A CATALOGUE OF QUASARS AND ACTIVE NUCLEI

(10th edition)

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1 Summary

The recent publication of the first release of the 2dF quasar catalogue (Croom et al. 2001) containing nearly 10 000 new QSOs, almost doubling the number of known such objects, led us to prepare an updated version of our catalogue of quasars and active nuclei which now contains 23 760 quasars, 608 BL Lac objects and 5 751 active galaxies (of which 2 765 are Seyfert 1). Like the ninth edition, it includes position and redshift as well as photometry (U, B, V) and 6 and 11 cm flux densities when available.
We also give a list of all known lensed and double quasars.

2 Introduction

The first catalogue of quasars was published in 1971 by De Veny et al. It contained 202 objects for which redshifts were published prior to june 1971. The number of known quasars has since steadily increased, but the recent release of the "2dF QSO redshift survey" (Croom et al. 2001) has almost doubled this number which is expected to increase again dramatically when the final 2dF catalogue will be published at the end of 2002 containing $\sim$ 15 000 new QSOs and when the "Sloan Digital Sky Survey" which should discover $\sim$ 100 000 QSOs will be completed in about 2004 (Fan et al. 1999)

Table 0: Increase with time of the number of known QSOs, BL Lacs and Seyfert 1s

QSO	BL Lac	Seyfert 1	reference
202			De Veny et al. 1971
2 251		190	Véron-Cetty & Véron 1984
2 835	73	236	Véron-Cetty & Véron 1985
3 473	84	258	Véron-Cetty & Véron 1987
4 169	117	358	Véron-Cetty & Véron 1989
6 225	162	575	Véron-Cetty & Véron 1991
7 383	171	695	Véron-Cetty & Véron 1993
8 609	220	888	Véron-Cetty & Véron 1996
11 358	357	1 111	Véron-Cetty & Véron 1998
13 214	462	1 711	Véron-Cetty & Véron 2000
23 760	608	2 765	present edition

In the present edition of this catalogue containing quasars with measured redshift known to us prior to May 1st, 2001, as in the preceding editions, we do not give any information about absorption lines or X-ray properties. But we give the absolute magnitude for each object and, when available, the 11 and 6 cm flux densities.

This catalogue should not be used for any statistical analysis as it is not complete in any sense, except that it is, hopefully, a complete survey of the literature.

3 Description of the catalogue

We have arbitrarily defined a quasar as a starlike object, or an object with a starlike nucleus with broad emission lines, brighter than absolute magnitude $M_B = -23$; only objects brighter than this limit appear in table 1.

In table 2, we list all confirmed, probable or possible BL Lac objects with or without a measured redshift, without consideration of their absolute magnitude. As better spectra are becoming available, broad emission lines have been detected in a number of objects formerly classified as BL Lac; they have usually been moved to table 1 (Véron-Cetty & Véron, 2000).

The Seyfert 1 galaxies have broad Balmer and other permitted lines; the Seyfert 2 galaxies have Balmer and forbidden lines of the same width. Osterbrock (1977; 1981) has divided the Seyfert galaxies showing broad Balmer lines (Seyfert 1) into five subgroups : Seyfert 1.0, 1.2, 1.5, 1.8 and 1.9 on the basis of the appearance of the Balmer lines. Seyfert 1.0s are "typical" members of the class, as described by Khachikian & Weedman (1971; 1974), while Seyfert 1.5s are objects intermediate between typical Seyfert 1 and Seyfert 2 galaxies, with an easily apparent narrow Hβ profile superimposed on broad wings. The classes Seyfert 1.2 or 1.8 are used to describe objects with relatively weaker and stronger narrow Hβ components, intermediate between Seyfert 1.0 and 1.5 and Seyfert 1.5 and 2 respectively. In Seyfert 1.9, although the broad Hα emission is clearly evident, broad Hβ cannot be detected with certainty by mere visual inspection of the spectra.

We have adopted the more quantitative classification introduced by Winkler (1992) :

S1.0	$5.0 < R$	
S1.2	$2.0 < R < 5.0$	
S1.5	$0.333 < R < 2.0$	
S1.8	$R < 0.333$	broad component visible in Hα and Hβ
S1.9		broad component visible in Hα but not in Hβ
S2		no broad component visible

where R is the ratio of the total Hβ to the [OIII]λ5007 fluxes.

Several objects have been found to show extreme spectral variability, changing from Seyfert 1.8 or 1.9 to Seyfert 1. In some cases these changes are consistent with changes in the reddening to the BLR while, in others, they are probably due to real changes in ionizing flux (Goodrich, 1989a; 1995; Tran et al. 1992b). In some Seyfert 2 galaxies, a broad Pa β line has been detected, indicating the presence of a highly reddened broad line region (Goodrich et al. 1994); we call these objects S1i. A number of Seyfert 2 galaxies have, in polarized light, the spectra of Seyfert 1s (Antonucci & Miller, 1985; Miller & Goodrich 1990; Tran et al. 1992a); we call them S1h. Typical full widths at half-maximum of the Balmer lines in Seyfert 1 galaxies lie in the range 2000-6000 km s^{-1}. However, there is a group of active galactic nuclei with all the properties of Seyfert 1 galaxies, but with unusually narrow Balmer lines (Osterbrock & Pogge, 1985; Goodrich, 1989b); they are defined as having the broad component of the Balmer lines narrower than 2000 km s^{-1} FWHM (Osterbrock, 1987); we call them S1n.

Table 3 lists "active galaxies" : Seyfert 1, 1.5, 1.8, 1.9, 1h, 1i, 1n, 2, and Liners (as defined by Heckman, 1980) fainter than the above quoted absolute magnitude. A number of galaxies with a nuclear HII region denoting a burst of star formation are also included, the reason being that they have been called Seyfert in the past and later reclassified; we consider it useful to keep trace of these reclassifications to avoid further confusion.

Table 4 lists the objects which once have been believed to be quasars or BL lac objects and are now known to be either stars or normal galaxies.

Table 1 contains 23 760 objects, table 2, 608 , table 3, 5 751 and table 4, 71.

The catalogue is believed to be complete for quasars, BL Lac objects and Seyfert 1 galaxies.

Since the discovery in 1979 by Walsh et al. of the first gravitationally lensed quasar, Q 0957+561, a number of such objects (44) and of physical pairs with separation less than 10" (11) have been found. They are listed in table 5. Mortlock et al. (1999) have stressed the difficulty sometimes encountered in distinguishing lensed quasars from physical pairs.

Tables 1, 2 and 3 give :

1) The most common name of the object. For the meaning and the sources of the designations see Hewitt & Burbidge (1987), Fernandez et al. (1983) and Kesteven & Bridle (1977). For the sources discovered by the ROSAT X-ray satellite, we have used the following acronyms : RXS for the sources appearing in the All-Sky Bright Source Catalogue (Voges et al. 1999), 1WGA for the sources published in the WGACAT catalogue (White et al. 1994) and RX for the others.

When the name is preceded by an *, the object has not been detected as a radio source, either because it has not been observed or because it is fainter than the sensitivity limit of the radio telescope used; there is no uniform upper limit to the flux density of the undetected objects.

2) The best available J2000 optical or radio coordinates; the J2000 positions have been converted from the B1950 positions using the matrix given by Aoki et al. (1983). No references are given for the sources of these positions. An O or an R following the coordinates means that the position given is either an optical or a radio position measured with an accuracy better than one arc sec. An A means that it is only an approximate position which may be wrong by several arc minutes. The availability of the Digitized Sky Survey (DSS) allows quick measurements of the optical position of any object brighter than ≈19.5 mag. It has already been used to measure the position of several hundred QSOs (Schneider et al. 1992; Bowen et al. 1994; Kirhakos et al. 1994; Véron-Cetty & Véron, 1996). Optical positions with an accuracy better than 2" have also been measured for the 19 369 galaxies in the Zwicky catalogue (Falco et al. 1999) and for the 12 921 UGC galaxies (Cotton et al. 1999).

3) The 6 and 11 cm flux densities (in Jy) with references to the literature. When several measurements are available we took arbitrarily one of them. When a reference is given for the 6 cm flux density but the value of the flux density itself is left blank and there is an * in column 1, only an upper limit is available and this upper limit is not much greater than 1 mJy; in case there is no * in column 1, the reference refers to a detection but at a wavelength other than 6 cm.

4) The redshift as published. An * in front of the redshift means that it has been estimated from a low dispersion slitless spectrum and is of lesser accuracy or even plainly wrong as the emission lines may easily be misidentified. We have given only those values which are described as probable in the original sources and not the possible values.

5) In this column an attempt has been made to classify the objects as follows :

- S1 Seyfert 1 spectrum with broad permitted hydrogen emission lines, without sufficent information for a more detail classification.
- S1.0, S1.2, S1.5, S1.8, S1.9, S1i, S1h, S1n (see above).
- S2 Seyfert 2 spectrum defined as having a strong [O III]λ 5007 line compared with Hβ, together with a [NII]λ6584 line of strength comparable with that of Hα.
- S3 Seyfert 3 or Liner as defined by Heckman (1980). Broad Balmer lines are observed in some Liners; they are called S3b.
  If these broad Balmer lines are only seen in polarized light, they are called S3h.
- S or S? These objects are probably or possibly Seyfert galaxies, but available data are insufficient for a more detailed classification.
- H2 Nuclear HII region, *i.e.* nucleus of a galaxy with an emission line spectrum similar to that of an emission nebula ionized by hot stars.
- HP A high degree of optical polarization (> 3%) has been measured (see for instance : Impey et al. 1991; Moore & Stockman, 1984).

Low redshift quasars are classified as S1 when a good spectrum shows that they are similar to Seyfert 1 galaxies.

In table 2, we find in this column :

BL	for a confirmed BL Lac object.
blank	for a probable BL Lac.
?	for a possible BL Lac.

6) The V, B−V and U−B photoelectric or photographic magnitude and colours, when available. (the survey of the literature for photographic colours may be incomplete) (an * in front of the magnitude indicates that the colours and the magnitude are photographic, while an R or an I indicates a red or an infrared magnitude). Maoz et al. (1993) have measured homogeneous V magnitudes for 354 QSOs with an accuracy of ±0.1 mag; they have been included. For a few objects, the O magnitude, measured on the blue Palomar Sky Survey plates, or the UK Science Research Council SRC-J Survey plates, believed to be accurate within ± 0.2 mag., has been extracted from the APS database (Pennington et al. 1993). For a number of objects we give the O magnitude, extracted from the USNO-A2 catalogue (Monet et al. 1996) or the Cambridge Automated Plate Measuring Machine (APM) catalogue (Irwin et al. 1994), recalibrated by E. Flesch (private communication); these magnitudes are flagged with an O. The O and Johnson B magnitudes are related by B−O = −(0.27± 0.06) (B−V) (Evans, 1989).

In the other cases, the magnitude given is an estimate as found in the original publications; these magnitudes are generally quite inaccurate and inhomogeneous; they are most often m_{pg} or B magnitudes instead of the Johnson V magnitude. Much care should be taken when using them for any purpose. Anyway, even when a photoelectric V magnitude is given, it is not very meaningful as most quasars are variable. On the other hand, the colours of quasars vary little, so the listed colours should be accurate. Again, it should be noted that some of the colours listed are photographic and, therefore, less accurate; moreover, in each catalogue of photoelectric measurements, the faintest objects measured are affected by relatively large errors; this too should not be overlooked. For the galaxies, in table 3, we have chosen the magnitudes and colours measured in the smallest possible diaphragm (preferentially 16 arcsec) as we are interested in the nucleus rather than in the galaxy itself.

7) The absolute magnitude M_B computed by assuming H_0=50 km s^{-1} Mpc^{-1}, q_0=0, and an optical spectral index α equal to 0.3 (defined as $S \propto \nu^{-\alpha}$) (Francis et al. 1991).

The absolute magnitude is computed as follows : M = m + 5 − 5 log D − k + Δ m(z) where m is the B magnitude, D = c/H_0 A, with A the photometric distance (Terrell, 1977) :

$$A = z[1 + \frac{z(1-q_0)}{(1+2q_0z)^{0.5} + 1 + q_0z}]$$

z is the redshift taken from column 5; k=$-2.5\log(1+z)^{1-\alpha}$ is the k correction, Δm (z) is a correction to k taking into account the fact that the spectrum of quasars is not strictly a power law of the form $S \propto \nu^{-\alpha}$, but is affected by emission lines and by the Ly α forest depleting the continuum to the blue of Ly α. Assuming that the spectrum is a power law with α=0.3 may not give the best possible estimate of the k correction (Wisotzki 2000).

The column labelled "V" gives the V magnitude when B−V is also given in which case we have used B = V+(B−V). When B−V is not given, this column usually gives the B magnitude, unless it is preceded by an R or an I; the R magnitudes have been transformed into the B system by using an average <B−R>=0.57 and the I magnitudes by using <B−I>=1.1 for low z QSOs. When the reference for the magnitude is Maoz et al. (1993), the magnitude is V and we have used <B−V>=0.40.

We list in table 1 those objects which have an absolute magnitude M_B brighter than −23; clearly some objects would move from table 1 to table 3 and vice versa if other values for q_0 and the spectral index were used or if an accurate B apparent magnitude was available for all objects.The variability may have a similar effect, as well as the size of the diaphragm used for the measurement as the contribution of the underlying galaxy for weak quasars may not be negligible.

8) The next three columns give the reference for the finding chart, the photometry and the redshift respectively. In many cases, the last reference in table 3 is that of the classification of the object (as a Seyfert galaxy or otherwise); in these cases the redshift can usually be found in Palumbo et al. (1983).

9) The B1950 position.

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5 References

Aoki S., Sôma M., Kinoshita H., Inoue K. 1983, A&A 128, 263
Cotton W.D., Condon J.J., Abrizzani E. 1999,ApJS 125,409
Crotts A.P.S., Bechtold J., Fang Y., Duncan R.C. 1994, ApJ 437, L79
De Veny J.B., Osborn W.H., Janes K. 1971, PASP 83, 611
Evans D.W. 1989, A&AS 78, 249
Falco E.F., Kurtz M.J., Geller M.J. et al. 1999,PASP 111,438
Fernandez A., Lortet M.-C., Spite F. 1983, A&AS 52, N^o 4
Francis P.J., Hewett P.C., Foltz C.B. et al. 1991, ApJ 373, 465
Garrett M.A., Walsh D., Carswell R.F. 1992, MNRAS 254, 27P
Goodrich R.W. 1989a, ApJ 340, 190
Goodrich R.W. 1989b, ApJ 342, 224
Goodrich R.W. 1995, ApJ 440, 141
Grundahl F., Hjorth J. 1995, MNRAS 275, L67
Heckman T.M. 1980, A&A 87, 152
Impey C.D., Lawrence C.R., Tapia, S. 1991, ApJ 375, 46
Irwin M., Maddox S., McMahon R. 1994, Spectrum 2,14
Kesteven M.J.L., Bridle A.H. 1977, J. Roy. Astron. Soc. Canada 71, 21
Khachikian E.E., Weedman D.W. 1971, Astrophysics 7, 231
Ledoux C., Theodore B., Petitjean P. et al. 1998, A&A 339, L77
Lidman C., Courbin F., Kneib J.-P. et al. 2000,A&A 364,L62
Lovell J.E.J., Jauncey D.L., Reynolds J.E. et al. 1998, ApJ 508, L51
Lubin L.M., Fassnacht C.D., Readhead A.C.S., Blanford R.D., Kundic T. 2000, AJ 119,451
Magain P., Surdej J., Swings J.-P. et al. 1988, Nat. 334, 325
Magain P., Surdej J., Vanderriest C., Pirenne B., Hutsemekers D. 1992, A&A 253, L13
McMahon R., Irwin M., Hazard C. 1992, Gemini 36, 1
Meylan G., Djorgovski S., Weir N., Shaver P. 1990, The Messenger 59, 47
Monet D., Bird A., Canzian B. et al. 1996, USNO-A2.0, U.S. Naval Observatory, Washington D.C.
Moore R.L., Stockman H.S. 1984, ApJ 279, 465
Mortlock D.J., Webster R.L., Francis P.J. 1999, MNRAS 309, 836
Osterbrock D.E. 1987, Lecture Notes in Physics 307, 1
Pello R., Miralles J.M., Le Borgne J.-F. et al. 1996, A&A 314, 73
Serjeant S., Lacy M., Rawlings S., King L.J., Clements D.L. 1995, MNRAS 276, L31
Smith R.J., Boyle B.J., Croom S. et al. 1999, Anglo-Australian Obs. Newsletter 91,12
Steidel C.S., Sargent W.L.W. 1991, AJ 102, 1610

Surdej J., Magain P., Swings J.-P. et al. 1987, Nat. 329, 695
Terrell J. 1977, Am. J. Phys. 45, 869
Tonry J.L. 1998, AJ 115, 1
Tran H.D., Miller J.S., Kay L.E. 1992a, ApJ 397, 452
Tran H.D., Osterbrock D.E., Martel A. 1992b, AJ 104, 2072
Véron-Cetty M.-P., Véron P. 1984, ESO Scientific Report N° 1
Véron-Cetty M.-P., Véron P. 1985, ESO Scientific Report N° 4
Véron-Cetty M.-P., Véron P. 1987, ESO Scientific Report N° 5
Véron-Cetty M.-P., Véron P. 1989, ESO Scientific Report N° 7
Véron-Cetty M.-P., Véron P. 1991, ESO Scientific Report N° 10
Véron-Cetty M.-P., Véron P. 1993, ESO Scientific Report N° 13
Véron-Cetty M.-P., Véron P. 1996, ESO Scientific Report N° 17
Véron-Cetty M.-P., Véron P. 1998, ESO Scientific Report N° 18
Véron-Cetty M.-P., Véron P. 2000, ESO Scientific Report N° 19
Véron-Cetty M.-P., Véron P. 1996, A&AS 115, 97
Véron-Cetty M.-P., Véron P. 2000, A&AR 10,81
Voges W., Aschenbach B., Boller T. et al. 1999, A&A 349,389
White N.E., Giommi P., Angelini L. 1994, IAU Circ. 6100
Wisotzki L. 2000,A&A 353,861

Table 5: Gravitationally lensed quasars and physical pairs. Col. 1 : name, col. 2 : short position, col. 3 : redshift of the quasar, col. 4 : redshift of the lens, col. 5 : separation in arcsec, col. 6 : references

Name	Position	z_{quasar}	z_{lens}	sep(")	Ref.
Lensed QSOs					
UM 673	0142−10	2.719		2.2	48
CTQ 414	0156−43	1.29		1.2	37
B2 0218+35	0218+35	0.936		0.33	11
HE 0230−2130	0230−21	2.162		2.0	58
Q J0240−343	0238−34	1.406		6.1	50
PKS 0411+05	0411+05	2.639	0.958	2.2	25,52
HE 0512−3329	0512−33	1.565	0.931	0.6	10
B 0712+472	0712+47	1.339		1.27	7
MG 0751+2716	0748+27	3.200	0.350		52
HS 0818+1227	0818+12	3.115		2.1	12
CLASS B0827+525	0827+52	2.064		2.8	23
APM 08279+5255	0827+52	3.87		0.4	26
RX J0911.4+0551	0908+06	2.800		0.8	1
SBS 0909+532	0909+53	1.377	0.830	1.11	22,30
1WGA J09212+4528	0917+45	1.66	0.31	6.93	41
FBQS J0951+2635	0948+26	1.24		1.1	45
BRI 0952−01	0952−01	4.43		0.95	34
Q 0957+561	0957+56	1.414	0.355	6.1	9,53
Q 1009−0252	1009−02	2.74		1.55	16
J 13.03	1015−20	2.55		0.84	49
IRAS F10214+4724	1021+47	2.286			46
B 1030+074	1030+07	1.535		1.56	7
HE 1104−1805	1104−18	2.303	0.729	3.0	28,56
PG 1115+080	1115+08	1.722	0.311	2.3	51,54
UM 425	1120+01	1.465		6.5	35
TEX 1152+199	1152+19	1.019	0.439	1.6	42
Q 1208+1011	1208+10	3.803		0.45	32
87GB 1359+1527	1359+15	3.235		1.7	42
H 1413+117	1413+11	2.546		1.4	31
HST J14176+5226	1415+52	3.4		3.2	4
B 1422+231	1422+23	3.62	0.339	1.3	43,51
Q 1429−008	1429−00	2.076		5.1	15
SBS 1520+530	1520+53	1.855		1.6	3
Q 1600+434	1600+43	1.61		1.38	20
Q 1634.9+26.7	1634+26	1.961		3.8	47
FIRST J1633+3134	1631+31	1.516		0.66	39
MC 1830−211	1830−21	2.507	0.885	0.60	27,29
TEX 1835−345	1835−34	2.78		1.0	55
MG 2019+1127	2016+11	3.273		3.4	24
87GB 20451+2632	2045+26	1.28	0.867	1.9	8
Q 2138−431	2138−43	1.641		4.5	14
H 2149-2745	2149−27	2.033		1.7	57
Q 2237+0305	2237+03	1.695	0.039	1.8	19
Q 2345+007	2345+00	2.15		7.1	44
Binary QSOs					
Q 0023+171	0023+17	0.945		4.8	18
CT 344	0103−27	0.848		0.3	21
PHL 1222	0151+04	1.91		3.3	36
CTQ 839	0250−33	2.24		2.1	38
Q 1145−071	1145−07	1.34		4.2	6
HS 1216+5032	1216+50	1.450		8.9	13
RRS IV 26,27	1343+26	2.030		9.5	5
RX J16290+3724	1627+37	0.923		4.3	33
Q J1643+31	1641+32	0.586		2.3	2
Q 2153−2056	2153−20	1.845		7.8	17
MGC 2214+3550	2212+35	0.877		3.0	40

(1) Bade et al. 1997
(2) Brotherton et al. 1999
(3) Chavushyan et al. 1997
(4) Crampton et al. 1996
(5) Crotts et al. 1994
(6) Djorgovski et al. 1987
(7) Fassnacht & Cohen, 1998
(8) Fassnacht et al. 1999
(9) Garrett et al. 1992
(10) Gregg et al. 2000
(11) Grundahl & Hjorth, 1995
(12) Hagen & Reimers 2000
(13) Hagen et al. 1996
(14) Hawkins et al. 1997
(15) Hewett et al. 1989
(16) Hewett et al. 1994
(17) Hewett et al. 1998
(18) Hewitt et al. 1987
(19) Huchra et al. 1985
(20) Jackson et al. 1995
(21) Junkkarinen et al. 2001
(22) Kochanek et al. 1997
(23) Koopmans et al. 2000
(24) Lawrence et al. 1984
(25) Lawrence et al. 1995
(26) Ledoux et al. 1998
(27) Lidman et al. 1999
(28) Lidman et al. 2000
(29) Lowell et al. 1998
(30) Lubin et al. 2000
(31) Magain et al. 1988
(32) Magain et al. 1992
(33) Mason et al. 2000
(34) McMahon et al 1992
(35) Meylan & Djorgovski 1989
(36) Meylan et al. 1990
(37) Morgan et al. 1999
(38) Morgan et al. 2000
(39) Morgan et al. 2001
(40) Muñoz et al. 1998
(41) Muñoz et al. 2001
(42) Myers et al. 1999
(43) Patnaïk et al. 1992
(44) Pello et al. 1996
(45) Schechter et al. 1998
(46) Serjeant et al. 1995
(47) Steidel & Sargent, 1991
(48) Surdej et al. 1987
(49) Surdej et al. 1997
(50) Tinney, 1995
(51) Tonry, 1998
(52) Tonry & Kochanek, 1999
(53) Tytler & Fan 1992
(54) Weymann et al. 1980
(55) Winn et al. 2000
(56) Wisotzki et al. 1993
(57) Wisotzki et al. 1996
(58) Wisotzki et al. 1999