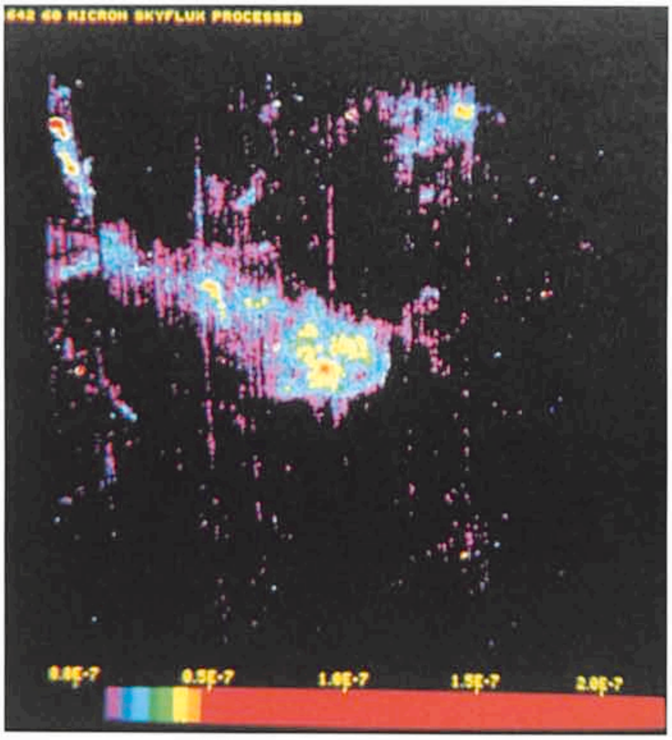

Figure 3: *Infrared (IRAS) surface brightness distribution at 60 μm in the area of L 1642. The marked area is shown in the optical image in Fig. 4. (This picture was kindly provided by R.J. Laureijs, Space Research Laboratory, Groningen.)*

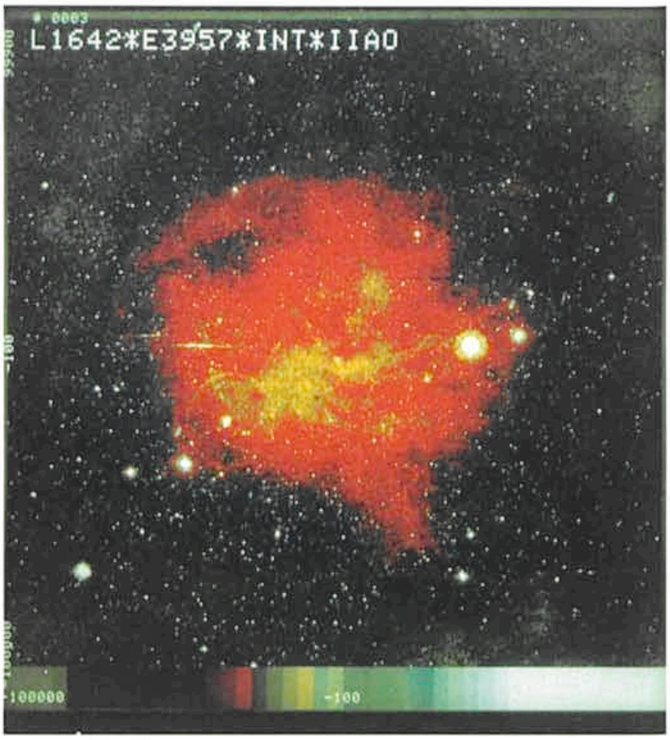

Figure 4: *Optical (blue) surface brightness distribution in the area of L 1642.*

scopes of the European Southern Observatory on La Silla since 1979. For these observations the southern dark nebula L 1642 at l = 210°.9, b = −36°.5 was selected in addition to L134. Based on our observations in 1980 and data available from IRAS we have recently completed a comparative infrared and optical surface brightness investigation of L1642 (Laureijs, Mattila and Schnur, 1987). Through the IRAS data we have a very effective method to determine the column density along each line of sight in and near the nebula. The 100 μm surface brightness distribution in the L 1642 area is shown in Fig. 3. For comparison we show in Fig. 4 the optical surface brightness distribution in the same area, measured on a blue (IIa-O) ESO Schmidt plate. It can be seen that high latitude dust clouds are effectively detected also by means of their scattered light, seen on deep photographic plates down to about the same levels as the thermal emission seen by IRAS. The lowest contours of both maps correspond to an extinction of ~ 0.2 magnitudes.

This investigation is a byproduct of the EBL measurements, but it is useful also on its own right:

From the relationship between the optical and infrared brightness in L 1642 we were able to derive e.g. the optical albedo of the dust and the ratio of visual to 100 μm opacity, which are important constraints to grain models.

4. New Measurements

In December 1987 we could spend again seven nights on L 1642 at the ESO 1-m and 50-cm telescopes under excellent sky conditions. By using the IRAS data we were this time able to considerably improve our measuring programme, since we had better means of identifying near the dark nebula regions which are free or almost free of dust. Guided by the IRAS data and our previous photometry we have also been able to locate probably the darkest and most opaque spot in the centre of L 1642 which provides the best zero point for the EBL measurement.

The photoelectric surface photometry of weak extended objects is hampered by the time variability of the airglow. One has to repeat normally in single beam photometry the ON and OFF source measurements after each other. We have been using a method in which the airglow fluctuations are eliminated by using simultaneous parallel observations with a monitor telescope (see Fig. 5). The efficient elimination of the airglow variations is demonstrated by Figs. 6a and b which show the sky brightness for a "standard position" in L 1642 as measured with the 1-m telescope through an 88" diaphragm in u and y during the night 15/16 December 1987. Also shown is the ratio of the 50-cm signal to the 1-m signal. As can be seen the ratio remains constant to within ±1% of the signal, which is the pure photon noise for the 40 sec integrations at the 1-m telescope.

The reductions of the observations are still going on at the moment. How-

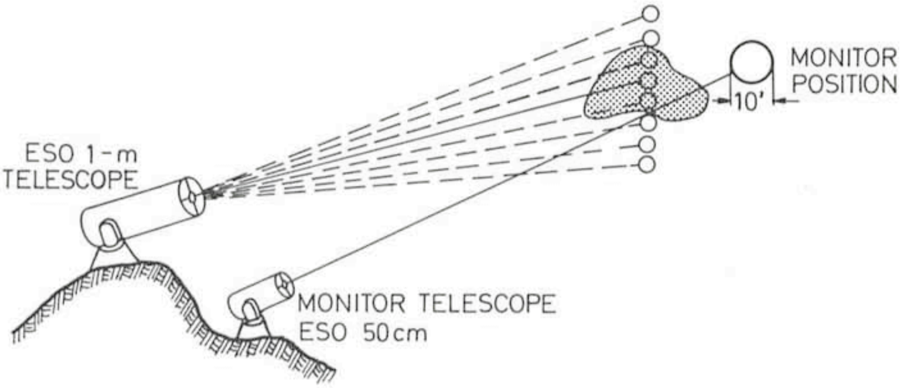

Figure 5: *The principle of elimination of airglow fluctuations by using two parallel telescopes.*

ever, thanks to the extremely good and stable sky conditions during these measurements and guided by our previous experience we are already hopeful to get this time a clearcut result on the weakness or the strength of the EBL.

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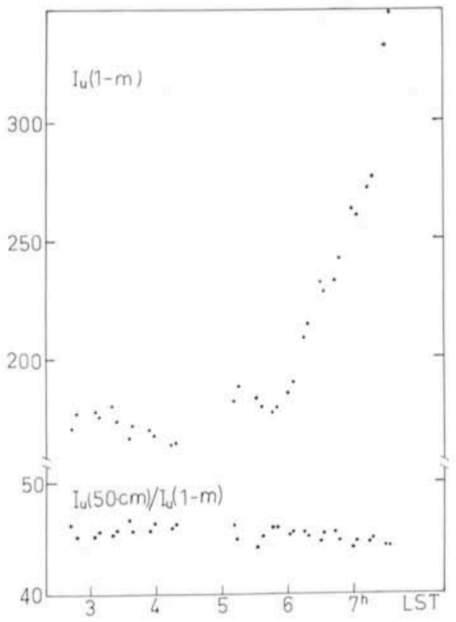

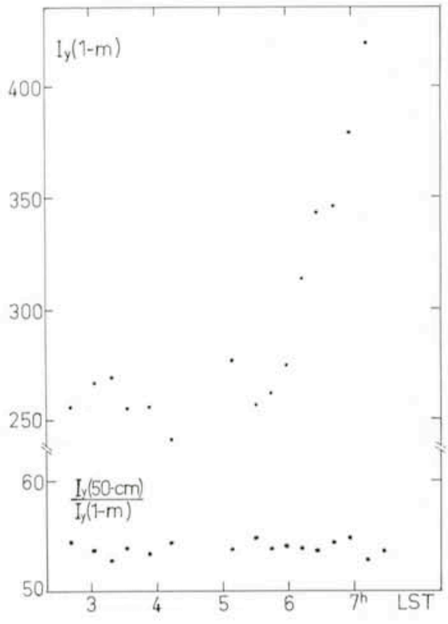

Figure 6a: *Variation of the night sky brightness in Strömgren u during the night 15/16 Dec. 1987. The upper part shows the signal measured in a fixed position at the centre of L 1642 through an 88″ diaphragm at the 1-m telescope. Units are 10^{-9} erg cm^{-2} s^{-1} sterad^{-1} Å^{-1}. The steep increase starting at LST 6^h is due to moonrise. Lower part is the ratio of the 50-cm and 1-m telescope signals.*

Figure 6b: *Same as Figure 6a, except for Strömgren y.*

MULTI-OBJECT SPECTROSCOPY WITH EFOSC:

Observations of Medium Distant Clusters of Galaxies

E. GIRAUD, ESO

1. Introduction

1.1 Context

Advances in the understanding of (a) galaxy and cluster evolution, (b) galaxy and cluster formation, and (c) their large scale distribution, have been made in the past years, but many questions are still open.

Colour variations of galaxies as a function of look-back time would arise from main-sequence turn-off points and would depend on how many stars evolve at what rate off the main sequence, on the star formation history and collapse time of galaxies. Demonstrating the evolution of galaxies (i.e. the more distant galaxies to have a younger population of stars) should be decisive for observational cosmology (see e.g. Butcher and Oemler 1978, Hamilton 1985, Spinrad 1986).

Hubble diagrams for brightest cluster members have shown a remarkably small scatter but large uncertainties due to stellar evolution are still present. Moreover the properties of these galaxies might be related to the density of the cluster core and the age through dynamical evolution (Hoessel and Schneider 1985). These evolutionary effects must be understood before any conclusion on the value of q_o and the geometry of the universe can be drawn.

Large redshift surveys (Arecibo, Harvard-Smithsonian CfA) have shown that inhomogeneities in the galaxy distribution can be characterized by voids, filamentary structures and strong clustering on small scales (e.g. de Lapparent, Geller and Huchra 1986). On large scales, inhomogeneities are still present at 100 h^{-1} Mpc. Understanding the large scale distribution of galaxies is certainly one of the fundamental problems of present observational cosmology.

Gravitational lenses with multiple imaging, due to the shear effect of a compact mass lying near the light beam coming from a distant object, have been observed (Liège Conference 1983). These spectacular gravitational mirages correspond to exceptional configurations. A more probable case corresponds to the gravitational amplification without multiple imaging by density inhomogeneities (i.e. the mean effect of several deflectors in a cluster; Weinberg 1976, Turner et al. 1986, Hammer and Nottale 1986). A rich compact cluster can be a powerful giant lens acting on the light of distant sources ideally located.

The observation of distant clusters may also give information on the geometry of the universe (Gunn and Gott 1972). For example, at z ~ 0.9, whether a cluster had time to form depends on H_o, q_o, and on the richness of the cluster.

For the understanding of these matters it is essential to have fair samplings of the universe. This is a long and difficult task which would require extensive observational efforts. More precisely, it would be necessary to perform a deep photometric and spectroscopic survey of distant galaxy clusters to detect evolutionary effects, and a wide angle medium deep redshift survey for the study of large scale inhomogeneities.

Figure 1: *Composite CCD image in the V-band of the central region (5.7 × 3.8 arcmin) of cluster Cl 1. North is up, east is left. The cluster core has been dimmed by ~ 1 mag in the image processing. The angular separation of the binary central system is 8 arcsec. (ESO 3.6 m + EFOSC; exposure time: 12 min).*

1.2 Photographic Surveys

A deep photographic survey of specific areas was carried out by Gunn, Hoessel and Oke (1986) with the 5-m Hale telescope and the 4-m Mayall telescope. This survey has led to the discovery of clusters up to z = 0.92. Coppi et al. reported observations of one of these clusters in the 48th issue of the *Messenger* (June 1987). They presented enlightening results on the probability to detect a cluster as a function of redshift.

A medium deep photographic survey of Abell clusters in the southern hemisphere, by Abell, Corwin and Olowin is nearly complete. In its present form, this catalogue gives information on (a) the apparent size of clusters, (b) the magnitudes of the 1st, 3rd and 10th brightest galaxies, and (c) the approximative number of objects brighter than ~ m (3) + 2 within a counting erea. These clusters should have redshifts almost entirely at z ≤ 0.4.[1] Prominent structures detected near the limit of the catalogue provide a basic list for observing medium distant (i.e. z ~ 0.2 – 0.4) southern clusters.

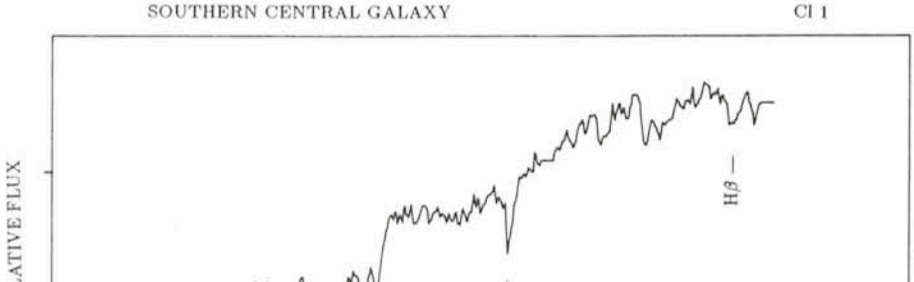

Figure 2: *A spectrum of the southern central galaxy of Cl 1, extracted from a multislit exposure with the B 300 grism. The measured redshift is z = 0.27. Spectra of 7 other galaxies were taken during this exposure. (ESO 3.6 m + EFOSC; aperture plate produced by the PUMA II machine.)*

2. Observations

Candidates were selected from this catalogue on the basis of the apparent luminosity of the first ranked object, the diameter (i.e. the compactness), and an estimate of the density enhancement over the expected background. Four superb clusters were observed with EFOSC mounted at the Cassegrain focus of the 3.6-m ESO telescope at La Silla. Photometry in B, V and Gunn I was recorded. The sky was clear and the seeing ~ 1.5 arcsec. The multi-object spectroscopic mode of EFOSC (MOS) was used to take spectra of the brightest objects. The techniques to operate the instrument and the automatic punching machine (PUMA II) are described in the Operating Manuals (Dek-

[1] Appreciable evolution is not expected in that range.

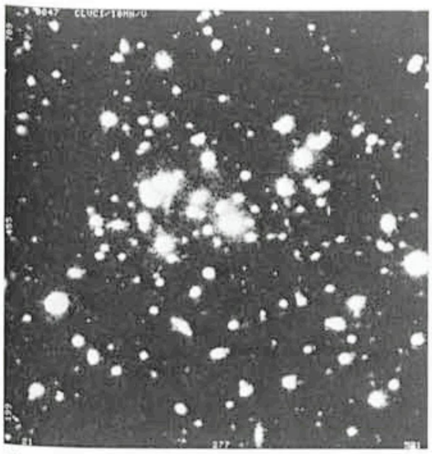

Figure 3: *CCD frame in the V band of the central part (2.8 × 2.8 arcmin) of the compact cluster Cl 2. North is up, east is left. (ESO 3.6 m + EFOSC; exposure time: 18 min.)*

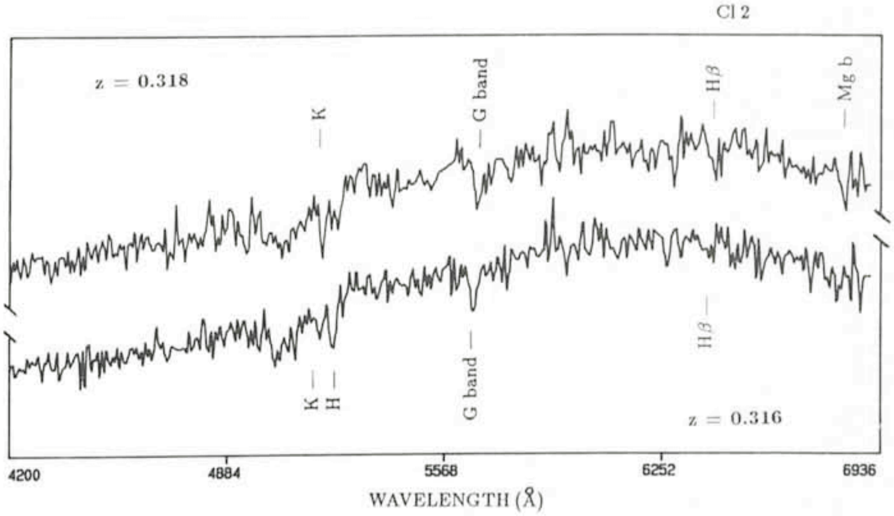

Figure 5: *Spectra of two galaxies of cluster Cl 2 extracted from the same 90-min multislit exposure as in Fig. 4. Magnitudes are V = 20.8 and V = 21.1 respectively. One of the spectra was shifted up for clarity.*

ker and D'Odorico 1985, 1986; Dupin and Dekker 1986). Results of MOS observations can be found in the Proceedings of the ESO-OHP Workshop on CCD detectors (D'Odorico and Dekker 1986) and in the *Messenger* No. 47 (Dupin et al. 1987).

The detector was ESO CCD No. 11, which is a high resolution RCA CCD (15 μm pixel). Direct images needed to prepare the masks for multi-object spectroscopy were acquired in the 2 × 2 binned mode. The masks were punched during the afternoon preceding the second observing night. Most spectra were taken through 20 arcsec slits. Round holes centred on field objects were used for the alignment of the masks on the fields. Two iterations and a final check (about 15 min) were necessary to make the alignment. The spectra were obtained with the B 300 grism, that gives a dispersion of 230 Å/mm and a total wavelength coverage of 3700–7000 Å. Wavelength calibration was accomplished with a helium lamp through the mask after each programme exposure. Spectrophotometric stars were observed for flux calibration.

The image of cluster Cl-1 presented in Figure 1 is a mosaic of CCD frames taken in the V-band. Exposure time is 12 minutes. This cluster is regular, very rich, with two giant cD type galaxies in its centre imbedded in an extended envelope and surrounded by a number of smaller elliptical or lenticular objects. The central part of the image has been dimmed by 1 mag in the image processing. Disk galaxies are found at larger angular distance from the centre. Brightest edge-on galaxies may be foreground objects. There is some evidence of subclustering around a third large galaxy 80 arcsec NNW. The apparent magnitudes of the first ranked central objects are V = 17.9 and V = 18.4. The projected separation of their centres is 8 arcsec. Reliable magnitudes can be measured down to V = 22.5. The redshift distance is z = 0.27. A spectrum of the southern central galaxy is shown in Figure 2.

This spectrum was extracted from a 75-minute multislit exposure after filtering for cosmic ray events and sky subtraction.

Cluster Cl 2 (Fig. 3) is regular, rich, compact, and has a triple core. The central galaxy (V = 19.3) is surrounded by a corona of E or S0 galaxies (V ~ 21). It has a redshift of z = 0.315 (Fig. 4). The similarity in redshift and the angular separation of CL 1 and 2 (60–70 h^{-1} Mpc) could infer that they belong to the same large-scale structure.

The central galaxy is very red (B–V = 1.6 mag). This is partly intrinsic (large 4000 Å break amplitude) and partly due to the shift of the spectral energy distribution (K term). A large amplitude of the 4000 Å break is generally suggestive of no ongoing star formation. Low val-

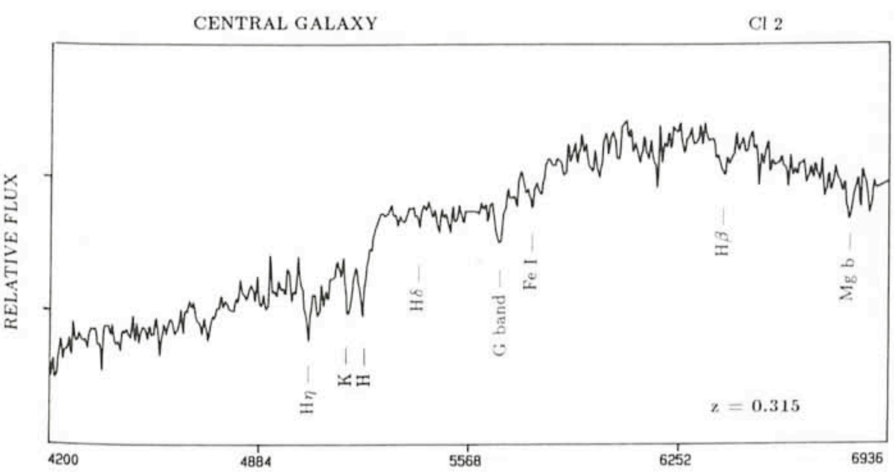

Figure 4: *A spectrum of the central galaxy of cluster Cl 2 extracted from a 90-min multislit exposure. The measured redshift is z = 0.315. Magnitude of the galaxy is V = 19.3.*

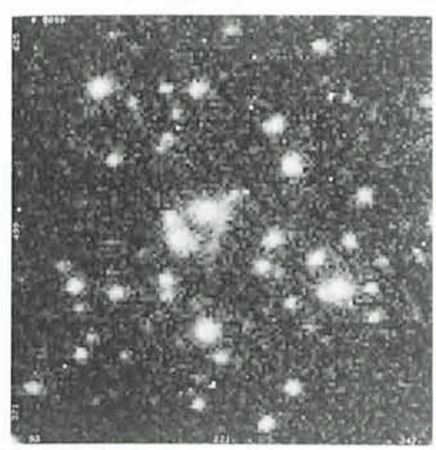

Figure 6: *A blue image of the central part of cluster Cl 2, showing an elongated structure near two large elliptical galaxies. The projected angular distance between these two galaxies is 7.5 arcsec. The arc-like structure and the centre of the nearest galaxy are separated by 2.8 arcsec in projection.*