X-shooter Science Verification Proposal

Title: Unveiling the nature of BALQSO: How do they really look like?

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Abstract:

Accretion disc outflows are an important part of the quasar phenomenon and the main manifestation of the active galactic nuclei (AGN) kinetic feedback. The absorption lines, produced by huge and fast outflows of ionized material, appear most conspicuously in the spectra of broad absorption line quasars (BALQSOs), making them key objects for studying the structure and emission/absorption properties of AGN. However, the nature of BALQSO is still poorly understood, and it is still unclear if they belong to the same population as normal non-BALQSO, or we are observing objects with the different physical origin, maybe in the early evolution stage. Unfortunately, little is known about their rest-frame optical and IR spectral properties. To unveil the nature of BALQSO in these energetic range, we propose XSHOOTER simultaneous high resolution broad-band observation of representative sample of 4 objects from the different z and the different subclasses of BALQSOs. Such spectra will be not only the unique source of information for understanding of broad-band properties of BALQSO, but also give us a hint how these sources fit to the unified model of AGN and our imagination of quasars evolution. We also want to search for special optical features in the spectrum which can be used as “markers” for recognizing BALQSO, independently from observation of CIV line. If found, these features can be applied for the identification of nearby sources, and, thus, may change our understanding of the nature of local Seyferts.

Scientific Case:

The nature of intrinsic absorption in quasars has important implications for physical models of the AGN “central engine” and, in general, for developing the unified model. The subclass of broad absorption line quasars (BALQSOs), characterized by strong, broad and blueshifted absorption troughs in their spectra, is the main manifestation of the important AGN phenomenon as outflows. BALQSOs are classified into high-ionization (“HiBALs”, show broad CIV absorption troughs) and low-ionization (“LoBALs”, in addition to HiBAL features, show broad absorption troughs in the MgII line) BALQSOs.
The nature of BAL quasars is still not well understood. The small percentage of BALQSOs among quasars ($\sim 10\%$) is generally interpreted as an orientation effect from the unified model (e.g. Weymann et al. 1991, ApJ, 373, 23). However, the properties of some LoBALs appear inconsistent with simple unified models and can be explained only by the evolution scenario, where BALQSO are young, in “cocoon” phase, quasars (e.g., Boroson & Meyers 1992, ApJ, 397, 442; Becker et al. 2000, ApJ, 538, 72). In this model broad absorption lines appear when a nucleus is blowing gas and dust off during a dust-enshrouded quasar phase, evolving to non-BAL quasars. If this view is correct, the infrared luminosity of BALQSOs (especially LoBALs) expected to be large. Indeed, the results from 2MASS Infrared survey shows not only the unusually high fraction of BALQSO at high redshift, but also that it consists only from LoBALs (Urrutia et al. 2008, arXiv0808.3668). Does this result mean that LoBALs are unique class of quasars, maybe even physically different from HiBAL? Can we see the difference between the rest-frame spectra of these two types? Unfortunately, if UV range of BALQSO spectra is pretty well studies, little is known about the rest-frame optical and IR spectral properties of these sources. Few random observations of low-z BALQSO show that H_α lines tend to have large blue asymmetries (e.g., Boroson & Meyers 1992), larger equivalent widths (comparing with non-BALQSOs) and even, for few LoBALs, we can see the H_α absorption (e.g., Aoki et al. 2006, ApJ, 651, 84). Therefore the question how mean spectra for these two type look like (and is any particular feature which is clearly pointed that we observe the BALQSOs, independently if we see the CIV or not) is still open.
Another important issue today is the definition of BALQSO itself. The traditional BALs are defined to have CIV absorption troughs broader than 2000 km s^{-1} (this width ensures that the absorption is from a nuclear outflow, and effectively excludes associated absorbers), however could potentially exclude unusual

or interesting BALs (e.g. Becker et al. 2000). Therefore, Trump et al. (2006, ApJS, 165, 1), inside his SDSS sample, "extended" BALQSO class including BALs absorption features at lower outflow velocities (within 3000 km s^{-1}). As a result, now significantly higher fraction of QSOs can be classified as BALQSO (e.g., in 2MASS survey, the fraction of BALQSO increase by two with the new definition) and BALQSO became the objects with both weaker and much narrower absorption troughs than has previously been supposed. Unfortunately, for many "new" BALQSOs we just observe these narrow features, without any evidences of broad troughs. Thus, the natural question arise "Are we still talking about physically same objects?" It's known that wide varieties of non-BAL absorption features (weak and narrow outflow lines) are just as common as BALs and generally seen in QSOs and AGN. The origin of them is remains poorly understood, and can be due to absorption at an intermediate redshift along the line of sight to the QSO, absorption within the host galaxy, or intrinsic absorption close to the QSO (including the so-called mini-BALS and associated absorption features). Clearly, we expect that the mean spectra of such "absorbed" QSOs are different from the classical BALQSO, but nothing was done in this direction so far.

The absorbers are often variable in their column densities, therefore it was quickly realized that only simultaneous observations from UV to near-infrared provide the most valuable information, since they cover an enormous range in ionization, as well as address the uncertain relationship between the absorbers at different wavelengths. XSHOOTER from this point of view is the ideal instrument - it allows us to study *simultaneously* the absorption systems at unprecedented spectral resolution over a wide energy range.

In order to reply to the questions addressed in the text, we propose to observe 4 sources, representing the two main classes of BALQSO (HiBALs and LoBALs) and two main groups ("new" and "traditional") at different redshift bins. For the first time obtained broad-band simultaneous spectra of BALQSO will help us to reply to the important questions concerning the physical nature of BALQSO. We will see how the rest-frame spectra of HiBALs and LoBALs look and is any general discrepancy in spectra which may pointed that these classes have different physical origin (as we discussed above). We will studied the possible difference in emission line or continuum properties between the "new" and "classical" BALQSO and, moreover, whether the BAL can be distinguished from non-BAL just on the basis of specific line properties. If we will be able identified a particular feature in the optical range, which can be used as a indicator of BALQSO (independently if we see the CIV or not), this may bring interesting consequence for nearby sources.

Targets and observing mode

Target	**RA**	**DEC**	z	**B** mag	**R** mag	**J** mag	**H** mag	**K** mag	**Mode** (slit/IFU)	**Time** sec
235253.51-002850.4	23 52 53.5	-00 28 50	1.624	18.5	18.0	17.1	16.3	15.7	slit	2600
221511.93-004549.9	22 15 11.9	-00 45 50	1.478	17.9	16.8	15.7	14.9	16.7	slit	2200
204039.47-060839.5	20 40 39.5	-06 08 40	2.268	17.9	18.0	16.6	16.2	15.6	slit	3000
LBQS 2212-1759	22 15 31.6	-17 44 08	2.217	18.4	16.7	15.5	15.04	14.5	slit	1800

Time Justification:

To achieve our scientific objectives we aim for a SNR$\geq$10 in the continuum over the whole rest-frame UV-Optical-NIR range, to be able to characterize properly the emission lines and absorption features. To estimate the exposure time needed to meet this requirement, we have used the web interface to ETC assuming a seeing of 0.8 arcsec, slit widths of 1.2-1.3 arcsec, and 3 days from new moon. We have obtained the BRJHK magnitudes for our objects from the literature and set a minimum SNR of $\sim$10 in each of those bands (up to the expected observed wavelength of H_α), which correspond to the exposure times in the enclosed table. All objects have good visibility from Paranal in both June and August.