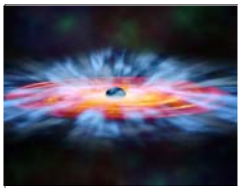

Absorption-Line Variability of Broad-Absorption Line Quasars

M. Dietrich, S. Mathur, & D. Terndrup (The Ohio State University)
P. Hall (York University)
K.M. Leighly & S.D. Barber (The University of Oklahoma)

Introduction

Among all quasars about 20% show strong, broad, and blue-shifted absorption troughs which are generally ascribed to absorption by fast out-flowing material (e.g., Murray et al.1995; Proga et al.2000; Weymann et al.1981). BALQSOs have been also suggested as an early stage of the active phase of a super-massive black hole which is still embedded in cool gas and dust which are radiatively blown out (e.g., Boroson & Meyers 1992; Voit et al. 1993; Gregg et al. 2006).

Variations of strength and shape of the broad absorption troughs is a well known phenomenon (e.g., Barlow 1993; Turnshek et al.1988). Variations of the absorption strength and even changes of the location in velocity space have been observed (Gabel et al. 2003; Hall et al. 2007) which can be interpreted by occultation of the central source by orbiting, strongly absorbing material. Recently, Hamann et al. (2008) reported the emergence of a high velocity outflow in a luminous quasar on a timescale of $\tau \leq 4$ years.

In recent years, several campaigns have been conducted to investigate BALQSO variability in more detail (e.g., Gregg et al.2006; Lundgren et al. 2007). Gibson et al. (2008, 2010) studied the variations of the broad absorption line features in the spectra of a sample of 14 BALQSOs. Based on spectra which cover 5 to 7 years with 2 to 4 epochs, they found changes in the profile strength and shape but those variations appear to follow no clear pattern.

It is possible that those changes happen gradually, but they can be dramatic as has been observed by Hall et al. (2011) for FBQS J1408+3954. The broad and deep FeII UV absorption troughs basically vanished completely over a period of between 1 and 9 years.

However, for a better understanding of the physical cause for those variations, monitoring with a higher sampling rate than previously is required.

Observations

We are observing a sample of 30 BALQSOs using the MDM observatory 2.4m telescope with OSMOS (spectral resolution $\Delta v \approx 190$ km s^{-1}) and the KPNO 4m telescope with RC CCD Spec (spectral resolution $\Delta v \approx 400$ km s^{-1}) to record optical spectra (Table 1). The targets have been selected for (i) brightness ($m_r \leq 19.0$), (ii) access to existing spectra for comparison (e.g. Corbin & Boroson 1996; Dietrich et al. 2002; Reichard et al.2003; Sargent et al. 1988; Weymann et al.1991), and (iii) redshift, i.e. z = 0.5 to 1.1 (to cover the MgII λ2798 – FeII UV range) and z = 2.0 to 3.0 (to cover the CIV λ1549 range). In addition, almost all of the BALQSOs have X-ray detections either with Chandra or XMM.

BAL QSO	RA	DEC	z	m_r	m_v	MDM Apr10	MDM May10	KPNO May10	MDM Mar11	KPNO May11	MDM May11	MDM Sep11	SDSS	QSO Sample	comment
SDSS0015+1438	00 15 27.7	+14 38 16	1.99	17.29	17.8							red	Nov00		little less absorbed
SDSS0122+1339	01 22 31.9	+13 39 40	3.06	18.26	18.5							red	Dec00		little less absorbed
SDSS0228+0002	02 28 44.1	+00 02 17	2.72	18.20	18.4							red	Nov00		no change
SDSS0242+0049	02 42 21.9	+00 49 12	2.06	18.18	18.5							red	Oct00		no change
SDSS0300+0048	03 00 00.6	+00 48 28	0.31	16.74	19.4							red	Sep00		less absorbed
SDSS0321+4132	03 21 08.5	+41 32 21	2.47	16.71	17.1							red	Jan06		no change
SDSS0737+3844	07 37 39.9	+38 44 13	1.40	16.99	17.7				red				Nov00		no change
SDSS0835+4352	08 35 26.0	+43 52 11	0.57	17.55					red				Nov01		MgII vanished
SDSS0840+3633	08 40 44.4	+36 33 28	1.23	16.59					red		obs		Feb02		little more absorbed
SDSS0845+3420	08 45 38.7	+34 20 44	2.15		17.2			red	red				Feb03		come back
SDSS0853+4633	08 53 57.9	+46 33 50	0.55	18.22						red			Nov01		no change
SDSS0909+0002	09 09 24.0	+00 02 11	1.87	16.68					red				Jan01		no change
SDSS0935+4953	09 35 53.0	+49 53 14	1.93		17.4	obs							Jan03	Mar89	no change
SDSS1007+0532	10 07 11.8	+05 32 09	2.14	16.22					red		obs		Jan03		less absorbed
TON34	10 19 56.6	+27 44 02	1.92	15.96					red		obs		Jun06	Nov81	come back
FBQS1151+3822	11 51 17.8	+38 22 22	0.34	15.50	15.8						obs				no change
Q1232+1325	12 34 58.1	+13 08 55	2.36		19.5			red						Apr89	strong change
Q1246-0542	12 49 13.9	-05 59 19	2.23		16.7	obs			red		obs			Apr89	less absorbed
Mrk231	12 56 14.2	+56 52 25	0.04		13.8	obs	obs	red	red	red				Nov92	nearly constant
SDSS1334-0123	13 34 28.1	-01 23 49	1.87		17.9	obs		red	red				May02	May88	more absorbed
SDSS1415+1129	14 15 46.2	+11 29 43	2.56	16.92					red		obs		Apr06	Apr89	more absorbed
Q1443+0141	14 45 45.3	+01 29 12	2.44		18.2	obs		red						May88	less absorbed
SDSS1543+5359	15 43 59.4	+53 59 03	2.37	17.04					red		obs		Apr02	Sep95	no change
SDSS1701+6412	17 01 00.5	+64 12 08	2.72	16.3				red	red				Jun00	Aug83	no change
PG1700+518	17 01 24.9	+51 49 21	0.29		15.1	obs	obs	red	red	red	obs	red		Sep80	little more absorbed
SDSS1709+6303	17 09 31.0	+63 03 57	2.40		18.4			red			obs		Sep00		no change
SDSS1720+5456	17 20 12.4	+54 56 01	2.10		18.7			red				red	Mar01		little less absorbed
SDSS1724+5710	17 24 13.3	+57 10 46	2.82		18.4			red					Sep00		less absorbed
SDSS2215-0045	22 15 11.9	-00 45 50	1.24	16.57	17.4							red	Sep00		more absorbed
SDSS2341+1449	23 41 50.0	+14 49 06	3.18	18.43	19.0							red	Nov01		no change

Table 1 – Overview of the BALQSO sample, the dates when spectra have been observed (obs) and the current status of the data reduction (red).

First Results

Currently, we are still in the data reduction process but we can already determine whether the BALQSOs of our sample display absorption line variability for the epochs we have analyzed so far.

In Table 1 we provide information on the variations which we have detected. It turns out that about 75% of our BALQSOs appear to show no or only very little variability of the broad absorption features (Tab.1, Fig.1). However, for 7 of our source we see strong variations (Figs. 2 – 4) and for SDSS0835+4352 we have detected a dramatic change in the MgII absorption strength (Fig.5) which is comparable to the change for FBQS J1408+3054 (Hall et al. 2011). The MgII line emission has basically vanished and a broad and strong MgII absorption feature has evolved between November 2001 when the SDSS spectrum was taken and May 2011 (KPNO).

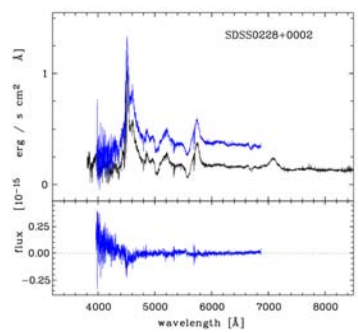

Fig.1 – SDSS0228+0002 shows basically no difference between the spectra taken in Nov.2000 (black) and in September 2011 (blue).

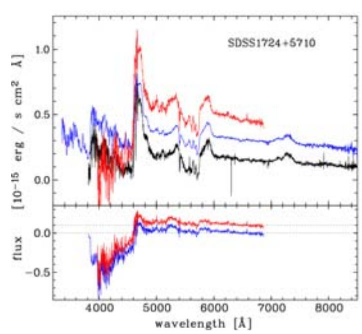

Fig.2 – SDSS1724+5710; from Sep.2000 (black), over May 2010 (blue) until Sep.2011(red) small variations of some absorptions features are visible.

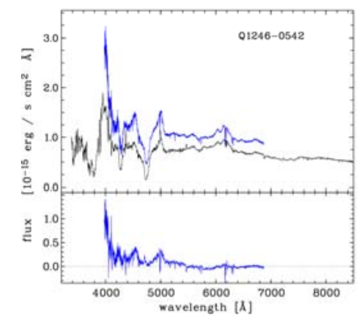

Fig.3 – For Q1246-0542 we can compare data taken in Apr.1989 (black) and in Mar. 2011 (blue). It can be seen that the absorption strength is weaker in Mar.2011 than in Apr.1989.

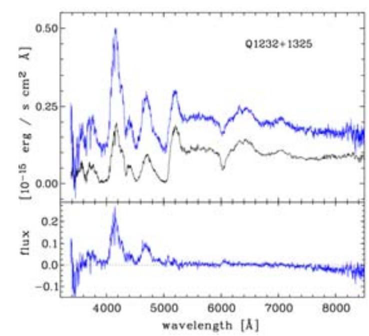

Fig.4 – Q1232+1325 exhibits a significant difference between the spectrum taken in Apr.1989 (black) compared to the one observed in May 2010 (blue).

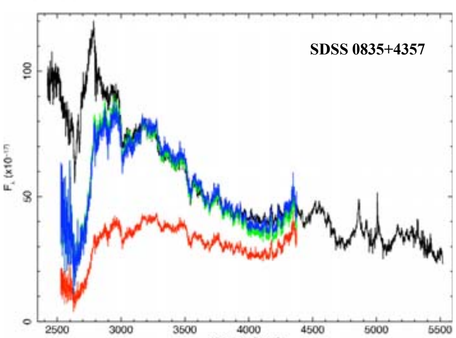

Fig.5 – Comparison of the SDSS spectrum of SDSS 0835+4357 which was taken in November 2001 (black) and the spectrum we observed in May 2011 at KPNO (red). The blue and green spectra a slightly differently scale versions of the May 2011 spectrum.

References

Barlow, T.A. 1993, PhD thesis, Univ.California
Boroson, T.A. & Meyers, K.A. 1992, ApJ, 397, 442
Corbin, M.R. & Boroson, T.A. 1996, ApJS, 107, 69
Dietrich, M., et al. 2002, ApJ, 581, 912
Gabel, J.R., et al. 2003, ApJ, 595, 120
Gibson, R.R., et al. 2008, ApJ, 675, 985
Gibson, R.R., et al. 2010, ApJ, 713, 220
Gregg, M.D., et al. 2006, ApJ, 641, 210
Hall, P.B., et al. 2007, ApJ, 665, 174
Hall, P.B., et al. 2011, MNRAS, 411, 2653
Hamann, F., et al. 2008, MNRAS, 391, L39
Lundgren, B.F., et al. 2007, ApJ, 656, 73
Murray, N. et al. 1995, ApJ,451, 498
Proga, D., et al. 2000, ApJ, 543, 686
Reichard, T.A., et al. 2003, AJ, 125, 1711
Sargent, W.L.W. et al. 1988, ApJS 68, 539
Turnshek, D.A., et al. 1988, ApJ, 325, 651
Viot, G.M., et al. 1993, ApJ, 413, 95
Weymann, R.J., et al. 1991, ApJ, 373, 23

Acknowledgements

This project has been support from NSF grant AST-0604066 (MD).