X-shooter Science Verification Proposal

What is the nature of the Weak Emission Line Quasars ?

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Abstract:

A population of quasars showing very weak broad emission lines has recently been unveiled at $z > 2.7$ based on SDSS spectra. These objects could either be quasars with extremely high accretion rates, high redshift counterparts of the so called BL Lac objects or quasars that have just started their quasar phase so that the broad emission lines are not yet photoionized. Spectra of these objects exist only in the UV rest-frame, such that only the high ionization emission lines have been observed. Observation of the optical rest-frame range for these targets, including low ionization broad emission lines and narrow forbidden emission lines, would allow to disentangle the aforementioned scenarii. In addition, a large wavelength coverage is mandatory to characterize the UV-optical continuum and compare it to other quasar populations, and to study the effect of dust.

Scientific Case:

Quasar spectra are characterized by a power-law continuum emission originating from matter accreted in the vicinity of a central black hole and by strong permitted broad emission lines (with FWHM > 4000 km/s for Type 1 quasar). These lines are Doppler broadened and originate from photoionized gas located $\sim 10^{17}$ cm from the black hole. This gas is either a wind originating from the accretion disk or is confined to individual clouds outside the disk.

The SDSS has allowed the discovery of intriguing objects, the so called Weak Emission Line quasars (WLQs), that show very weak broad emission lines (Fan et al. 1999, Shemmer et al. 2009, Diamond-Stanic 2009) characterized by equivalent widths (EQW) 5 to 10 times smaller than in typical quasars. Most of these objects have been detected at $z > 2.7$ based on optical SDSS spectra, such that only the high ionization lines (HIL: CIV $\lambda 1549$, CIII] $\lambda 1909$) have been observed. Near-Infrared spectra of these objects are actually missing and there is no evidence that lower ionization lines (LIL: MgII $\lambda 2800$ and Balmer lines) are as weak as the HIL. Only a few similar objects have been detected at lower redshift. Although these objects show stronger LIL than HIL, it is not clear whether they are actually low z counterparts of the objects unveiled by Diamond-Stanic et al. (2009). Especially, none of the objects having multi-wavelength data are both radio quiet and X-ray faint like the high z WLQs (Shemmer et al. 2009).

The nature of the WLQs is still puzzling. The most plausible explanation for the absence of HIL broad emission can be divided in three categories:

i) Apparent increase of the continuum emission: the low EQW of the HIL could be explained by an intrinsically faint continuum that appears brighter due to relativistic beaming. In this context, high z WLQs could be the high redshift counterparts of the local BL-Lac objects. The latter are Type 1 quasars observed pole-on. Due to this particular configuration and to relativistic beaming their spectra are featureless. *If WLQ are high-z BL-Lac, no emission lines should be observed in the near-UV-optical rest-frame range.*

ii) Abnormal continuum: the weakness of the HIL may be the consequence of an exceptionally high accretion rate in these sources, leading to a softer UV continuum that suppresses HIL. *On the contrary, LIL (Balmer and FeII lines) should be visible.* Observations of these lines would also allow to measure the accretion rate and further test this explanation.

iii) Evolutionary effect: in the disk-wind model of the broad line region, the HIL are emitted in the wind while the low ionization lines are emitted in the accretion disk. At the early stages of the quasar phenomenon, the low ionization gas should be photoionized before the high ionization gas (Hryniewicz et al. 2009). Reasonable assumptions suggest that completing the photoionization of the HIL needs 10 times longer than the photoionization of the LIL (10000 years vs 1000 years). *If correct, this scenario implies normal Eddigton ratios and absence of narrow emission lines (e.g. [OIII]$\lambda\lambda$ 4959,5007Å)*. The normal Eddington ratio derived from the MgII emission of the WLQ candidate SDSS J094533+100950 observed at intermediate redshift supports an evolutionary effect (Hryniewicz et al. 2009).

We propose to observe 1 WLQ at intermediate redshift (z =1.8; see Note) and 2 higher redshift objects ($2.7 < z < 3.5$) selected from the samples of Diamond-Stanic (2009) and Shemmer et al. (2009). These observations will provide key data for our understanding of the nature of WLQs. Our immediate goals are: 1) To detect low ionization lines (MgII and Balmer lines) or show that they are as weak as the high ionization lines; 2) To detect narrow emission lines (e.g. [OIII]$\lambda\lambda$ 4959,5007Å); 3) To compare the UV-optical spectra of these objects to their putative low redshift counterparts (3 objects) and to typical Radio Quiet Quasars.

Note: Although good quality optical spectra exist for HE 0141-3932 (UVES and EFOSC spectra; Reimers et al. 2005), they cover only the rest-frame UV range. MgII emission is detected in the EFOSC spectrum but with a too low S/N to measure an accurate accretion rate. There is no Near-Infrared spectrum for this target.

Targets and observing mode

Target	**RA**	**DEC**	**V** mag	**Mode** (slit/IFU)	**Remarks**
HE 0141-3932	01 43 33.6	-39 17 00	16.2 (B)	slit(1.6-1.5")	Priority 1, $z = 1.80$
SDSS J123132.37+013814.0	12 31 32.4	+01 38 14	18.7 (R)	slit(1.6-1.5")	Priority 2, $z = 3.23$
SDSS J114153.34+021924.3	11 41 53.3	+02 19 24	18.6 (R)	slit(1.6-1.5")	Priority 3, $z = 3.47$
If SV in August, SDSS J123132 and SDSS J114153 will be replaced by the next 2 targets					
SDSS J031712.23-075850.3	03 17 12.2	-07 58 50	18.8 (R)	slit(1.6-1.5")	Priority 2, $z = 2.70$
SDSS J010802.90-010946.1	01 08 02.9	-01 09 46	19.5 (R)	slit(1.6-1.5")	Priority 3, $z = 3.37$

Time Justification:

We will use long slit with width of 1.6-1.5". Nodding of the target along the slit will be performed to ensure proper sky subtraction. A S/N > 40 in the NIR is optimal to measure accurate EQW of Hβ, MgII and [OIII] lines or to put useful upper limits. This is achieved for the higher redshift objects with 8 exposures of 700s (high gain and bin 2x2). Each set of 4 exposures will be dithered along the slit following a ABBA sequence (with 1 exposure per position). Overheads for 4 exposures, including pointing+acquisition+slit setup (570s), readout time (4x27s for VIS) and telescope offsets (4x15s) amount to 738s. The total time amounts 8x700s+2x738s$\sim$2h for each of the higher redshift objects. For the intermediate redshift target HE 0141-392, the Hβ and Hα Balmer lines fall in regions of large atmospheric absorption. Only Hγ should be accessible. Because this line is intrinsically fainter, we need a S/N > 100 to ensure a secure detection. This is achieved with 4 exposures of 500s. The time needed for HE 0141-3932 is 4x500s+738s$\sim$46min.
The total exposure time requested amounts 0.8+2x2h = 4.8h.

References:

Diamond-Stanic et al. 2009, arXiv0904.2181
Fan et al. 1999, ApJ, 526, 57
Reimers et al. 2005, A&A, 435, 17
Shemmer et al. 2009, ApJ, 696, 580