Multi-object spectroscopy of the field surrounding PKS 2126−158: Discovery of a $z = 0.66$ galaxy group

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ABSTRACT

The high-redshift radio-loud quasar PKS 2126−158 is found to have a large number of red galaxies in close apparent proximity. We use the Gemini Multi-Object Spectrograph (GMOS) on Gemini South to obtain optical spectra for a large fraction of these sources. We show that there is a group of galaxies at $z \sim 0.66$, coincident with a metal-line absorption system seen in the quasar’s optical spectrum. The multiplexing capabilities of GMOS also allow us to measure redshifts of many foreground galaxies in the field surrounding the quasar.

The galaxy group has five confirmed members, and a further four fainter galaxies are possibly associated. All confirmed members exhibit early-type galaxy spectra, a rare situation for a Mg $\text{II}$ absorbing system. We discuss the relationship of this group to the absorbing gas, and the possibility of gravitational lensing of the quasar due to the intervening galaxies.

Key words: quasars: individual: PKS 2126−158 – quasars: absorption lines – galaxies: general – gravitational lensing

1 INTRODUCTION

Quasars located at high redshifts provide excellent probes of the intervening universe. As their light travels through the universe, it is partially absorbed by neutral hydrogen or metals such as magnesium – an effect detectable in the quasars’ optical and UV spectra.

These absorption lines provide an effective way of probing the evolution of metal-bearing gas over a large range of redshifts, as the sensitivity to absorption is largely independent of redshift, depending only on the background source’s surface brightness.

The Mg $\text{II}$ absorption systems in particular are most likely associated with foreground galaxies (Bergeron & Boisse 1991; Steidel et al. 1994, 2003), based on the velocity structure within the systems, the clustering properties of the absorbers, and the presence of metals that have most likely been produced locally. When identified, most of these galaxies appear to be spirals (e.g. Steidel et al. 2002), although absorbers have been found that span the range from late-type spirals to galaxies resembling present-day ellipticals (Steidel et al. 1994). The observational challenge then is to correctly identify the absorbing galaxies and build up a picture of the absorbing system. Such identifications allow one to track the evolution of metal-bearing gas and its relationship to galactic environment.

The identification of the object responsible for an absorption system involves finding a galaxy close to the line-of-sight to the quasar that has a redshift matching that of the absorption system. As such galaxies are often faint, to examine many in the vicinity of a given quasar requires relatively large amounts of telescope time, or a large degree of multiplexing. The advent of multi-object spectrographs on large telescopes has enabled more systems and galaxies to be examined, greatly assisting the identification of absorbing systems.

The identification of nearby galaxies close on the sky to a high-redshift quasar also allows us to address the question of gravitational lensing. The high redshifts of these quasars on face value imply very large luminosities, placing them at the high end of the luminosity function, where the slope of the function is steepest. If a small amount of magnification due to gravitational lensing is taking place, the intrinsic luminosity of the quasar will be reduced, changing the shape of the luminosity function. This is particularly important for the highest redshift quasars (such as those at $z > 6$, e.g. Richards et al. 2004), but also for those around $z \sim 3 – 4$.

In this paper we address these issues by targeting PKS 2126−158, a luminous high-redshift quasar that exhibits a number of metal-line absorption systems and has a large number of galaxies close to its line of sight, using the multiplexing capabilities of GMOS on the Gemini South telescope. We use imaging and low-resolution spectroscopy to obtain redshifts for many of the galaxies in the field, focussing on the $z < 1$ environment.

We describe this quasar and our observations of it and the surrounding field in Section $\text{A}$ while the results of the Gemini/GMOS observations are presented in Section $\text{B}$. The implications of these
results for the absorption line systems seen in the quasar’s spectrum are discussed in Section \[4\] and the possibility of magnification of this quasar due to gravitational lensing is discussed in Section \[5\]. A summary of the results is found in Section \[6\]. Note that throughout this paper we assume a standard ΛCDM cosmology, with $H_0 = 71 \, \text{km s}^{-1} \, \text{Mpc}^{-1}$, $\Omega_m = 0.27$ and $\Omega_{\Lambda} = 0.73$ (Spergel et al. 2003).

2 TARGET FIELD AND OBSERVATIONS

2.1 The quasar PKS 2126–158

The quasar PKS 2126–158 is a radio-loud, flat-spectrum quasar at a redshift of $z = 3.2663$. It was first identified by Condon, Hicks & Jauncey (1977) in optical follow-up of flat-spectrum sources from the Parkes 2700 MHz surveys, and at the time its redshift was measured it was only the fifth radio quasar with $z > 3$ (Jauncey et al. 1978).

PKS 2126–158 is known to be a very bright object at radio ($S_{2.7 \text{GHz}} = 1.17 \text{Jy}$, Wright & Otrupjec 1997), optical/near-infrared ($V = 16.92, I = 14.89$, Francis, Whiting & Webster (2000)) and X-ray ($F_{0.1-2.4 \text{keV}} = 2 \times 10^{-12} \text{erg s}^{-1} \text{cm}^{-2}$, Siebert et al. 1998) frequencies. These fluxes, combined with its relatively high redshift, mean it is among the most luminous quasars known.

The optical/near-infrared spectrum of PKS 2126–158 has a blue power-law shape for wavelengths longer than $V$ band (Francis et al. 2000), where the Lyα line falls. The flux drops off at shorter wavelengths due to absorption by the intervening gas of the Lyman alpha forest. Absorption systems with strong metal lines are observed at the redshifts indicated in Table 1. The relatively strong Mg II system at $z = 0.663$ is particularly relevant for this paper, and is discussed in more detail in Section 3.1.1.

The peculiar concentration of objects in the vicinity of PKS 2126–158 was first noticed from $K_s$-band images taken on 6 June 1993 by Drinkwater et al. (1997) with IRIS (Allen et al. 1993) on the Anglo-Australian Telescope in the course of identification of sources in the Parkes Half-Jansky Flat-spectrum Sample (PHFS). There are ~16 sources visible within 30 arcsec of the quasar, principally toward the east and south.

Veron et al. (1994) obtained spectra of the two bright sources to the west (designated therein as C1 and C2, at distances of ~5 and ~10 arcsec west of the quasar respectively). They were able to measure the redshift of C2 (an emission line galaxy) as $z = 0.210$, while the spectrum of C1 was inconclusive. This is the only redshift information available from the literature for objects in the vicinity of PKS 2126–158.

2.2 Gemini Observations

We used the Gemini Multi-Object Spectrograph (GMOS, Hook et al. 2003) on the Gemini South telescope, in Multi-Object Spectroscopy (MOS) mode, to obtain spectra for as many of the nearby objects as possible. Pre-imaging of the field was done with GMOS-South on 2003 July 15. The image, shown in Fig. 1, was constructed from six 300 sec exposures in the $i'$ filter (Gemini filter $i_s$, G0327), and has image quality of 0.7 arcsec (the image was binned 2 × 2 on-chip).

Since GMOS uses multiple slits in its multi-object mode, one cannot have slits overlapping in the dispersion direction (the horizontal direction in Fig. 1), particularly when the target objects are close together on the sky. For this project, this places a limit on the number of sources that can be observed in a single pointing (we had time for just a single mask setting). Fortunately, a judicious choice of position angle (in this case, 215° East of North) can enable a large fraction of the sources of interest to be placed on a slit. The large field of view of GMOS (~5.5 arcmin) also enabled a number of potentially interesting sources further from the quasar to be placed under a slit. These were selected either on morphology, or on their location in the field (i.e. whether a slit could be placed over them based on previously allocated slits). The locations of the targeted objects are shown in Fig. 1 while Fig. 2 shows each object in more detail, as well as the location of each slit.

Note that the limiting magnitude of the image is approximately $i_f' = 24.6$. At this magnitude, an $L_*$ galaxy is visible out to a redshift of 5. However, at the magnitude of the faintest spectroscopic target ($i_f' = 23.33$), an $L_*$ galaxy can be seen only out to $z = 0.73$ (although a 3$L_*$ galaxy survives the K-correction and can be seen out to $z \sim 5$).

The field was observed in queue mode on two nights – 2003 September 24 and 25 – with the chosen slit configuration, using the R150 grating and the GG455 long-pass filter, for a total exposure time of 2 hours. This was divided into sets of 3 × 1200 sec exposures at each of two grating settings, one on each of the nights. The data was binned on-chip by a factor of 2 in both spatial and dispersion directions.

The image quality, as measured from alignment images (with the mask in place) taken prior to the spectral observations, was noticeably worse on the second night (0.95 arcsec on night one, 0.95 arcsec on night two). This limited the signal-to-noise achieved in the spectra, and consequently several sources were unable to have redshifts measured (the spectra where redshifts were measured typically had $S/N \gtrsim 5$, while these few were significantly less than that).

The data were reduced using standard procedures from the Gemini IRAF package. The spectra were bias-subtracted and flat-fielded using calibration frames from the Gemini CAL unit. Wavelength calibration using CuAr arc spectra, as well as sky-subtraction, were performed on an individual slit basis, and the

<table>
<thead>
<tr>
<th>$z_{\text{abs}}$</th>
<th>Velocity range</th>
<th>Metal lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6631</td>
<td>$\delta v \sim 215 , \text{km s}^{-1}$</td>
<td>Mg II, Mg I, Ca II</td>
</tr>
<tr>
<td>2.3313</td>
<td></td>
<td>C IV, Si II</td>
</tr>
<tr>
<td>2.3941</td>
<td>$\delta v \sim 180 , \text{km s}^{-1}$</td>
<td>C IV, Si IV, Si II, Al II</td>
</tr>
<tr>
<td>2.4597</td>
<td></td>
<td>C IV, Fe II</td>
</tr>
<tr>
<td>2.5537</td>
<td></td>
<td>C IV</td>
</tr>
<tr>
<td>2.6378</td>
<td>$\delta v \sim 286 , \text{km s}^{-1}$</td>
<td>C IV, C III, Al II, Al III, Si II, Si III, Si IV, Mg I, O I, Fe II</td>
</tr>
<tr>
<td>2.6788</td>
<td></td>
<td>C IV, Si IV, C II, Fe II, N V</td>
</tr>
<tr>
<td>2.7281</td>
<td></td>
<td>C IV, Si IV, Si II, Fe II</td>
</tr>
<tr>
<td>2.7689</td>
<td>$\delta v \sim 350 , \text{km s}^{-1}$</td>
<td>C IV, Al II, Si II, C II, O I, Si IV, Al III, Fe II</td>
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<tr>
<td>2.8195</td>
<td></td>
<td>C IV, C II, Si II, O I</td>
</tr>
<tr>
<td>2.9071</td>
<td></td>
<td>C IV, Al II, Si III, Si IV</td>
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<tr>
<td>2.9675</td>
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<td>Lyman limit system</td>
</tr>
<tr>
<td>3.2165</td>
<td></td>
<td>C IV, Si IV, Si II</td>
</tr>
</tbody>
</table>

1 We assume $M_\text{**} = 5 \log_{10} h - 21.6$, Bell et al. 2003, and calculate K-corrections with template SEDs from Oke & Gunn 1983.
spectra were flux-calibrated using observations of the standard star EG131.

3 RESULTS

The measured redshifts for galaxies in the field of PKS 2126–158 are shown in Table 2. The galaxies are numbered according to their position on the image, and sorted in the table in order of decreasing redshift. The \( i' \) magnitudes shown are measured from the pre-imaging data (i.e. the image shown in Fig 1), calibrated on the Landolt standard fields SA95 and TPhe, using the transformations from Fukugita et al. (1996). We have converted these magnitudes into absolute magnitudes, \( M_{i'} \). The K-corrections were calculated using the template SEDs from Poggianti (1997) and the filter transmission function for filter iG0302 provided on the Gemini web site.\(^2\)

We find 8 galaxies with redshifts in the range \( 0.66 < z < 0.67 \), straddling the low redshift metal-line absorption systems seen

\(^2\) Note that this transmission function is for the equivalent \( i' \) filter at Gemini North, believed to be similar to the one used at Gemini South. The transmission function for the Gemini South filter was not available at the time of writing.
Figure 2. GMOS $i'$ images of individual targets, listed in the same order as in Table 2. The location of the slit used is indicated. Each image is centred on the object indicated at the top-right. The angular scale, which is the same in each image, is shown in the image of #35, at top-left.
The velocity dispersion of these eight galaxies is \( \sigma \approx 430 \text{ km s}^{-1} \), centred on a redshift of \( z_g = 0.6660 \). Three of these galaxies, however, are at large spatial separations from those close to the quasar. If we include just the four closest to the quasar – #17, #18, #19 and #20 – as well as #14, which is just close enough to be considered associated, we get \#18, \#19 and \#20 – as well as \#14, which is just close enough to be considered associated, we get \\

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\text{Object} & \rho & \text{Comments} \\
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\text{PEG} & \text{PEG} & \text{PEG} & \text{PEG} \\
\text{PEG} & \text{PEG} & \text{PEG} & \text{PEG} \\
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They are thus either red group (more likely in the case of \#15), or \\

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\text{PEG} & \text{PEG} & \text{PEG} & \text{PEG} \\
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\text{PEG} & \text{PEG} & \text{PEG} & \text{PEG} \\
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by D’Odorico et al. (1998). The spectra of these galaxies are shown in Fig. 4.

The velocity dispersion of these eight galaxies is \( \sigma = 430 \text{ km s}^{-1} \), centred on a redshift of \( z_g = 0.6660 \). Three of these galaxies, however, are at large spatial separations from those close to the quasar. If we include just the four closest to the quasar – #17, #18, #19 and #20 – as well as #14, which is just close enough to be considered associated, we get \( \sigma = 355 \text{ km s}^{-1} \) and \( z_g = 0.6662 \).

This velocity dispersion is characteristic of a group environment, rather than a more dense cluster environment which would show \( \sigma \approx 500 - 1200 \text{ km s}^{-1} \). It is, in fact, a relatively poor group, with only five members brighter than \( M_r = -21 \). There are at least four fainter galaxies for which we have not obtained spectra and which are thus also candidates for inclusion in the group (see Sec. 4 for further discussion). The remaining galaxies at \( z \approx 0.66 \) (\#24, \#03 and \#01) are part of the same large-scale structure that the group is embedded in, but not necessarily directly associated with the group itself.

In addition to this structure, we find several other features in redshift-space. There are two other main structures seen in the field, at \( z \approx 0.21 \) and \( z \approx 0.46 \) (and possibly \( z \approx 0.51 \)), although these are not as tightly grouped on the sky as the main group at \( z \approx 0.66 \). There are a number of field galaxies at other redshifts as well. We are thus seeing several features in the large-scale structure along the line-of-sight to PKS 2126–158. The spectra of the remaining galaxies with measured redshifts are shown in Figs. 4 & 5 and the distribution of galaxy redshifts can be seen in Fig. 6.

Of the remainder, six objects were identified as stars, and a further five had spectra of too low quality for a redshift measurement. Of these latter objects, two (\#11 and \#15) have extended morphologies in the \( i' - K \) GEMOS image, and \( i' - K \) colours redder than all the confirmed group members (\( i' - K \approx 4.7 \) and 4.0 respectively, cf. \( i' - K \approx 3 \) for the group members). They are thus either red galaxies in the \( z \approx 0.66 \) group (more likely in the case of \#15), or background galaxies (and redder due to their greater redshift).
Figure 3. Reduced GMOS-South spectra of the eight galaxies at redshifts of \( z \approx 0.66 \), listed in order of decreasing redshift. Likely members of the group are indicated. The flux scale is \( F_\lambda [10^{-18} \text{erg s}^{-1} \text{cm}^{-2} \text{Å}^{-1}] \), plotted as a function of observed wavelength. Note that the varying flux scale from spectrum to spectrum. The identities of certain spectral features are indicated, and residuals from night-sky emission lines at 5577 Å and 6300/6363 Å have been masked out. The noticeable spike at \( \sim 5890 \) Å in the spectrum of Obj#19 is a sky-subtraction artifact, caused by the location of this object close to the edge of a tilted slit (see the image in Fig. 2).

4 ASSOCIATION WITH ABSORBING SYSTEM

4.1 Is one of the identified galaxies the absorber?

As seen in Section 3 we find a concentration of galaxies in the redshift range 0.66 < \( z \) < 0.67. This coincides in redshift-space with a metal-line absorption system detected by Giallongo et al. (1993) and D’Odorico et al. (1998). The system consists of four components in velocity, with three species detected – Mg II and Ca ii, plus Mg i in the two highest column density components. The redshifts of the components are \( z = 0.6625, 0.6628, 0.6634 \) and 0.6637 (D’Odorico et al. 1998). This system is quite strong: the two strongest Mg ii components (at \( z = 0.6628 \) and \( z = 0.6625 \)) have column densities of \( 4.1 \times 10^{17} \text{ cm}^{-2} \) and \( 5.8 \times 10^{16} \text{ cm}^{-2} \) respectively (Ryabinkov et al. 2003; D’Odorico et al. 1998). Using the Doppler parameters quoted by D’Odorico et al. (1998), we can convert these to equivalent widths of 0.44 Å and 0.41 Å respectively (for the Mg ii \( \lambda 2798 \) line in the rest frame).

A key question is whether this system can be associated with the group of galaxies detected in our GMOS observations. The nearest of the galaxies to PKS 2126–158 is Galaxy #17, which lies at a distance of 51.2 kpc to the quasar’s line-of-sight (hereinafter QLOS). This places the QLOS in the outer parts of the galaxy’s halo. This separation is comparable to those seen in other absorption systems (see, for example, Steidel et al. (1997)). This galaxy, however, does show a large velocity offset from the absorbing system, with velocity differences \( \Delta v \equiv v_{\text{gal}} - v_{\text{abs}} \) with respect to the four components ranging from \( 430 - 610 \text{ km s}^{-1} \).

Galaxy #18 provides a much closer match to the velocities (\( \Delta v = 74 - 253 \text{ km s}^{-1} \)), and is only 61.2 kpc from the QLOS. It is also the brightest galaxy in the group, with \( i' = 20.34 \).

A relationship has been noted by Lanzetta & Bower (1990) between the equivalent width \( W \) of the Mg ii absorption system and the impact parameter \( \rho \) of the associated galaxy, where \( W \propto \rho^{-0.92 \pm 0.16} \). By converting the column density and Doppler parameters of the absorption lines, we can obtain the equivalent widths for the system: the four Mg ii \( \lambda 2796 \) lines from D’Odorico et al. (1998) yield rest-frame values of \( W = 0.41, 0.44, 0.13 \) and 0.13 Å (in order of increasing redshift).
Discovery of a $z = 0.66$ galaxy group

Figure 4. Reduced GMOS-South spectra of confirmed galaxies in the field of PKS 2126−158 with $z > 0.4$, listed in order of decreasing redshift. The flux scale is $F_\lambda [10^{-18} \text{erg s}^{-1} \text{cm}^{-2} \text{Å}^{-1}]$, plotted as a function of observed wavelength. The identities of certain spectral features are indicated, and residuals from night-sky emission lines at 5577 Å and 6300/6363 Å have been masked out.

Comparing with the Lanzetta & Bowen (1990) relationship, we find that the two stronger systems have $W$ values corresponding to $\rho \sim 30$ kpc, while the two weaker systems correspond to $\rho \sim 110$ kpc. The galaxies we have observed to be in the group all lie at impact parameters between these two values. There is, however, an object closer than the closest observed galaxy to the QLOS (# 17), which, should it prove to be at the same redshift, may be a counterpart to one of the stronger systems (see Section 4.2 for more discussion on this source).

If we focus just on the confirmed group members, the Lanzetta & Bowen (1990) relationship taken at face value indicates that none of these galaxies are suitable counterparts for the absorption system(s). Recent studies, however, such as that presented in Churchill et al. (2005), indicate that there is much more scatter in the $W - \rho$ relationship than the Lanzetta & Bowen (1990) relationship would suggest. This calls into doubt its utility in making predictions about the likelihood of potential absorbers. The Churchill et al. (2005) results suggest that the observed galaxies can indeed be considered potential hosts of the absorber, even with their relatively large impact parameters. The identity of the absorber then is still an open question.
Figure 5. Reduced GMOS-South spectra of confirmed galaxies in the field of PKS 2126–158 with \( z < 0.4 \), listed in order of decreasing redshift. The flux scale is \( F_{\lambda} \left[ 10^{-18} \text{erg s}^{-1} \text{cm}^{-2} \text{\AA}^{-1} \right] \), plotted as a function of observed wavelength. The identities of certain spectral features are indicated, and residuals from night-sky emission lines at 5577 \( \text{\AA} \) and 6300/6363 \( \text{\AA} \) have been masked out.

Figure 6. Distribution of measured redshifts of galaxies in the field of PKS 2126–158.

4.2 An alternative absorbing galaxy.

There are three objects closer to PKS 2126–158 than Galaxy #17. These can be seen in Fig. 4 along with some of the group members. A spectrum of the object west of PKS 2126–158 was observed by Veron et al. (1990) (their C1). They were unable to measure its redshift, but its optical and near-infrared colours are similar to their C2 (the next galaxy to the west), which they found to be at \( z = 0.21 \). It is therefore likely that this galaxy is foreground to the group at \( z \sim 0.66 \).

The remaining two nearby objects were not able to be observed in our GMOS observations (due to the limitations of slit placement). Object X1 appears to be stellar in morphology, and has colours \( i' - K = 1.78 \) – not typical of a galaxy at the same redshift as the group. Similarly, the more distant (from the QLOS) object X3 has a stellar morphology, and even bluer colours than X1 (\( i' - K = 1.49 \)), and thus is likely to be a star.

The closest object to the quasar, X2, has an extended, non-stellar morphology, and redder colours than X1 or X3: \( i' - K = 2.97 \), similar to the colours of the galaxies in the group at \( z \sim 0.66 \). It may thus be a galaxy in the same system. This putative galaxy would then lie at a projected distance of \( \sim 23 \text{ kpc} \) from the QLOS, making it a possible candidate as a host of the absorbing system. Its impact parameter provides a good match to the stronger absorption systems, if one uses the \( W - \rho \) relationship of Lanzetta & Bowen [1990]. A further point in its favour is its extended, somewhat elongated morphology – suggestive of a disc galaxy, matching the morphology of many Mg II-absorbing galaxies.

4.3 Intra-group gas as an absorber.

Is the absorbing gas necessarily associated with a galaxy? The fact that we have a group environment means that the velocity dispersion is comparable to the rotational velocities of the individual galaxies. Galaxy interactions are then more likely to strip gas from...
galaxies and leave it in the intra-group medium. Such interactions could date from the formation epoch of the group, or from more contemporary encounters. An potential example of such an interaction, based on imaging data, is the pair #17 and #18. The velocity difference between the two ($358 \text{ km s}^{-1}$), is comparable to the velocity dispersion of the group, and so is feasible for an interaction.

A close-up of this pair of galaxies is shown in Fig. 8. There is evidence for a connection in flux between the two, with the flux in the “bridge” region reaching $> 7\sigma$ above the background. There is certainly no spectroscopic sign of any strong interaction taking place, with both galaxies exhibiting simple passive elliptical spectra. However, sensitive narrow-band imaging may be able to detect Hα emission from ejected gas in the vicinity of the galaxies, and would prove a good test of this interaction hypothesis.

### 4.4 Summary and Discussion

PKS 2126–158 is observed to have a strong Mg II absorption system at the same redshift as the group of galaxies detected through our GMOS spectroscopy. All the nearby galaxies that have spectroscopy are observed to be ellipticals: each shows a passive elliptical galaxy spectrum, and none shows evidence for on-going star-formation (for instance, through the presence of an [O II] emission line), which would indicate the presence of large amounts of gas.

Many Mg II absorbers are identified with spiral galaxies (e.g. Steidel et al. 2002), although this is by no means an exclusive statement. Steidel et al. (1994) found that Mg II absorption could be found in galaxies resembling present-day ellipticals as well as late-type spirals. Jenkins et al. (2005) found Mg II absorption associated with two S0 galaxies, and recent studies (Churchill et al. 2005) have found a small fraction of elliptical absorbers. The latter studies also indicate that the absorption is also relatively patchy, and so one (or more) of the galaxies could have isolated areas of absorbing gas that happen to fall across the QLOS, but are not themselves an important overall part of the galaxy. This may be similar to the situation observed by Bowen et al. (1995), who failed to find absorption associated with two elliptical galaxies despite their small impact parameters.

It is possible that there is intra-group gas responsible for the absorption, although there is little direct evidence for this at this stage. The best candidate, however, for the absorber is probably galaxy X2. It is closer to the QLOS, and shows a much less uniform morphology than the identified galaxies. Ultimately, a spectroscopic confirmation of its redshift is the only way to be sure – future observations will hopefully resolve this question.

### 5 THE LIKELIHOOD OF GRAVITATIONAL LENSING

PKS 2126–158 is rather luminous at all frequencies from radio to X-ray. We would like to know whether it is intrinsically luminous, or has been magnified through gravitational lensing by some intermediate mass distribution. Strong lensing can be ruled out, as PKS 2126–158 is not multiply-imaged – even at VLBI resolution ($\sim 1 \text{ mas}$), it shows a distinct core-jet structure (Stanghellini et al. 2001).

Magnification due to gravitational lensing is still possible without multiple images being detected. There are two contexts in which this can take place: either a single image is produced, or there are indeed multiple images but at either faint levels or unresolved separations. Since VLBI observations place quite strong limits on the existence of optically-unresolved images, for lensing to be taking place we would require the production of a single image only.

However, Keeton, Kuhlen & Haiman (2005) find that this is possible only when the lensing is due to massive cluster-sized haloes ($\gtrsim 10^{13.5} M_{\odot}$). Our observations show that the largest mass concentration along the line-of-sight is merely a galaxy group. The total luminosity of all galaxies in the group is $\sim 3 \times 10^{11} L_{\odot}$ (assuming an absolute magnitude of the Sun of $M_V = 4.45$,
and taking into account all possible members, including X2 and
and the fainter objects in Fig. 1. For reasonable mass-to-light ra-
tios, the group mass will be much less than the threshold given
by Keeton et al. (2005). This is supported by the non-detection
by Crawford & Fabian (2003) of any extended X-ray emission in
Chandra images of PKS 2126−158, indicating the lack of hot cluster
gas around or in the foreground of the quasar. We can thus rule
out the possibility that PKS 2126−158 is being magnified by any
significant amount. Its large apparent luminosity is then indeed in-
dicative of its intrinsic power.

6 SUMMARY

We have observed the field surrounding PKS 2126−158 with Gem-
mini South + GMOS in multi-object spectroscopy mode, measuring
the redshifts of most of the nearby galaxies. We find a group of
galaxies at $z \sim 0.66$, at a similar velocity to a metal-line absorp-
tion system seen in the quasar’s spectrum. The group has five con-
firmed members, and a further four fainter galaxies are seen nearby
and are possibly associated. There are a further three galaxies close
in redshift but at large separations on the sky – while not part of the
group, they are certainly part of the same large-scale structure.

We have also made use of the multiplexing capabilities of
GMOS to measure the redshifts of many other galaxies in the field,
and we see several distinct features in redshift-space foreground to
the group. These observations, in showing the lack of a large cluster
in front of PKS 2126−158, indicate that the likelihood the quasar
is lensed is small.

While the group as a whole appears to be associated with the
absorption system, the fact that the redshifts of a number of nearby
candidates have not been measured means some doubt remains as
to the identity of the absorber. If the absorber is associated with the
identified galaxies however, this would be a rare example of an Mg II
absorption system associated with an early-type galaxy.

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