X-shooter Science Verification Proposal

Title: The interplay between quasars and diffuse gas studied with close quasar lines of sight

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Abstract:

X-shooter, with its unique characteristics of efficiency, resolution and spectral coverage, makes possible for the first time the observation of a fair sample of quasar pairs at $z \gtrsim 2$ with separation $\lesssim 1$ arcmin (corresponding to ~ 1 Mpc comoving). They represent a fundamental tool to investigate the spatial distribution of matter at high redshift, and the effects of galactic winds and AGN feedback on the intergalactic medium. Here, we propose to study the radiative feedback of a foreground quasar on its surrounding medium with the analysis of the spectrum of a background quasar with an angular separation of ~ 15", corresponding to ~ 120 proper kpc at the redshift of the foreground quasar, $z = 2.11$. The detection of a metal absorption system and/or of a variation in the properties of the Lyα forest at this redshift will allow us to constrain the radiative lifetime and the isotropy of the quasar ionizing source. The spectrum of the foreground quasar, in particular in the near-IR range, is necessary to determine its accurate systemic redshift. We ask for a total of 4 hours of observation.

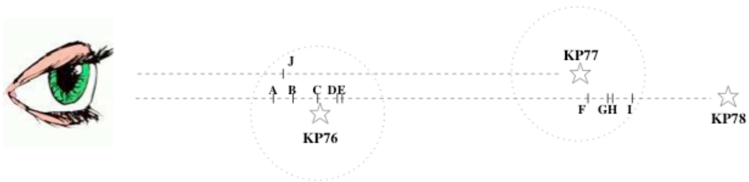
Scientific Case:

During the quasar era ($1 < z < 3$), the star-formation rate, the comoving density of active galactic nuclei (AGN), and the merger rate of galaxies, are all observed to reach their peak values. Furthermore, the bulges of all local galaxies harbor supermassive black holes (SMBH, Kormendy & Richstone 1995, ARA&A, 33, 581), the masses of which are tightly correlated with the properties of their host spheroids (Magorrian et al. 1998, AJ, 115, 2285; Ferrarese & Merritt 2000, ApJ, 539, L9; Gebhardt et al. 2000, ApJ, 539, L13). These pieces of evidence have led many to speculate that some "feedback" mechanism couples the quasar phase of rapid SMBH growth with the evolution of its host galaxy (e.g., Silk & Rees 1998, A&A, 331, L1; Kauffmann & Haehnelt 2000, MNRAS, 311, 576; Wyithe & Loeb 2003, ApJ, 588, L69; Granato et al. 2004, ApJ, 600, 580; Menci et al. 2006, ApJ, 647, 753). Besides explaining the correlation between black holes and bulges, feedback from an AGN has also been invoked as the energy source which quenches star formation in massive galaxies, leaving them "red and dead". Although AGN feedback has become a ubiquitous ingredient of models of galaxy evolution, its full mechanism and how it operates on different scales is poorly understood, both in theoretical and observational aspects.

One of the observed effects of the radiative feedback from quasars is the decrease in the number of absorption lines in their vicinity, known as the proximity effect (Bajtlik et al. 1988, ApJ, 327, 570), which provides a measurement of the UV background (e.g., Scott et al. 2000, ApJS, 130, 67). If nature provides a nearby background quasar sight line, one can also study the "transverse proximity effect", which is the expected decrease in absorption in a background quasar Lyα forest, caused by the transverse ionizing flux of a foreground quasar (see Figure 1). The main advantage with respect to the standard proximity effect is that the proper distance at which the influence of the quasar is being investigated is well determined by the separation of the two lines of sight, this is not the case along the same line of sight where peculiar velocities can affect the measured redshift distance.

Measurements of the transverse proximity effect can in principle constrain the radiative lifetime and the isotropy of the sources (e.g., Goncalves et al. 2008, ApJ, 676, 816). For a typical bright quasar ($V \sim 18$) radiating isotropically at $z \simeq 2.5$, the sphere within which its flux dominates over the metagalactic background has a physical radius of $r \sim 5 - 10$ Mpc. The corresponding light travel time is $15 - 30$ Myr. A number of quasi-independent arguments have suggested that bright quasars typically have lifetimes of

Figure 1: Schematic view of the transverse proximity effect for a triplet of QSOs. The dotted circles represents the proximity regions of the foreground QSOs - spheres of physical radius ~ 5 Mpc - where the ionizing flux from the nearby quasar is expected to exceed that due to the metagalactic background by more than one order of magnitude, if the quasars radiate isotropically and their luminosities have remained approximately constant over the last 20-30 Myr. Adapted from Goncalves et al. (2008).



$10^6 - 10^8$ yr (see, e.g., Haehnelt et al. 1998, MNRAS 300, 817; Richstone et al 1998, Nature 395, 14; Martini & Weinberg 2001, ApJ 547, 12; Yu & Tremaine 2002, MNRAS 335, 965; Steidel et al. 2002, ApJ 576, 653) so that the potential sphere of influence of the UV radiation from bright quasars and the timescale of quasar "events" may fortuitously be of the same order. The relevant angular scales are $\theta \lesssim 10'$ on the sky at $z \sim 2-3$, with the amplitude of the expected effects varying as $1/\theta^2$ and proportional to the (far-UV) luminosity of the sources. While the effects on the Lyα forest are quite hard to detect (e.g., Fernández-Soto et al. 1995, MNRAS 277, 235; Crotts & Fang 1998, ApJ 502, 16; Croft 2004, ApJ 610, 642; Schirber et al. 2004, ApJ, 610, 105), a promising approach is that of investigating the presence of metal absorption systems at the redshift of the foreground source and closely examine their ionization state to determine the strength of the ionizing radiation field (e.g., Goncalves et al. 2008; Prochaska & Hennawi 2009, ApJ, 690, 1558). In order to get significant results, a fair number of quasar pairs have to be collected and the systemic redshift of the foreground quasar have to be precisely determined by means of near infrared spectroscopy.

These studies were limited by the dearth of close quasar pairs bright enough to be observed with the high-resolution spectrographs at the 8-10m class telescopes (see e.g., D'Odorico et al. 2006, MNRAS, 372, 1333), while the available lower-resolution spectrographs have, in general, narrow spectral coverages, and too low resolutions to reliably identify the metal absorption lines, in particular, in the Lyα forest region. The quasar pair proposed for this observation has a proper separation of ~ 120 kpc at the redshift of the foreground quasar, $z \simeq 2.115$. Thus, we will be sampling a regime where the effects of the radiative feedback from the quasar should be extremely important. Its observation would have been unfeasible with a UVES-like instrument due to the faintness of the targets, while X-shooter provides the ideal combination of sensitivity, spectral range and resolution.

Calibration strategy:
Standard calibration

Targets

Target	**RA**	**DEC**	**V** mag	z	**Mode** (slit/IFU)	**Remarks**
SDSS J21463-0752	21 46 20.7	-7 52 50	19.65	2.115	slit	Sep. 15"
SDSS J21463-0753B	21 46 21.0	-7 53 04	20.30	2.577	slit	

Time Justification:
We have used the X-shooter ETC (version 3.2.8) to compute the exposure time needed to reach a signal-to-noise ratio of ~ 10 in the Ly-α forest region, and ~ 15 in the C IV forest region, for the chosen targets. Assuming a seeing of 0.8", we adopt a slit of 0.8" in the UV and of 0.7" in the VIS in order to partially resolve Ly-α and C IV lines, respectively. In the case of the foreground quasar 1 hour of observation is sufficient also for the near-IR arm, where we adopt a slit of 0.9". For the background quasar, which is fainter, we require 2 hours of osbervation in order to reach the desired signal-to-noise ratios. We ask for a total of 4 hours, including overheads, having split the observation in exposures of half an hour each. We verified that up to 5 days from the new moon are acceptable for the observation of these faint sources.