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Letter to the Editor

HS 1216+5032: a new double QSO separated by 9"

H.-J. Hagen[1], U. Hopp[2], D. Engels[1], and D. Reimers[1]

[1] Hamburger Sternwarte, Gojenbergsweg 112, D-21029 Hamburg, Germany
[2] Universitäts-Sternwarte München, Scheiner Str. 1, D-81679 München, Germany

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Abstract. We report the discovery of a double QSO which was found during verification observations of QSO candidates of the Hamburg Quasar Survey. The A component has an apparent B magnitude of 17.2 and a redshift of 1.45. At a distance of 9$''$.1 there is a second QSO with a B magnitude of 19.0 and the same redshift. In the range of the optical spectra obtained both objects show CIV (1549Å), CIII] (1909Å) and MgII (2798Å) emission lines. In the spectrum of the B component there is well seen a broad CIV absorption line with nearly the same redshift which cannot be seen in the spectrum of the A component. In addition to the large separation of the two QSOs this strengthens the assumption that this pair is a genuine binary QSO and not a gravitationally lensed single QSO. This new pair offers the possibility to measure the transverse size of Lyα clouds in the yet-unexplored redshift range z<1.4 with HST.

Key words: Quasars: general – Quasars: individual: HS 1216+5032

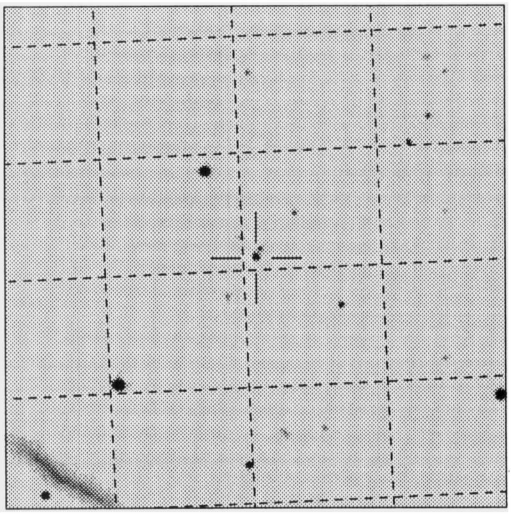

Fig. 1. Finding chart for HS 1216+5032.
Equatorial coordinates of the A component (equinox 1950): $\alpha = 12^h16^m13^s.4$ $\delta = +50°32'14''$.

1. Introduction

For the Hamburg Quasar Survey (HQS) objective prism plates taken with the Calar Alto Schmidt telescope are digitised with a PDS microdensitometer. Subsequent semiautomated quasar candidate selection among the detected spectra provide QSO candidate lists (see details in Hagen et al. 1995) which are mainly verified by slit spectroscopy at the 2.2m telescope of the German-Spanish Astronomical Center on Calar Alto in Spain (DSAZ). The HQS is aimed at finding bright (B≤17.5) high redshift (z≤3.2) QSOs for further high resolution spectroscopy in the optical and the UV (Groote et al. 1989, Reimers et al. 1989, Hagen et al. 1992, Reimers et al. 1995a)

Double QSOs have been shown to be an important tool in measuring the transverse sizes of intervening absorbing clouds (Smette et al. 1995). HS 1216+5032, which we here report on, is well-suited to UV spectroscopy in order to measure transverse dimensions of Lyα forest clouds in the largely unexplored redshift range 0.8≤z≤1.4. Due to its redshift no optical thick Lyman limit system can appear above ≈ 2200Å. With a linear separation of 80 h_{50}^{-1} kpc it samples Lyα clouds on a scale slightly smaller than the expected characteristic cloud sizes. For the purpose of measuring cloud sizes a genuine binary QSO offers advantages compared to a lensed system where the geometry is often not well known.

Send offprint requests to: H.-J. Hagen,
e-mail: hhagen@hs.uni-hamburg.de

* Based on observations from the German-Spanish Astronomical Center, Calar Alto, operated by the Max-Planck-Institut für Astronomie, Heidelberg, jointly with the Spanish National Commission for Astronomy

2. Observations

2.1. Discovery

During a follow-up spectroscopy campaign from 14th to 16th March 1995 at the 2.2m telescope of the DSAZ a spectrum of the A component was taken. The Boller & Chivens spectrograph was used with a 240Å/mm grating and the CCD was binned in 2 pixels parallel to the direction of dispersion which yielded a resolution of ≈20Å. The spectrograph was rotated to a sky position angle of 155° to align the slit on a neighboured object which could be seen on the finding chart (Fig. 1) obtained from digitised Calar Alto Schmidt direct plates (Hagen et al. 1995). The obvious QSO candidate A was confirmed as a QSO with redshift 1.45. The second object B, weaker by about a factor of 6, only produced a very low signal to noise spectrum. But the shape of the continuum was similar to that of the A component and an emission line at the same position of the A component MgII line was detected at a significant level. The CIV emission line at a redshifted wavelength of ≈ 3800Å could only be detected with difficulty because of the strong associated absorption and the loss of light due to atmospheric refraction. Further observations were necessary.

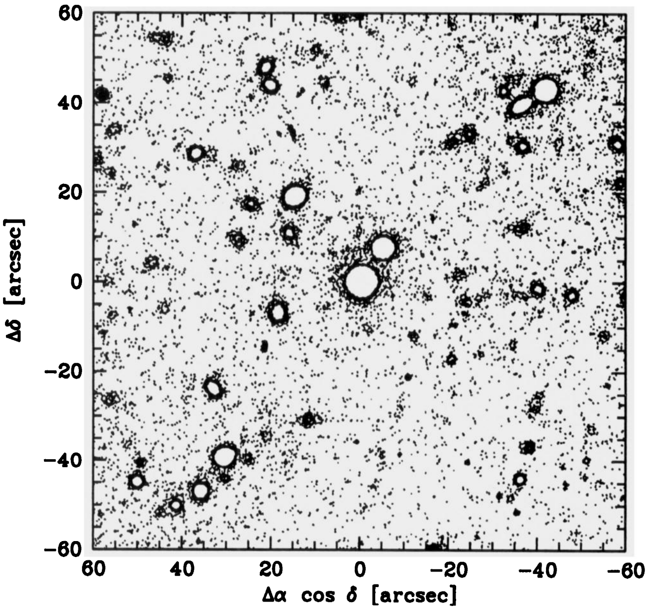

Fig. 2. Plot of the central part of the coadded direct images. The contour levels represent multiples of background noise above background. The estimated limit of the image is R≈22.5.

2.2. Further observations

In May the exposure could be repeated with the same instrumental configuration. The 3600 s exposure confirmed the nature of these two objects (Fig. 3). One should keep in mind that the slit was aligned on the objects and not to the direction of the atmospheric refraction in order to obtain both spectra with one exposure. Due to possible alignment errors and object acquisition with the brighter component this could cause the loss of light in the blue part of the B component.

In June three 400 s direct images were taken with the 3.5 m telescope on Calar Alto equipped with the focal reducer and a Röser R2 filter (Röser & Meisenheimer 1991) under medium seeing conditions of 1″ to 2″. The image data were flatfield corrected with a dusk sky flat, aligned and coadded (Fig. 2).

3. Results

Two dimensional Gaussians were fitted to the direct image data of both components and several neighboured objects. No elongation of one of the components or greater multiplicity could be detected. The position difference of the components yielded a distance of 9″.1 and from the ratio of the central intensities a magnitude difference of ≈1.8 was determined. For the A component an apparent B magnitude of 17.2 could be derived from the calibration of the Schmidt plates with an error of 0.5 (for details of the calibration procedure see Hagen et al. 1995 and references therein). The continuum flux of the slit spectrum yielded a slightly smaller value of 17.0.

The redshifts of the two components were independently determined using a Gaussian centering algorithm. For the A component three lines (CIV, CIII], and MgII) yielded a value of 1.450. Only two lines (CIII] and MgII) could be used for the B component. Their positions resulted in a value of 1.451.

The spectra (Fig. 3) demonstrate that (i) the two components have identical redshifts within the errors of $\Delta z = \pm 0.005$ and that (ii) the spectra show distinct differences in that component B has a broad CIV absorption line in the blue wing of the CIV emission line. Probably component B is a BAL QSO. The combination of the large angular separation of 9″.1 between the components, which would require a very large deflector mass in case of a gravitational lens origin of the pair, with the distinctive differences between the spectra almost exclude a gravitational lens origin. The deep image in Fig. 2 also shows no hints for an intervening large mass like a giant galaxy or a galaxy cluster. Of course the possibility remains that in case of a BAL covering factor well below 1, two different light paths might lead to differences in the BAL profiles, – indeed small such differences appear to have been observed in the fourth component of the multiply lensed QSO H 1413+117 (Angonin et al. 1990) – but the more probable case is that HS 1216+5032 is a genuine

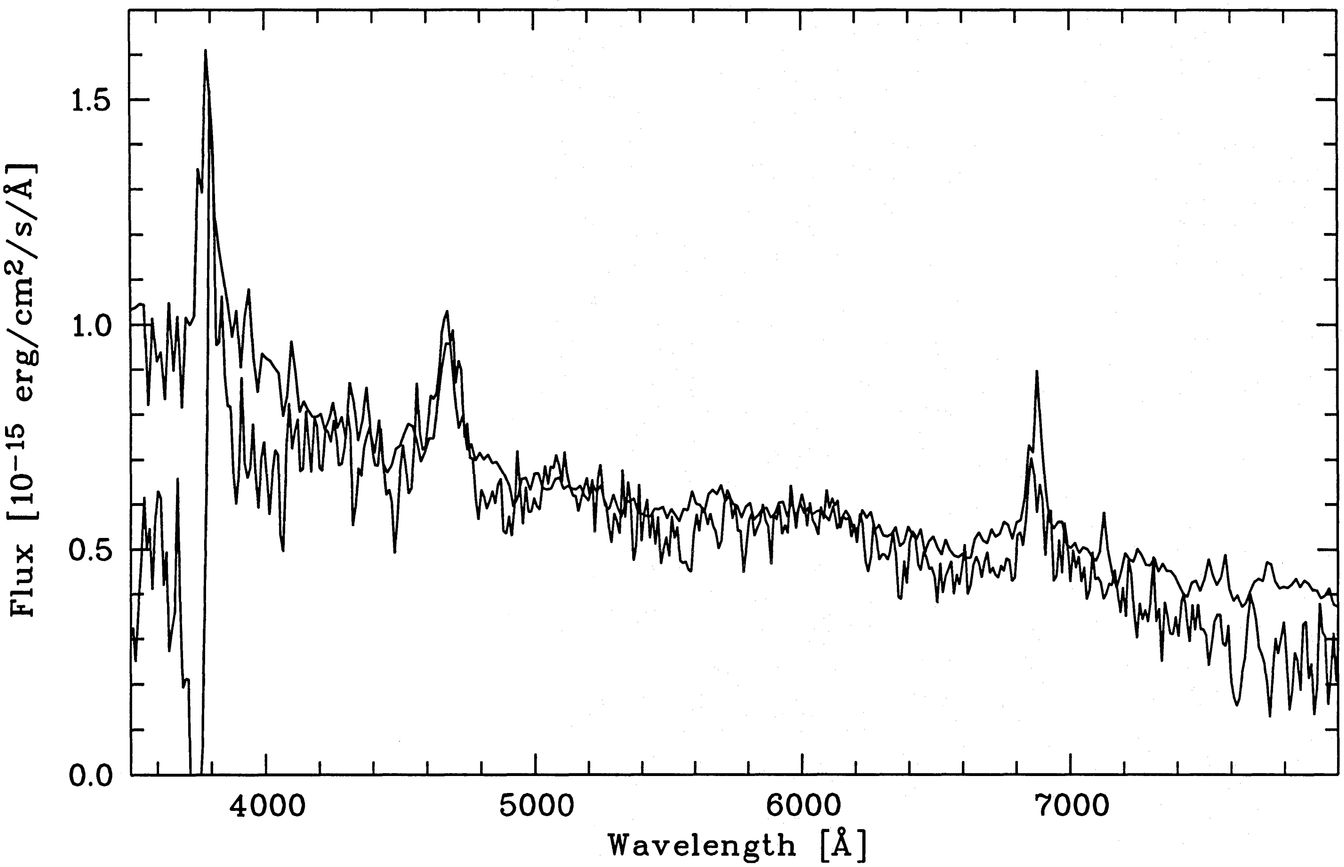

Fig. 3. Optical spectra of both components of HS 1216+5032. The lower line represents the flux of the B component scaled with a factor of 4.

QSO pair. A genuine QSO pair with known geometry of light paths offers a much easier way to determine transverse sizes of absorbing clouds along the light path, in particular sizes of the numerous Lyα clouds.

4. Discussion

The nature of the Lyα forest clouds is still debated in spite of considerable recent progress both on the observational and the theoretical side. While at least a large fraction of low redshift Lyα clouds seems to be related to galaxies or to large scale structure (Bahcall et al. 1993, Stocke et al. 1995, Lanzetta et al. 1995, Le Brun et al. 1995), the high redshift clouds (z>1.7) do not show clustering in space, contrary to metal containing systems and seem to be not related to normal galaxies (Sargent 1980). On the other hand, recent very high S/N and spectral resolution data show that in Lyα forest clouds with log $N_H \geq 14.5$ metals (CIV) are common (Cowie et al. 1995, Tytler et al. 1995). Low redshift Lyα clouds also show a different redshift distribution (nearly flat for z<1, still consistent with no evolution) compared to the z>1.7 clouds which show rapid evolution (e.g. Murdoch et al. 1986).

So the question is still open whether we see two different Lyα forest populations which occupy different fractions at high and low redshifts. If so, the transition from one dominant type to the other apparently lies in the yet largely unknown redshift range z=1 to z=1.6.
Besides the form of evolution, one key property for the understanding of the physical conditions in Lyα clouds (density, temperature, ionization) is the geometrical size of the clouds.
Here we have recently seen considerable progress:

- at high redshift ($1.7 \leq z \leq 2.3$) the bright new pair HE 1104 – 1805 (d=3$''$.1) has yielded a lower limit for the cloud sizes D of D>350 h_{50}^{-1}kpc (for the lens at 1.66) or D>180 for the lens at 1.32 (Smette et al. 1995).
- at lower redshifts there is up to now only Q 0107 – 025 (d=1$'$.44, z=0.95) which had been observed with the FOS of the Hubble Space Telescope and yielded D>340 h_{50}^{-1}kpc (Dinshaw et al. 1995a, 1995b).

With HS 1216+5032 we discovered a bright QSO pair with favourable properties for a Lyα forest cloud size study: it is not a lensed QSO; with B_A=17 and B_B=19 it is bright enough for a HST FOS study; the projected separation of the lines of sight of 80 h_{50}^{-1}kpc samples well the

expected cloud sizes of several hundred kpc. The object is in particular a welcome supplement to the cloud size study at z≈1 to 1.7 in HE 1104-1805 (25 h_{50}^{-1}kpc) – for which HST spectra have recently be taken by the present group – and Q0107-025 (1100 h_{50}^{-1}kpc).
According to Bahcall et al. (1993) and Reimers et al. (1995b) we expect 15 to 20 Lyα forest lines in the range 2200Å to 2920Å (z=0.8 to 1.4).
The only studied pair at this angular distance is Q1343+2640 (z=2.03, d=9″.5) where due to the faintness of both components (B>20) only the small wavelength range 3500Å to 3700Å could be studied, with 8 coincidences and 4 anticoincidences in Lyα lines (Dinshaw et al. 1994).

The new pair will also contribute to improving our knowledge of the Lyα forest cloud number density dN/dz in the range z=1 to 1.4 since on the scale of 80 kpc, metal lines will show much stronger differences than Lyα lines and can be distinguished from the latter.
Finally, we also expect some new information on the sizes of metal line absorbing clouds. According to the known CIV and MgII systems number statistics (Sargent, Boksenberg & Steidel 1989, Steidel 1990, Steidel & Sargent 1992) we expect altogether 3 CIV systems (2 in UV) and one MgII (optical).

5. Conclusions

With HS 1216+5032 we found a double QSO which is an ideal target for Lα cloud studies. High resolution UV and optical spectroscopy of the two components has to be done to elaborate the differences and similarities of the two lines of sight and to determine better redshift values. This will provide limits for the cloud sizes in the redshift range from 0.8 to 1.4.

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