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The Red Bright Quasar Survey (RBQS)

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Abstract. We are using the UK Schmidt telescope (UKST) to carry out a new objective prism survey, covering 2000–3000 square degrees of high galactic latitude sky in the equatorial region. The survey is targeted at discovering both bright ($R < 18$) quasars in general and bright high redshift ($2 < z < 4$) quasars in particular, which will be valuable for high resolution spectroscopic follow-up studies. We are using a mixture of ultra-violet excess (UVX) and a new template matching technique to identify all the bright quasars. Details of the project are discussed and some preliminary results of the survey are presented.

1. Introduction

The discovery and detailed study of high redshift quasars provides important observational information on the structure, history and evolution of the Universe. Bright quasars are particularly valuable as probes for determining the chemical evolution, and the clustering properties of the intervening gas clouds and galaxies (e.g. Blades et al. 1988).

At present, the southern sky compared to the northern sky has a considerable lack of bright high redshift quasars. Consequently, our aim in this project is to find a number of very bright quasars in the south similar to those found in the north (Q1107+487: m(v) = 16.7 & $z_{em} = 3.0$; Q1442+295, m(v) = 16.2 & $z_{em} = 2.7$ (Sanduleak & Pesch, 1989); HS1700+6416, m(v) = 16.1 & $z_{em} = 2.72$ (Reimers et al. 1989); HS1946+7658, m(v) = 15.85 & $z_{em} = 3.02$ (Hagen et al. 1992)).

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There is still considerable uncertainty in the normalisation and redshift evolution of the quasar luminosity function (e.g. Hewett et al. 1993; Miller et al. 1992). With a new sample of ~100 bright quasars it will be possible to investigate the evolution of the bright part of the quasar luminosity function over a large redshift range. There is evidence from a variety of sources that the Palomar-Green bright quasar survey may be incomplete by a factor of 3. This has been seen most clearly in the multi-colour search of Goldschmidt et al. (1992), but is supported by unpublished results from the Second Byurkan Survey and the Hamburg Survey. An accurate definition of the bright end of the luminosity function is essential if we are to disentangle the effects of density and luminosity evolution.

This survey will also enable a new study of the spatial distribution and correlation function of quasars on very large scales. For example, Clowes and Campusano (1991) have presented evidence of a large concentration of quasars extending over several hundred Mpc. Our new survey should provide an independent test of whether such apparent concentrations are real or an artifact of the limited and inhomogeneous statistical samples currently available.

In this paper we describe a new survey we have initiated at the UKST to find quasars suitable for these applications.

2. Quasar Survey

2.1. UK Schmidt Telescope

The survey is based on low dispersion (2400 Å/mm at Hγ) objective prism plates and films. We are using "red" sensitive emulsions, either Kodak IIIaF or Tech Pan, to give an effective wavelength coverage of 3200–6900 Å.

To date there have been five observing runs on the UKST. With an exposure time of 20 mins for a IIIaF plate and 15 mins for Tech Pan film it is possible to take more than 10 UKST fields per night. From these observing runs we have 72 6×6 degree plates and films taken between 0 and -10 degrees in declination. There are a further twenty or so suitable IIIaF archive prism plates in the declination range -10 to $+10$ degrees. After eliminating poor quality plates this still leaves us with over 2000 square degrees already surveyed. The exposure time is a compromise between achieving a decent limiting magnitude (R~18) and not saturating the brighter objects in order to be still capable of recognising quasars at R~15. A wavelength limit of ~6900 Å extends further to the red allowing Lyman α to be visible to redshifts of ~4. The IIIaJ surveys tended to have saturated objects at brighter magnitudes (Hazard, 1991) and a wavelength cutoff of ~5300 Å making them better for faint, lower redshift surveys.

In the survey we are predominately using the Tech Pan film as it is proving to give a higher signal to noise ratio than the IIIaF (sky noise is a factor 2 smaller on the Tech Pan film). For the fainter objects this gives a spectrum where it is easier to detect the "real" features. Another advantage of Tech Pan film is that it is cheaper than its IIIaF counterpart.

2.2. APM Scanning and Object Selection

The prism plates and films are digitised at the APM (Automated Plate Measuring) facility in Cambridge. Objects are pre-selected using UKST R survey direct plates to define a magnitude limited sample (R < 18). This provides a coordinate list which is then fed to the APM scanner and the spectra of some 30000 to 60000 objects per plate are then automatically extracted. The extracted spectral data are analysed in order to identify the quasar candidates using techniques similar to those developed at the APM facility by Hewett et al. (1985) for the lower redshift objects ($z < 3$) in the IIIaJ surveys. We have developed an algorithm to detect the higher redshift objects ($2.5 < z < 4$) and other non-UVX quasars based on a median template method. It was necessary to design a method similar to that discussed by Hewett and Irwin (1987) because of the difficulty in analysing the head of the spectrum unveiled by the "red" emulsion. Objects are first binned on a grid, the coordinates of which are defined by sorting objects by colour (the half-power point of the spectrum expressed in Å) and spectral magnitude (integral of the spectral flux). A template is formed in each bin by first scaling all objects in that bin to have a common intensity and then finding the median spectral flux at each wavelength pixel. The difference between a target spectrum and the appropriate median template is then used to compute a modified Kolmogorov-Smirnov (K-S) statistic for each object. Fig. 1 shows a plot of the K-S statistic as a function of colour. A single "3 σ" cutoff is used to define candidate objects. Objects lying beneath the cutoff have small differences compared to the median templates (i.e. are "normal" Galactic foreground stars) and the unusual objects with significant spectral differences of any nature, lie above the cutoff.

The technique was tested on the South Galactic Pole (SGP) field and found all the known non-UVX quasars above the magnitude cut of R = 18. A complementary UVX selection criterion is used for the lower redshift objects. All selected candidates are checked on the plates and films to remove any contaminated spectra.

2.3. Spectral Follow-up

The first two stages of this project are well in-hand, and the techniques being used are proving to be extremely effective for selecting suitable candidates. We are obtaining approximately 60 UVX objects and 80 template-selected objects per field. The third stage of the project is the confirmation of the quasar candidates using spectroscopy. The MMT (in collaboration with Chris Impey and Nadine Dinshaw), ANU 2.3m, and FLAIR on the UKST have been used for follow-up.

The overall timing of the project is dependent upon both the availability of telescope time and the rate at which candidates can be observed per run. For instance a candidate rate of 80–90 per night is possible using FLAIR. However, only objects brighter than $R < 17.5$ can be observed using this system, as was shown on a trial run in October 1993. The first test of the median template approach for candidate selection, found a R = 17.5; z = 3.4 quasar, 2355+0108 (see Fig. 2), very suitable for the fourth stage, high resolution follow-up spectroscopy.

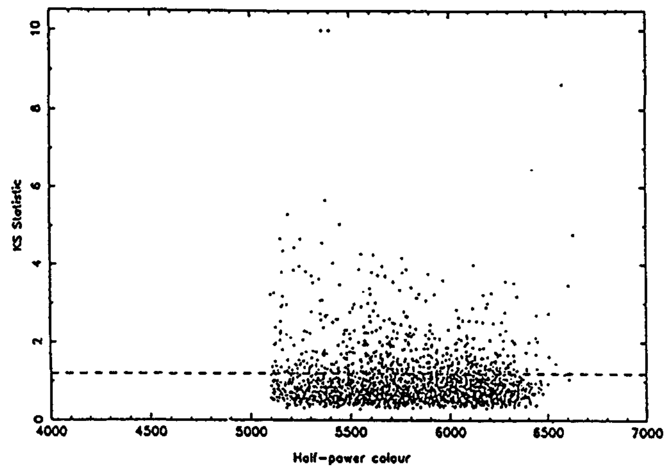

Figure 1. A plot of K-S statistic against colour (half-power) for a magnitude range of R = 13.0–14.0 in field F859. The objects that lie above the cutoff (dashed line) have significant spectral differences from the median templates. Blue spectra with colours below 5100 Å were selected separately using UVX.

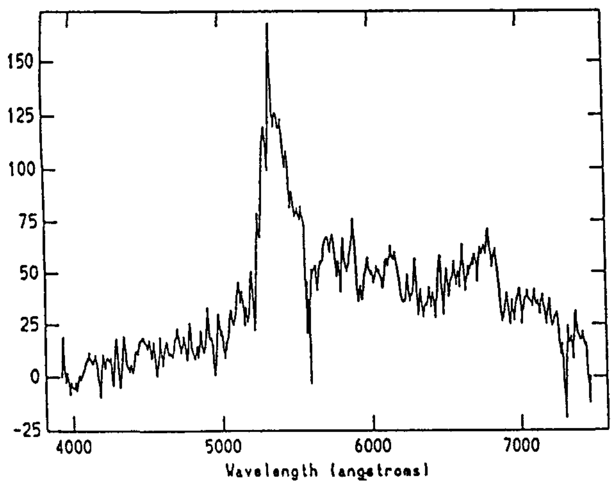

Figure 2. A new bright high-redshift (R = 17.5 z = 3.4) quasar, 2355+0108 (23 55 34.83, 01 08 23.8, B1950.0), confirmed with FLAIR in October 1993. The axes are counts against wavelength.

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3. Discussion

We have spent much time in refining the selection processes for the IIIaF plates and Tech Pan films to give a high return rate of quasars to candidates. Typically, of the UVX objects selected, 40 per cent observed will be quasars. As the median template method has only been active since September 1993 the success rate is hard to gauge, as not all objects selected from a field have yet been observed. Presently the objects from both the UVX selection and the median template method are biased toward those candidates we consider most likely to be quasars. The remainder of the candidates selected from the fields will also be observed in due course. There have been 15 fields scanned by the APM so far, the rest will be scanned over the next two years. A few fields will have all candidates observed to determine a completeness correction for the whole survey. Further completeness checks will be made using model quasar spectra at different magnitudes and redshifts.

The survey is now well under way, in the future we can expect a sample of bright high redshift objects, suitable for high resolution follow-up studies and to aid in the determination of the bright luminosity function and spatial distribution of quasars.

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References

Blades J.C., Turnshek D. & Norman C.A., 1988, in *QSO Absorption Lines: Probing the Universe*, STScI Symposium Series 2, Cambridge

Clowes R.G. & Campusano L.E., 1991, MNRAS, 249, 218

Goldschmidt P., Miller L., La Franca F. & Cristiani S., 1992, MNRAS, 256, 65P

Hagen H.-J., Cordis L., Engels D., Groote D., Haug U., Heber U., Kohler Th., Wisotzki L. & Reimers D., 1992, A&A, 253, L5

Hazard C., 1991, ASP Conf. Ser. 21, p.170

Hewett P.C., Irwin M.J., Bunclark P., Bridgeland M.T. & Kibblewhite E.J., 1985, MNRAS, 213, 971

Hewett P.C. & Irwin M.J., 1987, Patt. Rec. Lett., 5, 113

Hewett P.C., Foltz C.B. & Chaffee F.H., 1993, ApJ, 406, L43

Miller L., Goldschmidt P., Franca F.L. & Cristiani S., 1993, in *Observational Cosmology*, ASP Conf. Proc. 51, G. Chincarini, A. Iovino, T. Maccacaro & D. Maccagni, eds, p.614

Reimers D., Clavel J., Groote D., Engels D., Hagen H.-J., Naylor T., Wamsteker W. & Hopp U., 1989, A&A, 218, 71

Sanduleak N. & Pesch P., 1989, PASP, 101, 1081

Discussion

Hawkins: In the early days of objective prism work, success rates were typically 20 per cent or less. Do you have any reason to believe that you will be able to do better than this ?

Sealey: For the median template method we are unable to comment on this, as we have only just started employing this technique. We will hopefully be able to address this question in a few months. For the UVX selected objects we presently have a success rate of $\sim$ 40 per cent.