Poster contributions of the "Advanced Lectures on the Starburst-AGN Connection", Eds. R. Mújica, I. Aretxaga & D. Kunth, 2001, INAOE Electronic Edition (http://www.inaoep.mx/∼agn00/posters.html), pp. 9-11

The FIRST-APM QSOs Survey in the SBS sky region

Chavushyan V.H[1], **Verkhodanov O.V.**[2] **Mújica R.**[1], **Valdés J.R.**[1], **and Carrasco L.**[1,3]

[1] Instituto Nacional de Astrofísica Optica y Electrónica, Tonantzintla, Puebla, México.
[2] Special Astrophysical Observatory, Russian Academic of Science, Nizhnij Arkhyz, Karachai-Cherkess Republic, 357147, Russia.
[3] Observatorio Astronómico Nacional, UNAM, Ensenada, B.C., México

Abstract. The main goal of the FIRST-APM QSO Survey (FAQS) is to compile the most complete sample of bright QSOs, located in the well optically investigated area of the sky covered by the Second Byurakan Survey (SBS). Here we report the first results of our ongoing study based upon the cross-identification of the FIRST radio catalog and the Automated Plate Measuring Machine (APM) optical catalog. The overlapping sky area between the FIRST and the SBS surveys is about 700 deg^2. Our compiled list of sources for this overlapping region contains ~ 400 quasar candidates brighter than $B = 18\overset{m}{.}5$. Of which, about 90 objects are already spectroscopically classified. These objects were discovered maynly by the SBS survey. During 1999, we have carried out spectroscopic observations for more than 100 FAQS objects with the 2.1m telescope of the Guillermo Haro Astrophysical Observatory (GHO). Until now we have found 33 new QSOs, 2 Seyfert Galaxies, 15 emission line galaxies, 1 BL Lac, and 45 high galactic latitude stars. Amongst the 33 QSOs, we have found two broad absorption line (BAL) QSOs: FAQS J151113.7+490557 and FAQS J161744.4+515054. These two BAL QSOs are radio-loud, and have radio-to-optical flux ratios (*log R*) with values of 1.1 and 2.5 respectively. The last object being the brightest radio-loud BAL QSO known, with a flux density of 99.8 mJy at 1.4 Ghz.

1. Introduction

QSO surveys may provide basic information to understand a number of cosmological key issues, such as: the epoch of galaxy formation, the physics of the AGN phenomenon, the formation and evolution of large scale structure. So far, over 11000 QSOs are known (Véron-Cetty & Véron 1998). Several fundamental questions are still open in relation to the nature of these objects and the internal relationships between their physical properties. For instance, their surface and space densities are quite important for the understanding of evolutionary aspects. The latter requires always data from complete samples of objects, in terms of redshift and of intrinsic luminosity.

The ideal searching technique should produce a sample that includes 100% of the objects of interest and that is free of contaminating objects. However, in practice, one faces a trade-off between maximizing the level of completeness of the sample, and at the same time, minimizing the number of confusing objects within it. The degree of completeness can in theory be determined by comparing the results from different survey techniques (e.g. multicolor selection vs slitless spectroscopy).

Historically, the optical QSO samples have been selected either on the basis of their emission lines or peculiar colors. The QSOs can also be found by their radio, X-ray and/or their infrared properties and/or their variable nature. Optically selected quasar samples are the most complete ones. However, every survey technique has a redshift and luminosity-dependent selection biases (Wampler and Ponz 1985). Taking into account the selection effects, inherent to every technique adopted to search for QSOs, is obvious that only the combination of the different search techniques for the different spectral ranges, will yield a complete sample of QSOs, with an adequate representation of all their inherent properties (Hartwick & Shade 1990, Chavushyan 1995).

The emphasis on optically selected samples is due to the efficiency of the techniques in finding the objects of interest. Radio selected samples suffer the difficulty of identifying their optical counterparts, a difficulty arising from poor radio positions. Furthermore, in the past, radio selected samples have been largely insensitive to radio quiet objects, which make up the majority of the QSO population. Yet, optically selected quasar samples have their own disadvantages. These samples usually exclude QSOs with atypical colors. A radio selected sample that reaches faint flux limits, such as FIRST, shall be immune to optical color selection effects.

The FIRST radio survey (Becker et al. 1995) provides a new resource for constructing a large quasar sample. With positions accurate to better than $1''$ and a point source sensitivity limit of 1 mJy, it goes $\sim$ 50 times fainter in flux, than any previous radio survey. A QSO survey based on FIRST and APM (Irwin 1998) catalogs is the FBQS (Gregg et al. 1996). Unfortunately, in the area covered by the FBQS there are not complete optically selected samples of QSOs. Hence, it is very difficult to estimate the completeness of the survey, as well as, the number of missed quasars in the optical sample conformed by the FBQS.

In order to circumvent this problem, we have started a multiwavelength search of QSOs in the Second Byurakan Survey (SBS) sky area, we also made use of radio and X-ray data. The SBS is a low resolution objective prism survey with a limiting magnitude of $B \sim 19\overset{m}{.}5$, that covers 1000 square degrees in the sky region defined by $07^h43^m < R.A. < 17^h17^m$ and $+49° < Dec. < +61°$ (Markarian and Stepanian 1983; Stepanian 1994a). The SBS has produced one of the largest and most homogeneous complete sample of bright QSOs (Stepanian 1994b; Stepanian et al. 1999) with accurate BV photometry (Chavushyan et al. 1995, 1999). Amongst the bright quasar surveys the SBS is the only slitless survey which covers a large, continuous area of the sky. In this survey, stellar and non-stellar objects are selected jointly.

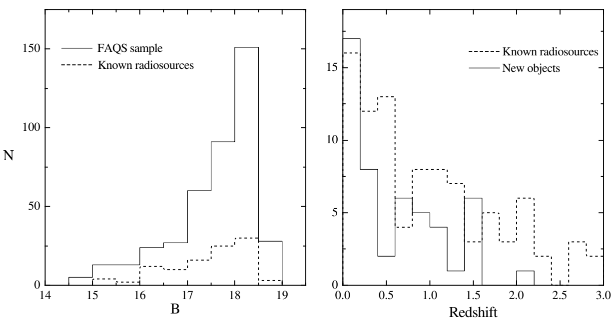

Fig. 1. The histograms of the magnitude and redshift distributions for the FAQS sample.

2. The sample

As a first step, in order to detect the missing QSOs in the SBS, and to create the most complete QSO sample, we have used the deep radio (FIRST) and optical (APM) databases. We call this sample FAQS. The overlapping area between FIRST and SBS surveys is quite significant, covering about 700 deg^2. We have cross-identified the FIRST catalog with APM objects. Adopting the following selection criteria:

1. Coincidence of the positions of the FIRST and APM objects within a $3''$ radius;
2. Objects classified as stellar-like on APM;
3. APM B–magnitudes between $14\overset{m}{.}5$ and $18\overset{m}{.}5$

The procedure of cross-identification was made with the CATS database routines (Verkhodanov et al., 1997, *http://cats.sao.ru*), operating with the 1999 July version of the FIRST catalog.

Our list of sources in this overlapping region contains ~ 400 objects, of which 90 were previously known AGNs, mainly discovered by the SBS.During 1999, we have carried out spectroscopic observations for about 100 FAQS objects.

3. Observations

Three observing runs in 1999 were allocated to our project. The observations were carried out with the 2.1m GHO telescope and the LFOSC (Zickgraf et al. 1997) focal reducer equipped with a 600×400 pixel CCD. A set-up covering the spectral range of 4200-9000 Å with a dispersion of 8 Å/pixel was adopted. The effective instrumental spectral resolution being about 16 Å.

3.1. Preliminary results

In this subsample we have found 33 new QSOs, 2 Seyfert Galaxies, 15 emission line galaxies, 1 BL Lac, and 45 high galactic latitude stars.
Among the 33 QSOs, we have found two broad absorption line (BAL) QSOs, namely, FAQS J151113.7+490557 and FAQS J161744.4+515054. These BAL QSOs are radio-loud, and have a radio-to-optical flux ratios, *log R* (Weymann et al. 1991), equal to 1.1, and 2.5 , respectively. The last object has a flux density of 99.8 mJy at 1.4 GHz, being the brightest radio-loud BAL QSO known so far.
This long-term project will allow us to compile the first multiwavelength complete sample of bright quasars. This new complete sample of QSOs will help to address several unsolved questions, such as the surface density of bright quasars and whether or not there is different evolution between radio-loud and radio quiet QSOs.

This work has been supported by **CONACYT** research grants **No. 28499-E**, **No. G2858-E**, and **J32178-E**

References

Becker, R.H., White, R.L., and Helfand, D.J. 1995, ApJ, 450, 559
Chavushyan, V.H. 1995, PhD thesis. Nizhnij Arkhiz
Chavushyan, V.H., Stepanian, J.A., Balayan, S.K., and Vlasyuk, V.V. 1995, Astr. Lett. 21, 804
Chavushyan, V.H. et al. (in preparation)
Gregg, M.D., Becker, R.H., White, R.L., Helfand, D.J., McMahon, R.G., and Hook, I.M. 1996, AJ, 112, 407
Hartwick, F.D.A., and Shade, D. 1990, ARAA, 28, 437
Irwin, M. 1998. *http://www.ast.cam.ac.uk/~apmcat/*
Markarian, B.E., and Stepanian, J.A. 1983, Astrofizika, 19, 639
Stepanian, J.A. 1994a, DSci thesis. Nizhnij Arkhiz

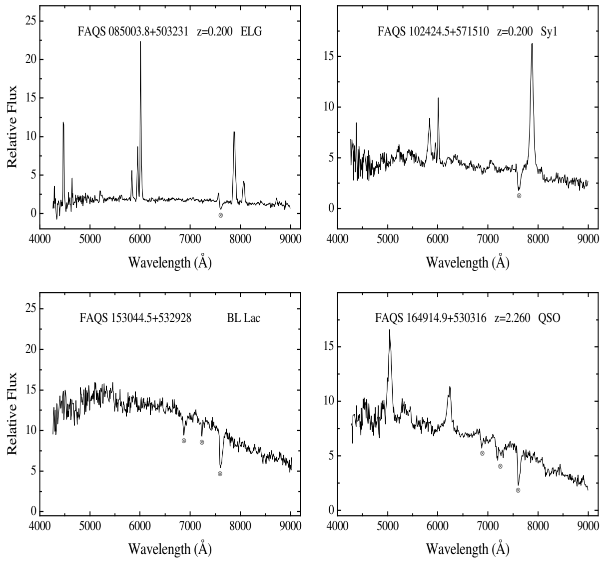

Fig. 2. Typical examples of LFOSC spectra of different type of objects contained in the FAQS sample. Telluric absorption features are marked by encircled crosses.

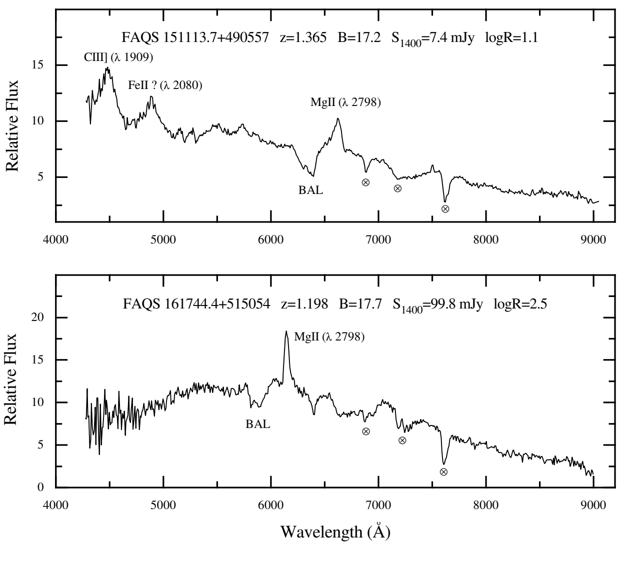

Fig. 3. The spectra of the radio-loud BAL QSOs found in the FAQS. Telluric absorption features are marked by encircled crosses.

Stepanian, J.A. 1994b. In "Astronomy from Wide-Field Imaging". Eds. H.T. MacGillivray et al., 731

Stepanian J.A., Chavushyan, V.H., Carrasco, L., Tovmassian, H.M., and Erastova, L.K. 1999, PASP, 111, 1099

Verkhodanov, O.V., Trushkin, S.A., Andernach, H., Chernenkov, V.N. 1997. In "Astronomical Data Analysis Software and Systems VI". Eds. G. Hunt & H.E. Payne. ASP Conference Series, 125, 322

Véron-Cetty, M.-P., and Véron, P. 1998, A Catalog of Quasars and Active Nuclei, ESO Sci. Rep. No. 18

Wampler, E.J., and Ponz, D. 1985, ApJ, 298, 448

Weymann, R.J., Morris, S.L., Foltz, C.B., and Hewett, P.C. 1991, ApJ, 373, 23

Zickgraf, F.J., Thiering, I., Krautter, J., Appenzeller, I., Kneer, R., Voges, W.H., et al. 1997, A&AS, 123, 103