What can we learn from VIRMOS quasars?

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Abstract. Large, homogeneous quasar samples are necessary tools for the study of QSO statistics, cosmological tests, large scale structure and AGN evolution. These samples must be complete within well defined flux limits at all redshifts. An observational strategy without previous photometric selection of quasar candidates is described, based essentially on the VIRMOS Survey spectroscopy.

1 Samples of quasars: why?

Thanks to their high luminosities, quasi-stellar shape and strong emission lines, both photometry and spectroscopy of quasars are rather easy. The average redshift of quasar samples is still relatively high in spite of the continuous increase of galaxy redshifts, so, large and homogeneous quasar samples are useful for cosmological purposes, in particular for the study of: i) the statistics of the AGN, which will help to progress towards a better understanding of the ‘unified’ models, ii) large scale structure (clustering of QSOs and of QSO absorbers), and iii) for the global evolution of the AGN population and its links with normal galaxies. Recent observational data on the evolution of the density of quasar light in the universe both from radio and optical quasars show a reversing of the evolution around $z = 3$ ([1]). Since 1993, the corresponding theoretical understanding is in continuous progress, in terms of Eddington-limited growth of Super Massive Black Holes embedded in growing dark halos, (eg. [2]; [3]; [4]), undergoing successively turning-on and turning-off on short time-scales ([5]) through either viscous instabilities ([6]) or tidal interactions ([7]). The latter authors find ‘negative’ density evolution (DE) at $z > 3$, corresponding to the birth of galaxies, and ‘positive’ luminosity evolution (LE) at $z < 3$, corresponding to the progressive depletion of material to accrete.

2 Cosmological Tests with Quasars

With a complete quasar sample, it is possible to perform geometrical cosmological tests. ([8]) compute a characteristic scale $\lambda_{QQ} \simeq 100 \, Mpc$, from the quasar-quasar correlation function, fix $\lambda_{QQ} = 125 Mpc$ and constrain $(\Omega_m, \Omega_\Lambda)$ almost independently of the evolution. Eliminating anisotropies in the power
Figure 1: Left: Likelihood map in the $(\Omega, \Lambda)$ plane, [14]. Right: PDE parameter in bins of redshift, [15]

spectrum of the 3D correlation function computed from redshift surveys of galaxies and quasars constraints on $\Lambda$ and $\Omega^{0.6}/b$ [9], [10]. [11] analyse the angular size-redshift relation of double-lobed FIRST quasars.

Given a data set, any assumption on the cosmological parameters leads to constraints on evolution, and conversely, as was done from quasar counts assuming Pure Luminosity Evolution (PLE) [12] or Pure Density Evolution (PDE).

Assuming constant PLE parameter $k_L$ over the redshift range $[0.3, 2.2]$, the V/Vmax Statistics applied to the AAT sample [13] favors the couple of values $(\Omega = 0.5 \pm 0.3, \ 2\sigma; \ \Lambda = 0.6 \pm 0.4)$ (Fig. 1a) [14]. (quite compatible with the recent results shown in this conference by both SN teams)

Perhaps the most questionable hypothesis in LVW is that the luminosity evolution parameter $k_L$ is constant over the redshift range $[0.3, 2.2]$. Fortunately, it has been shown that either PLE or PDE with a roughly constant $k$ is not too bad an approximation, at least in the limited redshift range $0.7 \leq z \leq 1.7$ (Fig. 1b) [15].

So far, cosmological constraints from quasar samples have been obtained from simplistic evolution schemes only, however the actual evolution appears to be far more complex at redshifts $2 < z < 3$. The theoretical progresses mentioned above will allow better constraints to be extracted in this way from quasar samples complete at all redshifts.

3 Multicolor selection, and the problem of the redshift range $2.5 \leq z \leq 3.2$

Before using quasar samples for cosmological purposes, one must beware of observational biases. Multicolor techniques such as UVX or BRX are very efficient in defining quasar candidates in various redshift ranges. More precisely, the most known UVX selection is extremely efficient for (blue) quasars up to
redshift \sim 2.2 \) (see for example \cite{13}, \cite{16}), while BRX selection reveals quasar candidates at even higher redshift \((z \geq 3, \cite{16})\). However, in all recent attempts to construct a complete catalog, a problem occurs for quasars whose redshift belongs to the interval \(2.5 \leq z \leq 3.2\) where the multicolor techniques cannot usually distinguish between quasars and main sequence stars, because of quasars’ stellar-like colors. Using an appropriate combination of filters this redshift interval can be restrained but it has never been completely covered until now.

Fig. 2 shows the superposition of the (simulated) quasar trails and the (observed) main sequence stars \cite{17} with \(m_B \in [21, 22.5]\) in the redshift ranges \([2.5, 2.8]\) and \([3.5, 3.7]\) in the \(-(B-V)/(V-R)\) plan.

4 The VIRMOS quasars

Several samples of typically a few thousand quasars, a size quite convenient for most of the above purposes, are planned or are presently being assembled (see several contributions at this conference). Most of them, however, are based on the preselection of quasar candidates, in order to optimize the efficiency of telescope time. Preselection makes the completeness questionable both at low redshift (morphological preselection of a stellar shape, incompleteness by a factor up to 5 \cite{15}), and at high redshift (color preselection, results from color-color diagrams of \cite{16} still reveals a strong bias in the range \(2.2 \leq z \leq 3\), exactly where a reversing of evolution is observed).

A promising observational strategy is allowed by the VIRMOS Survey, which could avoid the main drawbacks of preselection. To improve the efficiency of all quasar studies, one obviously has to increase both the size and the upper redshift limit of the sample, and to be as complete as allowed over the whole redshift range. The VIRMOS spectroscopic large survey of faint galaxies will
provide the opportunity of assembling such a sample. This is because stars and stellar objects are only a marginal population of the deep sky, allowing the spectroscopy of a large fraction of stellar objects to be done. At this conference, O. Le fevre already described the main characteristics of this survey. For our concern, what is important with respect to most previous or future quasar surveys, is that there will be NEITHER color NOR morphological preselection of quasar candidates, but only some random selection for the shallow sample. The obvious advantage will be the possibility to test the completeness of the most current surveys, both at low and high redshift, which are based on morphological and color preselection, respectively. We expect to assemble 2 unbiased samples, \((1300^{+500}_{-500})\) quasars brighter than \(I=22.5\) from the shallow survey and \((700^{+600}_{-300})\) quasars brighter than \(I=24\) from the deep survey. Furthermore we are examining the possibility to get a third, color-selected, sample of \(4500^{+500}_{-500}\) quasars, which would be far larger, but biased because obtained by spectroscopy of candidates based both on color preselection in the associated MEGAPRIME photometric survey and on counterparts of sources in the XMM Deep Survey (see the contribution of M. Pierre, this conference) which will have at least some common fields with MEGAPRIME and VIRMOS surveys.

In brief, the VIRMOS quasar sample will offer the opportunity to check the usual modes of selection of quasar candidates, to study numerous absorbers, to study jointly active galaxies and quasars in a complete sample containing both with essentially common selection criteria, and, last but not least, it will be partly free of biases in the redshift range \(2 < z < 3\) where evolution is specially complex.

References

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