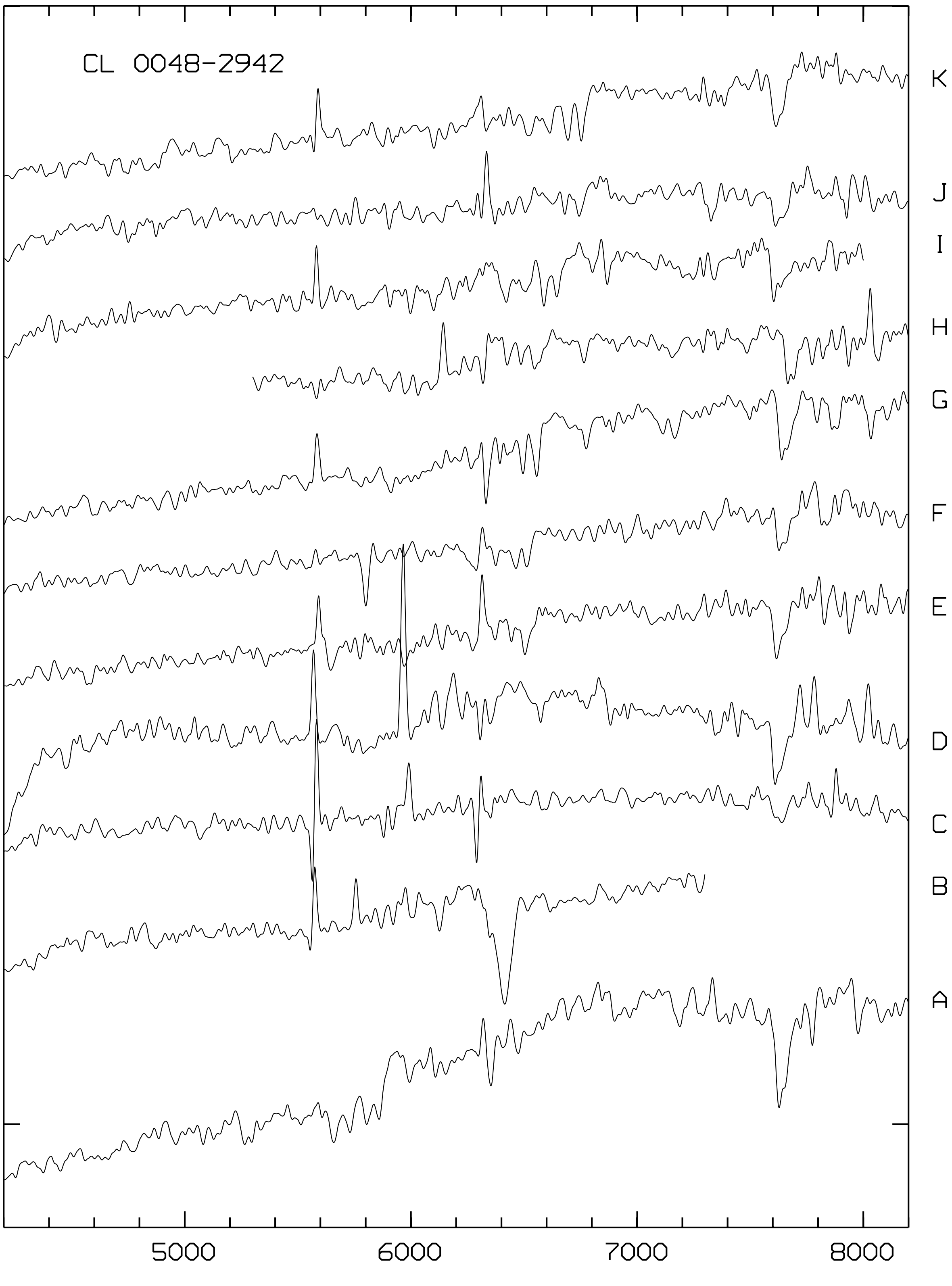

Figure 3: Spectra for CL 0048-2942, with z = 0.49, 0.64 and 0.70

would like in order to prevent stellar library degeneracy, i.e. having two different stellar types with spectral energy distribution similar enough to be indistinguishable in a mathematical sense. Some super metal rich stars will also be included.

This method was already applied with very good results to a sample of Active Galactic Nuclei (Serote Roos, 1996, PhD Thesis, University of Paris).

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