PROFILE OF A KEY PROGRAMME

# A Homogeneous Bright Quasar Survey

*C. BARBIERI[1], S. CRISTIANI[1], P. ANDREANI[2], R. CLOWES[3], A. GEMMO[1], C. GOUIFFES[2], A. IOVINO[4], F. LA FRANCA[1,5], A. SAVAGE[6], R. VIO[1].*

*[1]Department of Astronomy, Padova, Italy; [2]European Southern Observatory; [3]Royal Observatory, Edinburgh, Great Britain; [4]Brera Observatory, Italy; [5]Institute of Radio Astronomy, Bologna, Italy; [6]UK Schmidt Telescope Unit, AAO, Australia*

## 1. The Dreams

As extremely luminous objects visible to high redshifts, quasars have long offered the promise of directly exploring the distant Universe. Counting quasars, however boring and repetitive it may appear, allows one to address basis issues in Cosmology, such as: when did quasars form and how evolved the gravitational engine providing their extreme energies? How are quasars related to galaxies? When did galaxies form? What structure has the Universe at the largest scales? On what scale does the Cosmological Principle finally apply? Which models can explain plausibly the transition from the smooth Universe of the microwave background to the very inhomogeneous Universe of today?

## 2. The Reality

A number of quasar surveys, carried out with different techniques and limiting magnitudes, have yielded in the last years a considerable insight, and details of the evolutionary history of the quasar population are slowly emerging as the database increases. Clustering of quasars on small scales has now been confirmed at the 5 $\sigma$ level of significance[1] and there is also evidence for evolution of the QSO correlation function with cosmic time.

With the development of new techniques for automatic detection and analysis of images, a powerful tool has become available to astronomers. However, to obtain useful cosmological information, it is necessary to carry out statistically well-defined surveys, allowing one to quantify selection effects in the first place and to minimize the subsequent investment of telescope time for spectroscopic confirmation of the candidates. The relevance of this point is well illustrated by the chronic issue of isotropy in the extant samples.

In another context, while Wampler and Ponz[3] indicated that redshift- and luminosity-dependent biases may superpose to the point of allowing marginal consistency with no evolution, at the other extreme Marshall[4] claimed that optical samples whose magnitudes are evaluated by means of simple iris photometry, after only a mean correction for lines, provide bias-free slope and evolution rate of the LF with statistical uncertainties of only a few per cent in all parameters, including the evolutionary time scale. The difficult evaluation of the so-called *Bennett effect*[5,6] and the "contamination" of the continuum magnitudes by the lines entering the various filter bandpasses give origin to the above-mentioned contradiction. The problems in the evaluation of the QSO evolution rate in the presence of observational biases are explained in detail by Cavaliere, Giallongo and Vagnetti[7]. In order to understand and account for these selection effects, we have been studying the field of SA 94 for many years with complementary techniques[2].

As a consequence of the unsatisfactory database, the shape of the Luminosity Function and the determination of the form of evolution as $L \propto (1+z)^k$ or $L \propto e^{T/\tau}$ are uncertain. Trends of this form, potentially telling about the mechanism to fuel the central engine (in principle they can reveal if the QSO phenomenon is driven by the surrounding environment or determined by its nuclear conditions only), maybe spuriously favoured by fits that overlook the observational biases. To probe the real trend, not only the database at faint magnitudes has to be enlarged[8,9], but also the incompleteness at bright magnitudes should be bound or removed with better samples allowing an adequately sophisticated analysis.

The PG bright quasar survey[16], at the bright end of the Log N–Log S diagram, is especially affected because of the shape of the luminosity function and of the low ratio ($\simeq$2.5) F/$\sigma$, where F is the flux and $\sigma^2$ is the variance of the magnitudes, compared to other existing samples. A true increase of information about LF shape and evolution is obtained only combining rich "homogeneous" samples, i.e. with sensibly matched signal-to-noise ratios: if anything F/$\sigma$ ought to be larger for the brighter samples with a magnitude limit crossing the steep branch of the LF.

The present situation of quasar counts (for quasars with $z < 2.2$) is summarized in Figure 1.

## 3. Our Plans

From the above considerations it can be easily seen that a new survey (F/$\sigma$ > 4) is required for the bright part of the

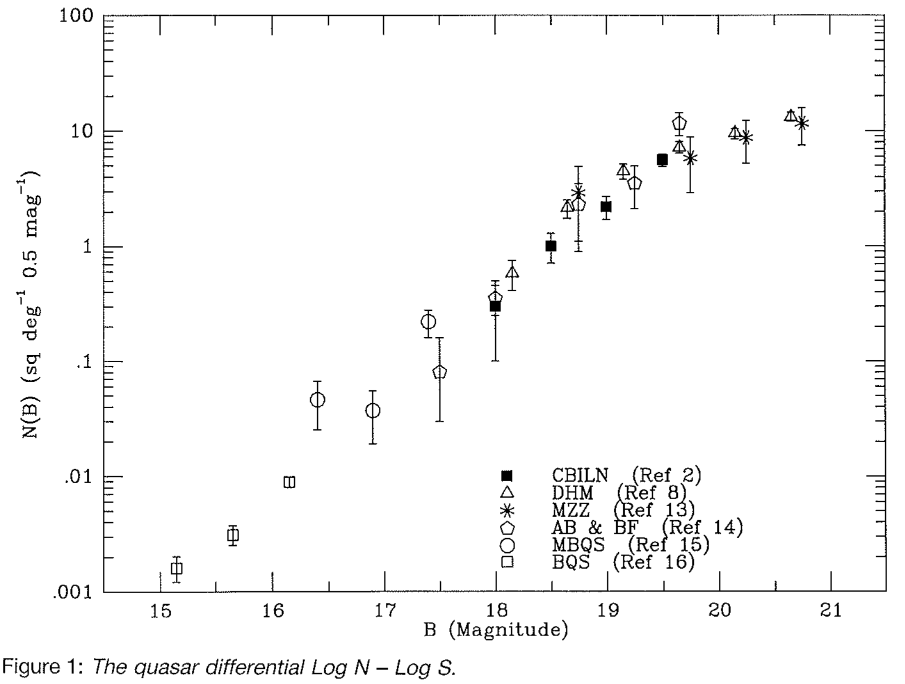


Figure 1: *The quasar differential Log N – Log S.*

Log N – Log S diagram where the PG sample is incomplete and the information from other surveys is still scanty. This happens at 16 < B < 18.25, where we expect surface densities of $10^{-2}$ and 1 quasar (z < 2.2) per square degree, respectively.

In order to obtain a number of quasars statistically significant we need to survey an area of the sky of 2000 sq. deg. We have selected the zone around the south galactic pole, extending below b = −60°, which has the following advantages:

(a) the galactic absorption is minimized. It may be argued, in fact, that the imperfect knowledge of the galactic extinction prevents a determination of a photometric scale better than a tenth of a magnitude and, ultimately, from a detailed understanding of the fluctuations of the quasar surface density[10]. Furthermore, at lower galactic latitudes the reddening would oblige us to loosen the colour-selection criteria, whose even small modification would bring in the quasar locus a number of galactic candidates very expensive in terms of telescope time

(b) the contamination from galactic objects is minimized. We expect to find a large number of quasars and, of course, a much larger number of candidates. Even a small departure from high galactic latitudes would again increase the number of spurious candidates to an unbearable level

(c) a number of other surveys, with complementary techniques, have been carried out on this area of the sky, providing an easy way to calibrate our selection criteria and check the effectiveness and completeness of our search. Other surveys will be carried out in the future: for example ROSAT, which will allow to compare X-ray and optical quasar properties; or galaxy redshift surveys[11] which would provide the information about the low-redshift absorbers of the spectra of our higher-redshift bright quasars, etc.

To cover this area of the sky, 77 fields (1925 sq. deg) of Schmidt telescope plates are needed. They will be taken in five (U, B, V, R, I) bandpasses (in place of the 2 or 3 commonly used) not only to select also high redshift candidates (which at those magnitudes will be a small fraction of the quasars), but especially to reduce the locus occupied by stars to a tiny fraction of the multidimensional colour space, thus increasing the success rate and minimizing the time required for follow-up spectroscopy. The plates are taken within a short time in order to reduce the effects of variability and reach objects about one magnitude fainter than the limit of the survey. Quasar counts are obtained independently in B, V and R in order to disentangle the K-correction effects. The candidates are selected on the basis of clustering analysis on the multicolour space[12].

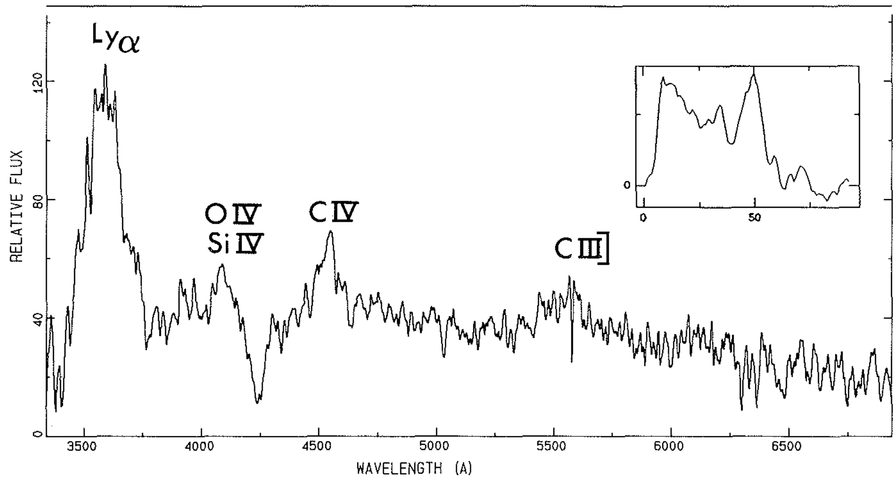


Figure 2: *Our first Key-Programme quasar. In the upper right (with the direction of the dispersion inverted) the tracing of the AQD objective prism spectrum.*

To obtain reliable LFs, a good photometric UBVRI calibration is required, and this is accomplished with photoelectric photometry at the 1-m and with CCD photometry at the 2.2-m telescope.

An analogous project in the northern hemisphere will be started with the Asiago Schmidt telescope and will eventually enable us to obtain significant statistics down to B ≃ 15.5.

## 4. More Dreams . . .

A better understanding of the quasar luminosity function will not be the only outcome of this programme:

(a) we expect to find a few hundred Seyfert galaxies for which a fine tuning of the multicolour technique will allow us to determine a complete sample

(b) a study of the variability of the objects (by comparison with the plates of the original ESO blue survey) will allow us to study the LF of the BL Lac objects (and to check the completeness of the quasar survey), for which only scanty information is available at present

(c) the large-scale clustering of quasars, for which almost nothing is known, will be studied

(d) precise statistical information will be available for millions of objects, which can be used for stellar counts, galaxy studies, crosscorrelation with catalogues at different wavebands, etc.

## 5. First Results

The first observations of quasar candidates, selected on plate material previously taken at UKSTU and ESO, started last September. The first one and a half field were completed, objects in five more fields were observed. An improved AQD[17] selection technique, for UKSTU objective prism data, was successfully tested, with encouraging results both in terms of success rate and completeness, aiming at a sample of QSOs up to z ≃ 3. After the second run (in November) the first meaningful counts will be produced.

In Figure 2 the spectrum of the first confirmed quasar of our Key-Programme is shown. It is nothing special (apart from the probable Broad Absorption Lines) but it has already more than one hundred comrades. And when a thousand of them will gather, some revolution may burst.

In this way, counting, counting, we hope to fulfil our dreams . . .

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