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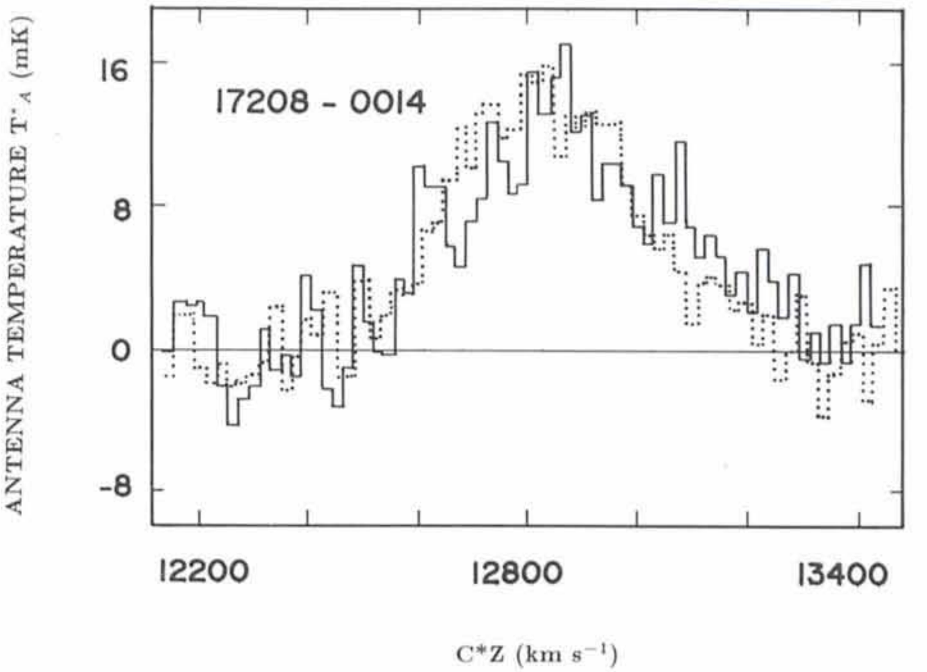

Figure 4: *CO(1→0) emission profile of an ultraluminous infrared galaxy as observed with SEST (solid line) and the NRAO 12-m telescope (dotted line). This type of observation shows that luminous infrared galaxies are extremely rich in interstellar molecular gas.*

Blue Galaxies in the Field of the Quasar PKS0812+02

E. GIRAUD, ESO

1. Introduction

Some galaxy clusters at z=0.3–0.4 have a higher frequency of galaxies with signs of recent star formation or nuclear activity than their nearby counterparts. The most luminous red galaxies in these clusters, however, do not show any evidence of evolution. At higher redshift (z=0.7) there seems to be a significant variation in the 4000Å break amplitude of the reddest galaxies (Dressler, 1987; see also Giraud, 1990), suggesting that evolution of the most passive galaxies has also been detected.

Low-redshift quasars ($z \leq 0.4$) are not found in very rich clusters of galaxies. Nevertheless they appear to be located in regions of higher-than-average galaxy density (Yee and Green, 1984). The environment of quasars at $z \sim 0.6$ is sometimes radically different. Some of them are found in environments as rich as those of Abell class 1 clusters (Yee and Green, 1987). While at higher redshift field contamination is necessarily large, Tyson (1986) and Hitzen, Romanishin and Valdes (1991) have also reported an apparent excess of galaxies near quasar at $0.9 \leq z \leq 1.5$.

These sets of observations indicate that there has been a rapid evolution of clusters in the range z=0.2 to 0.7.

The nature of the population of clusters containing quasars is not well known. Results on two of these have shown that they have a large blue population (Yee, 1988). In fact, the cluster which is apparently associated with PKS0812+02 at z=0.403 (Fig. 1) has a fraction of blue objects larger than any of the ten clusters at z = 0.3 observed so far in the GC3 programme. According to Yee, this structure is compact and centrally concentrated and has a richness between that of class 0 and 1.

Observing the population in the field of PKS0812+02 is important for the following reasons:

(a) the cluster membership has to be carefully checked since a quasar in a cluster is a rare event, and because the population in this probable cluster appears to be photometrically different;

(b) its redshift is in the range where there seems to be a dramatic evolution of clusters.

Obtaining spectra of blue galaxies is important for understanding the nature of this intriguing population.

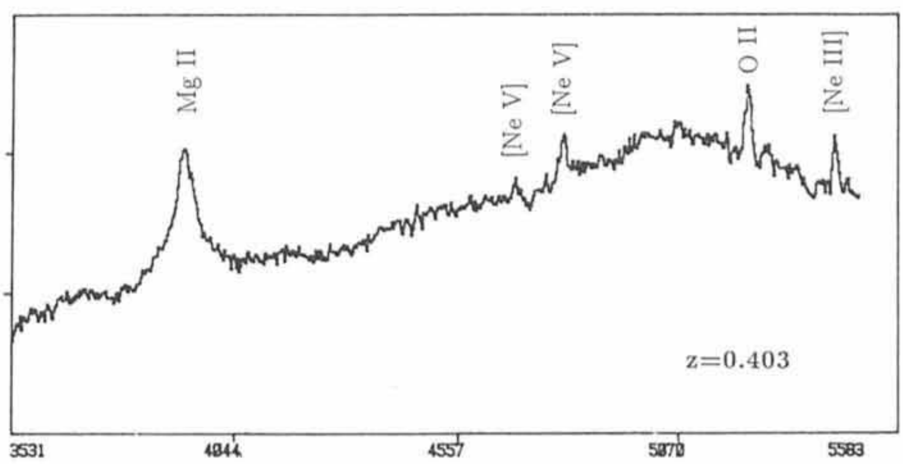

Figure 1: *A blue spectrum of PKS0812+02 obtained with the NTT and EFOSC2 at a resolution of 2Å per pixel (Grism No. 3). The observation was done to check the feasibility of blue spectroscopy with a TH CCD (January 30, 1990; exp.:1800 s).*

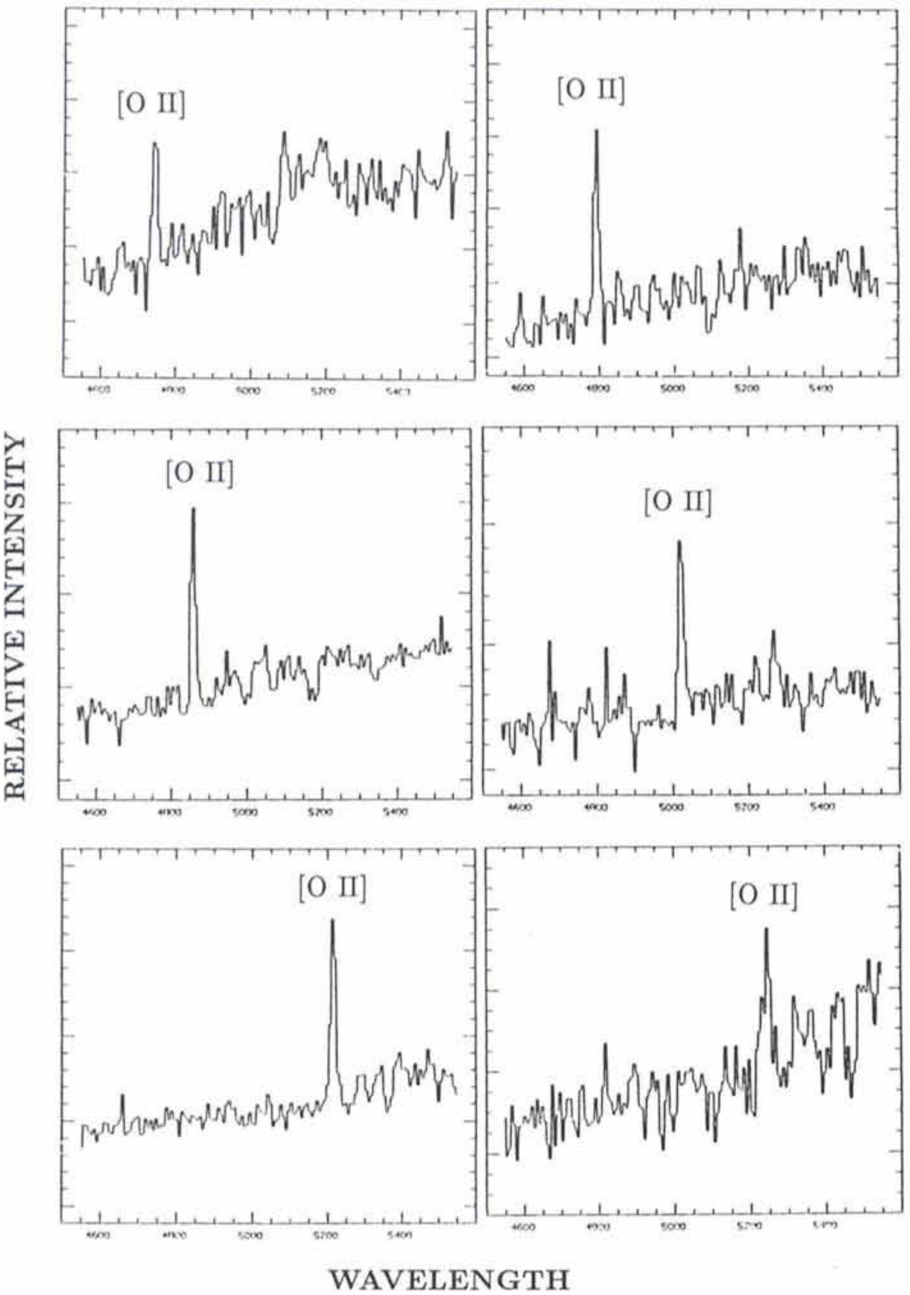

Figure 2: *Spectra in the region of the [O II] λ 3727 Å emission line of 6 blue galaxies in the field of PKS 0812+02. Redshifts range between $0.273 \leq z \leq 0.406$.*

TABLE 1: *Data for galaxies in the field of PKS 0812+02*

Ident.	V	B−V	z	EW(Å)
(1)	(2)	(3)	(4)	(5)
PKS	17.10*	0.18*	0.403	**
No. 1	20.7	1.35	0.305	–
No. 2	22.2	1.05	0.285	50
No. 3	21.6	1.15	0.347	40
No. 4	21.3	0.95	0.303	30
No. 5	21.2	1.35	0.307	–
No. 6	21.0	1.05	0.399	28
No. 7	21.1	1.45	0.325	–
No. 8	21.2	1.15	0.406	15
No. 9	21.2	1.00	0.273	12

Notes: * from Véron's catalogue (1989)
** not measured

2. Blue Galaxies in the PKS 0812+02 Field

The spectroscopic observations were made at La Silla with EFOSC mounted at the 3.6-m telescope. One multislit exposure (7200 s) was obtained through cirrus on December 18, 1990, and repeated (3600 s) the next night. Six blue galaxies with V magnitudes between $21.0 \leq V \leq 22.2$ and three red galaxies have been selected. All blue galaxies are

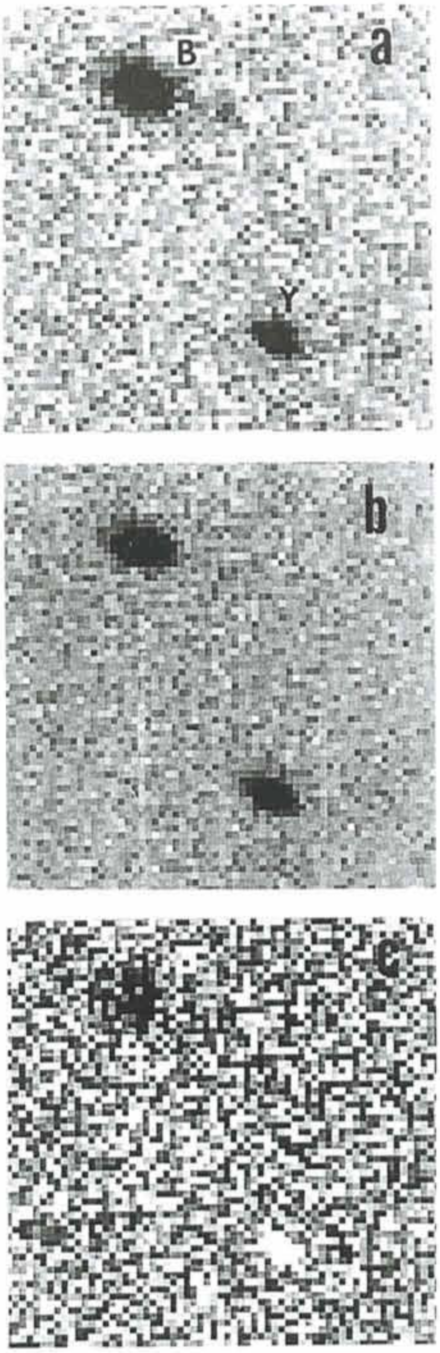

Figure 3: (a) *A V-band image of an emission-line galaxy at z = 0.2 (B) and of a yellow galaxy at z = 0.3 (Y) obtained with EFOSC2 at the NTT (seeing 0."81),* (b) *Same as (a) but in the I-band (seeing 0."85),* (c) *the ratio of the V/I images showing that the region close to the nucleus of the blue galaxy is very blue. The objects are in the field of Cl 0500-24.*

found to have a well visible [O II] λ 3727 Å emission line (Fig. 2) and the red objects have a rather large 4000 Å break amplitude.

The redshift of the galaxies show that we are not observing a cluster at the same redshift as the quasar. Seven objects out of nine could be in a cluster or a loose structure at $z \sim 0.3$ and two blue objects have the same redshift as the quasar (Table 1). Galaxy No. 6 is physically linked by an O II bridge to the quasar (Guzzo et al., 1988).

Perhaps the most surprising point is not that the cluster and the quasar are at different redshifts. The singularity is that this apparent cluster has such a peculiar population. Firstly it has a large blue excess, secondly it does not contain a core of very bright elliptical galaxies, thirdly the velocity spread is higher than expected. If giant elliptical galaxies were born in high density peaks of the initial density distribution, their absence suggests that there is not here a strong gravitational potential. There are indeed 10 red galaxies in the range $20.7 \leq V \leq 22$, implying the presence of a cluster. But the velocity range of the blue galaxies and the apparent compactness of the structure also suggests that we are observing a filament in the line-of-sight. Understanding the geometry of this structure would require more spectroscopic work.

The measurements of the [O II] λ 3727 Å equivalent width E(W) show that four of the blue objects have E(W) > 25 Å indicating that they are "bursting" objects or have nuclear activity. The absolute magnitudes of these galaxies are similar to those of the 6 "bursting" objects in Cl 0500-24. But in that case the redshift range $0.314 \leq z \leq 0.333$ is compatible with that of a rich cluster at $z = 0.32$. Possible explanations on the nature of these objects include galaxy interactions, environment dependent bursting, nuclear processes. Good spatial resolution imaging can tell us whether the star formation is across the entire disk, nuclear, associated with companions.

An example of an emission-line galaxy at $z = 0.2$, observed with EFOSC2 at the NTT (March 1990), is shown in Figure 3. Also shown is a red galaxy at $z = 0.3$. The V image (Fig. 2a, seeing 0".81) is slightly more extended than the I band image (Fig. 2b, seeing 0".85) indicating that the star-forming region is larger than the old component. A grey scale of the V-I colour (Fig. 2c) shows that the bluest part is in the central region implying that activity close to the nucleus plays a role in this object.

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Artificial Intelligence for Astronomy

ESO course held in 1990

H.-M. ADORF, ST-ECF/ESO

Introduction

To many people "Artificial Intelligence" is as fascinating as astronomy, to some it is a mystery and to some simply an annoyance. By constructing appropriate computer software, researchers in artificial intelligence laboratories around the world attempt to solve a variety of tasks generally considered to require some form and degree of intelligence. Among these tasks we find natural (written) language processing, speech processing, vision, symbolic computation (as opposed to numeric computation), various forms of formal reasoning such as theorem proving and uncertainty reasoning, learning, game playing and so on. A number of interesting results have been obtained in the past, but progress has been generally slower than anticipated by early enthusiasts, a phenomenon not unknown in other scientific areas.

A formal definition of artificial intelligence cannot be provided, but for our purpose it suffices to say that "AI", as it is often simply called, consists of the science of processing symbols by computers. What exactly is subsumed under the AI umbrella changes with time, a fact which has nicely been summarized in Tesler's law: "AI is whatever hasn't been done yet."

A Brief Excursion Into History

The roots of today's AI adventure can be traced back several centuries. The ancient Greeks already explored the rules governing our everyday logic. In the 17th century Blaise Pascal and Gottfried Wilhelm Leibniz dreamt of machines that could perform intellectual tasks. Boole and DeMorgan in the 19th century devised "the laws of thought" (i.e. propositional calculus) and developed rules for formal reasoning by manipulating symbols. Early in our century the eminent German mathematician David Hilbert posed several difficult problems, among them the question whether mathematics could eventually be completely formalized using a logical calculus. This conjecture was refuted through subsequent important discoveries by the logicians Kurt Gödel (1931) and Alonzo Church (in the 1930s) and one of the legendary fathers of computers, Alan Turing (1930s–50s).

Gödel, for instance, found the then shocking "Incompleteness Theorem" (see e.g. Hofstadter, 1979) which essentially says that within every formal theory there will be some conjecture which is *undecidable;* using predicate logic, neither its truth nor its falsity can be proved within the set of notions and axioms used for their formulation. This discovery ended speculations about the possibility of doing mathematics solely by mechanical theorem provers.

Turing made a number of important contributions to the general field of computing. In 1936, before the invention of 'real' computers, he posed the *halting problem:* "Is it possible to (mechanically) prove for every computer programme whether it will eventually stop?" His an-