A&A 382, L26–L28 (2002)
DOI: 10.1051/0004-6361:20011798

Astronomy & Astrophysics

Discovery of a new quadruply lensed QSO: HS 0810+2554 – A brighter twin to PG 1115+080*

D. Reimers[1], H.-J. Hagen[1], R. Baade[1], S. Lopez[2], and D. Tytler[3]

[1] Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, 21029 Hamburg, Germany
[2] Departemento Astronomia, Universidad de Chile, Casilla 36-D, Santiago, Chile
[3] Department of Physics and Center for Astrophysics and Space Sciences, University of California, San Diego, C-0424, La Jolla, CA 92093-0424

Received 3 December 2001 / Accepted 16 December 2001

Abstract. We announce the probable discovery of a new very bright gravitationally lensed QSO, HS 0810+2554 ($z = 1.50$, $V = 15.3$). The gravitational lens character has been discovered serendipitously by means of short (12 times 1 s) HST/STIS target acquisition images. The coadded images show a close bright double A ($V = 16.0$) and B (16.7) separated by $0\farcs25$ plus two fainter images C (17.4) and D (18.8). There is also evidence for a lens galaxy in the center of the images which is fainter than A by a factor of ≤ 30 at 7150 Å. The image configuration resembles very much that of PG 1115+080 except that in HS 0810+2554 image splittings ($\leq 1''$) are smaller by a factor of ~ 2.5 and HS 0810+2554 is brighter by $\sim 1^{\rm m}$.

Key words. galaxies: quasars: individual HS 0810+2554 – galaxies: quasars: general – cosmology: gravitational lensing

1. Introduction

Gravitational lenses have become an important tool of observational cosmology. Multiply imaged QSOs can be used to determine the Hubble constant H_0 from observed time delays between the images (Refsdal 1964), to study the distribution of matter in a mass-selected sample of galaxies, to investigate the QSO geometry by means of wavelength dependent image amplification due to microlensing (Wisotzki et al. 1993, 1998), and last not least to get information on the spatial distribution of intergalactic matter in the distant universe (Lopez et al. 1999).

The Hamburg-All Sky Bright QSO Surveys (cf. Hagen et al. 1995; Reimers & Wisotzki 1997) which are based on digitized objective prism plates over $\sim$22 500 deg^2 from the Calar Alto (HQS) and ESO Schmidt telescopes (HES) have produced roughly half of the known bright ($B < 17$) QSOs and have as such been a rich source of gravitationally lensed QSOs; in fact 6 multiple QSOs have been discovered so far (for reference cf. Hagen & Reimers 2000).

Due to seeing limitations optical imaging surveys from the ground can detect only multiply images with fairly large image separations which favours giant E galaxies as lenses.

In this letter we announce the serendipitous discovery of a multiply imaged QSO with four images within $1''$ during high resolution spectroscopy of a bright QSO with HST/STIS.

2. Observations and discussion

HS 0810+2554 was discovered on a digitized objective prism plate of the HQS (Hagen et al. 1995) and published in a list of bright QSOs (Hagen et al. 1999) with $V = 15.3$ and $z = 1.5$. Due to its extreme brightness we proposed it as a target for high-resolution UV spectroscopy with HST/STIS with the aim to detect the warm-hot intergalactic medium at $z > 1$ via intergalactic OVI absorption lines (cf. Reimers et al. 2001) and got 19 orbits HST time.

The HST observations were conducted between November 5-11 2001, with a surprising result: the target acquisition images taken with STIS show four images, in a configuration similar to that of PG 1115+080 (cf. Fig. 1).

Send offprint requests to: D. Reimers,
e-mail: `dreimers@hs.uni-hamburg.de`

* Based on observations with the NASA/ESA Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by Aura, Inc., under NASA contract NAS 5–26 555 and on observations at the German - Spanish Astronomical Center (DSAZ) on Calar Alto, Spain.

Article published by EDP Sciences and available at http://www.aanda.org or http://dx.doi.org/10.1051/0004-6361:20011798

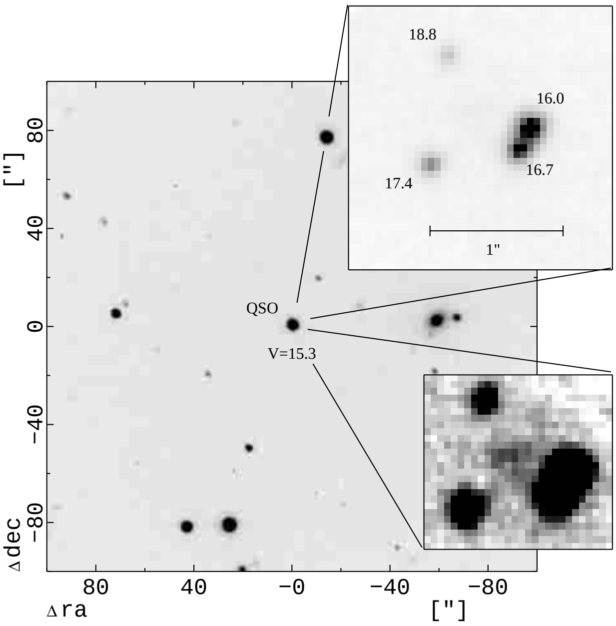

Fig. 1. Johnson V image of HS 0810+2554 (Calar Alto 3.5 m telescope, 120 s, March 21, 1996). The small panels show logarithmic plots of the coadded acquisition STIS/HST images (effective wavelength 7150 Å, exposure time 12 s). The displayed brightnesses were computed by dividing the total brightness of $V = 15.3$ according to the counts ratios. Notice the faint probable lensing galaxy in the center of the 4 images.

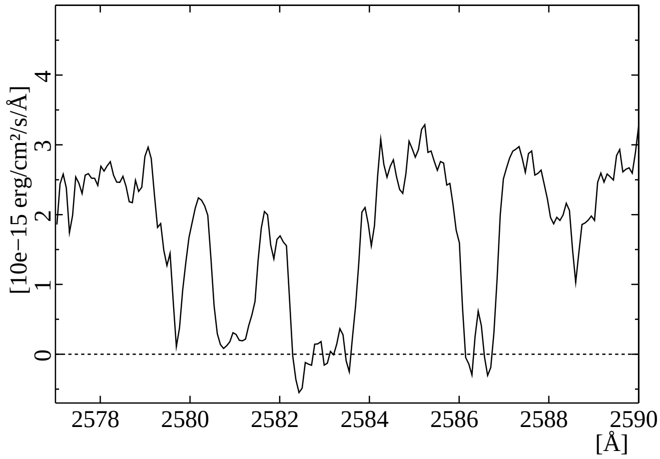

Fig. 2. The STIS spectrum taken with both A and B in the aperture shows blacked out cores (zero flux) in the strongest Ly α forest lines which is only possible if the absorption spectra of both components are identical.

There are several arguments which leave no doubt that we have discovered a new four-image lensed QSO:

– The image configuration: two extremely bright point sources plus two slightly fainter ones within $0\farcs8$ with no further objects within $20''$;
– Although the coadded STIS acquisition image has only 12 s exposure time, there is already unambiguous evidence for a faint extended object between the four images. We estimate an integrated brightness of the propable lensing galaxy being a factor of ≤ 30 fainter than A at 7150 Å (the effective wavelength of the STIS F28X50LP longpass filter);
– The two bright images A ($V = 16.0$) and B (16.7) must have identical absorption spectra, since the high resolution STIS-Echelle spectrum taken with both A and B in the aperture shows blacked out cores (zero flux) in the strongest Ly α forest lines which is only possible if the absorption spectra of both components are identical (cf. Fig. 2). A red B companion of A, on the other hand, would show up at the longest wavelengths of our optical spectrum and can be excluded.

Although these observations would be still consistent with A/B being a physical binary QSO, the image configuration and in particular its striking similarity with PG 1115+080 strongly suggests that HS 0810+2554 is a lensed QSO with four images.

PG 1115+080 was the second lensed QSO discovered (Weymann et al. 1980). In addition to the four images, the QSO host galaxy forms an Einstein ring visible in Nicmos H band (Impey et al. 1998). PG 1115+080 is one of the few lenses where there is sufficient information to infer the Hubble constant from measured time delays (Schechter et al. 1997; Impey et al. 1998).

While the morphological similarity of HS 0810+2554 with PG 1115+080 (CASTLE survey (`http://cfa-www.harvard.edu/castles`) is striking, the image separations in the former are smaller by roughly a factor of 2.5 suggesting a smaller mass of the lensing galaxy if the geometry (lens redshift) should turn out to be similar. Since the time delays vary with the square of the angular sizes of lens systems, the observed time delays in PG 1115+080 of the order of 20 days suggest a rather short time delay for HS 0810+2554.

Without redshift information the lensing galaxy G of HS 0810+2554 is difficult to compare with that in PG 1115+080. The latter is at $z = 0.29$ and fainter in V by $3\fm84$ than image A (CASTLE survey (`http://cfa-www.harvard.edu/castles`). HS 0810+2554 has a similar ratio between G and A at 7150 Å. This would imply a lower M/L of the lensing galaxy at a comparable redshift. Further speculations on the lens redshift are not useful at the present time. The next observational steps to be taken are obvious, and this rapid letter intends to motivate observers to conduct the observations:

– Identify spectroscopically C and D as QSO images. The spectrum of A/B shows strong CIV and CIII lines (Hagen et al. 1999);
– Identify the lensing galaxy and measure its redshift which may be possible with upcoming integral field spectrographs combined with adaptive optics;
– Identify a possible DLA system caused by the lensing galaxy by means of high resolution optical spectra;

– Take high angular resolution HST images as for the CASTLE survey.

HS 0810+2554 has not been detected as a radio source according to NED.

Acknowledgements. This work has been supported by the Verbundforschung of the BMBF/DLR under grant No. 50 OR 9911 1. SL acknowledges financial support by a FONDECYT grant No. 3000001.

References

Hagen, H.-J., & Reimers, D. 2000, A&A, 357, L29
Hagen, H.-J., Groote, D., Engels, D., & Reimers, D. 1995, A&AS, 111, 195
Hagen, H.-J., Engels, D., & Reimers, D. 1999, A&AS, 143, 483
Impey, C. D., Falco, E. E., Kochanek, C. S., et al. 1998, ApJ, 509, 551
Lopez, S., Reimers, D., Rauch, M., et al. 1999, ApJ, 513, 598
Refsdal, S. 1964, MNRAS, 128, 295
Reimers, D., & Wisotzki, L. 1997, The Messenger, 88, 14
Reimers, D., Baade, R., Hagen, H.-J., & Lopez, S. 2001, A&A, 374, 871
Schechter, P. L., Bailyn, C. D., Barr, R., et al. 1997, ApJ, 475, L85
Weymann, R. J., Latham, D., Roger, J., et al. 1980, Nature, 285, 641
Wisotzki, L., Köhler, T., Kayser, R., & Reimers, D. 1993, A&A, 278, L15
Wisotzki, L., Wucknitz, O., Lopez, S., & Sørensen, A. 1998, A&A, 339, L73