Astron. Astrophys. 329, L25–L28 (1998)

ASTRONOMY AND ASTROPHYSICS

LETTER

Letter to the Editor

HS 1543+5921 – a bright z = 0.807 QSO in the center of the 'Seyfert' galaxy SBS 1543+593*

D. Reimers and H.-J. Hagen

Hamburger Sternwarte, Universität Hamburg, Gojenbergsweg 112, D-21029 Hamburg, Germany

Received 26 August 1997 / Accepted 9 October 1997

Abstract. We show that the 'Seyfert' galaxy SBS 1543+593 is a by-chance projection of the center of a nearby galaxy (z = 0.009) onto the bright QSO HS 1543+5921 (z = 0.807). The quasar has been discovered independently by the Hamburg Quasar Survey, an automated survey for bright QSOs based on digitized objective prism Schmidt plates. Direct imaging and subsequent spectroscopy of a faint (R = 22^m) HII region in the foreground galaxy allowed to measure the redshift of the galaxy which is a dwarf spiral or irregular galaxy ($M_R \simeq -16.8$). The galaxy center is located less than 3" from the QSO. We briefly discuss a possible gravitational lensing effect.

Key words: Quasars: individual: HS 1543+5921 - Galaxies: individual: SBS 1543+593 - Cosmology: gravitational lensing

1. Introduction

SBS 1543+593 is a "very blue" galaxy in the second Byurakan Survey (SBS) which was classified as a Seyfert galaxy according to its energy distribution in the continuum (Markaryan et al. 1986). Martel & Osterbrock (1994) took spectra of SBS 1543+593 in the wavelength range $\lambda\lambda$ 5055 - 7850 Å and noticed a "strong smooth nonthermal continuum with no emission lines except possibly at λ 5055 Å, the blue edge of the spectrum, and at λ 5350 Å, where a bump is present". They were unable to give a redshift of the supposed Seyfert galaxy. In the course of the Hamburg Quasar Survey we automatically rediscovered it as HS 1543+5921, a bright z = 0.807 QSO which we found peculiar since it was centered on a galaxy and had a close (5") companion. With the suspicion that this pair might be an object gravitationally lensed by the galaxy we took further spectra of both the companion and the blue galaxy. In parallel we noticed that it was apparently the same object as SBS 1543+593. We show that the blue galaxy is a by chance projection on the z = 0.807 QSO and that the objects are physically unrelated.

Send offprint requests to: D. Reimers, dreimers@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 National Commission for Astronomy

2. Observations

HS 1543+5921 was discovered through its UV excess by the routine quasar search on a digitized objective prism plate of the Hamburg quasar survey (HQS). The data base and the digitization technique are described in Hagen et al. (1995). The position of the QSO is $15^h44^m20.^s1 + 59^\circ 12' 26''$(2000). The object was observed during a routine QSO candidate follow-up observing run using the Calar Alto 2.2m telescope in August 1993 and was identified as a $z \simeq 0.81$ QSO. However, it had been recognized from the digitized direct Schmidt plate which is always used in parallel for the detection of overlaps, that the object is extended with a diameter of $\sim 40''$, impossible for a z = 0.8 quasar host galaxy. Further observations were made in August 1995 with CAFOS at the Calar Alto 2.2m telescope. A direct CCD image showed a close (5") companion. The spectrum of the companion is that of a K star, unrelated to both the QSO and the galaxy (Fig. 4). The 1995 CCD image also showed that the galaxy contains bright knots, supposedly HII regions, which offered the chance to obtain a redshift of the galaxy.

2.1. The z = 0.807 *QSO*

The spectrum of the quasar HS 1543+5921, shown in Fig. 1, has been taken on March 2, 1997 with CAFOS at the Calar Alto 2.2m telescope, with a resolution of $\sim$ 18 Å (9 Å per pixel). Wavelength and flux calibration followed standard procedures. According to the spectrophotometry the brightness of the QSO was B = 16.8, V = 16.4. The spectrum illustrates why Martel & Osterbrock (1994) had been unable to assign a redshift to the suspected Seyfert galaxy. The wavelength range of their spec-

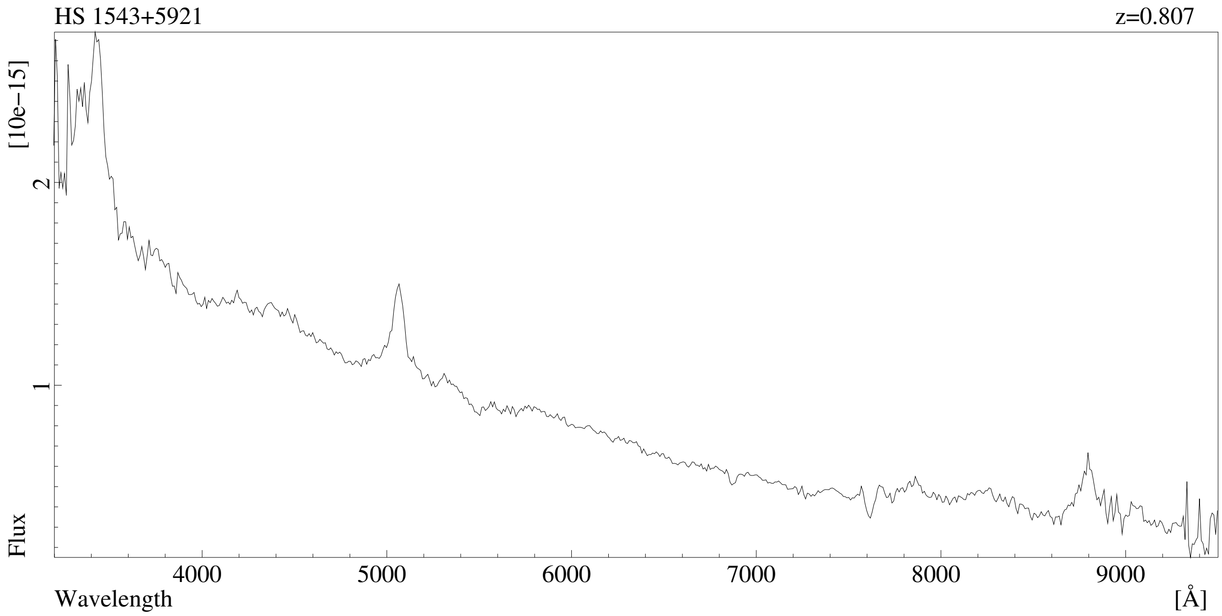

Fig. 1. Spectrum of HS 1543+5921 taken with CAFOS at the Calar Alto 2.2 m telescope. Flux is given in units of 10^{-15} erg cm^{-2} s^{-1} Å^{-1}.

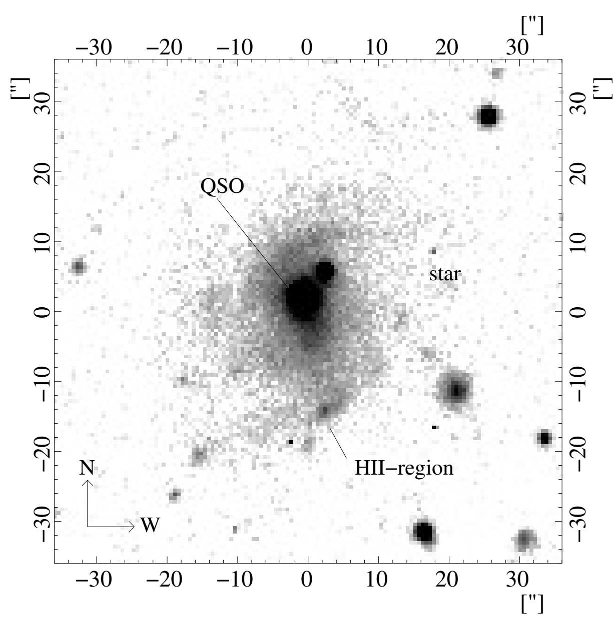

Fig. 2. 800 sec. (Johnson-)R image of SBS 1543+593 taken with CAFOS. The locations of the spectra of the QSO (Fig. 1), the star (Fig. 4), and the HII region (Fig. 5) are marked.

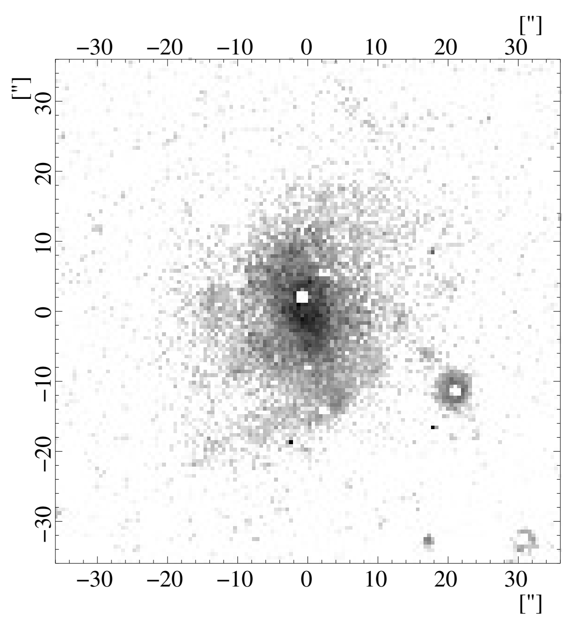

Fig. 3. Same image as in Fig. 2 after subtraction of all point sources

trum contains no QSO emission lines, except that they noticed correctly both the red wing of Mg II at the edge of their spectrum and the FeII bump $\lambda\lambda$ 2950 Å at 5350 Å. The QSO is located 2.″4 from the center of the galaxy (Fig. 2), which might make it an interesting target for high-resolution spectroscopy of the interstellar (IS) medium of the foreground galaxy. We notice, however, that reddening of the QSO must be marginal, since the quasar is still extremely blue to the shortest observed wavelengths. At our resolution, IS absorption lines like CaII H + K or NaD are not detectable.

2.2. The foreground galaxy

In Fig. 2 we display a 800 sec R-image of the galaxy taken with CAFOS at the 2.2m telescope. In order to be able to recognize more clearly the position of the QSO relative to the foreground galaxy, we have subtracted the QSO image (and all other point source images) from Fig. 2. The result is shown in Fig. 3. This has been accomplished using DAOPHOT using a point spread function determined from 5 stars in the image. According to its morphology the galaxy is a spiral or irregular galaxy (of the LMC type) with the QSO about 2.″4 NNE of the center. Together with the QSO spectrum we have taken a 50^m exposure spectrum

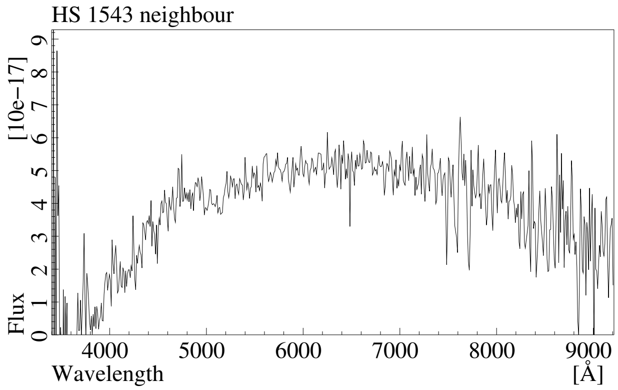

Fig. 4. Spectrum of the star close to the QSO

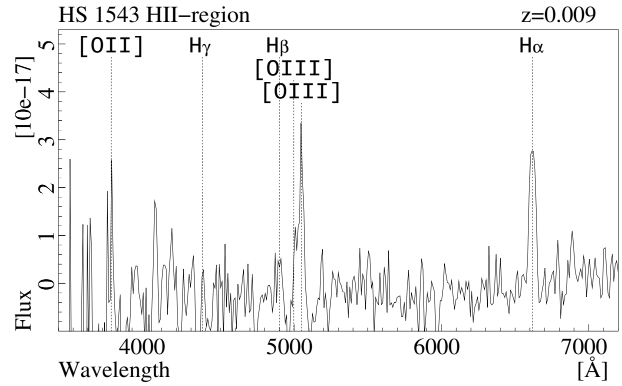

Fig. 5. Spectrum of the HII region in the southern spiral arm marked in Fig. 2.

of the faint knot (R $\simeq 22^m$) in the southern spiral arm (Fig. 5). As expected it is an HII region spectrum with Hα and [OIII] clearly visible at a redshift of 2700 km/s (z = 0.009) and no detectable continuum. Combined with a maximum visible diameter of $\sim$ 40" (in N-S direction measured at the R= 24^m/arcsec^2 isophote) this yields a galaxy diameter of d $\simeq$ 12.7 h_{50}^{-1} kpc. A modulus of m $-$ M = 33.7 ($\hat{=}$ 54 Mpc h_{50}^{-1}) and R (Galaxy) $\simeq$ 16.9 lead to $M_R = -16.8(L_R \approx 3 \cdot 10^8\ L\odot)$. Both luminosity, size and morphology are consistent with a dwarf spiral or irregular galaxy. On the basis of the available image which has been taken under good (1") seeing conditions, it is not clear whether the QSO shines through the bulge of the foreground galaxy or just outside of it.

3. Discussion

It is clear from the above presented observations that SBS 1543+593 is not a Seyfert galaxy but a by chance projection of the center of a dwarf galaxy on to a distant QSO and that the two objects are physically unrelated. However, this rare configuration offers two advantages.

At first, the QSO is bright enough for high resolution spectroscopy with a 10m class telescope with the possibility to study the IS medium of the dwarf galaxy through IS absorption lines. In addition, the galaxy might cause an image splitting and/or amplification due to the gravitational lensing effect, as the configuration is similar to the Einstein cross (Huchra et al. 1985).

The likelihood of multiple imaging can be estimated by comparing the projected mass surface density Σ within 2.″4 of the galaxy center with the critical density Σ_c (Subramanian & Cowling, 1986, hereafter S & C, Refsdal & Surdej, 1994). The apparent luminosity within 2.″4 is R= 19.3 from which $L_R = 5 \cdot 10^7$ $L_\odot$ h_{50}^{-2}. Assuming M/L= 10(100) we obtain from Eq. 44 (S & C) a mean mass surface density within 2.″4 of Σ = 0.19 (1.9) g cm^{-2}. The critical density for multiple imaging Σ_c (Eq. 43, S & C) is $\sim$ 7 g cm^{-2}. For a centrally peaked elliptical lens (cf. Fig. 3) the necessary and sufficient condition for multiple imaging is $\Sigma(0) > \Sigma_c(1{+}\cos\beta)/2$ where $\Sigma(0)$ is the central projected mass density and sin β the eccentricity. For M/L = 10, the condition $\Sigma(0) > 6$ g cm^{-3} is difficult to fulfill and multiple imaging is improbable. On the other hand, the morphology of the galaxy might be more complicated. In that case the condition for multiple imaging can be much weaker (Subramanian & Cowling, 1986). Since the projected mass density at the position of the QSO is much less than Σ_c, the optical depth for microlensing is correspondingly small (cf. Refsdal & Surdej, 1994).
How probable is the observed close association of a bright QSO with a nearby galaxy? The number of QSOs with B $\leq$ 16.9 is about 1 per 25 deg^2 (Köhler et al. 1997). The probability to find that QSO in a specific circle with radius 2.″4 is then $18/(25 \cdot 3600^2) \approx 5 \cdot 10^{-8}$. The number of galaxies with $z < 0.01$ and R $\leq$ 17 detectable on our direct plates is about 3 per deg^2. This yields to the combined probability per 25 deg^2 of $\approx 4 \cdot 10^{-6}$ which for the completed part of the HQS (10^4deg^2 or 400 Schmidt fields) leads to a probability of $\approx 1.5 \cdot 10^{-3}$.

This value is similar to the 10^{-3} or 10^{-4} estimated by Schneider at al. (1988) for the Einstein cross. We note in passing that the Einstein cross has been discovered independently as a QSO candidate by automated search techniques of the HQS a few years ago. The low a posteriori probability for the observed QSO/galaxy association – in particular since another case with low probability is already known – might mean that an amplification bias due to the gravitational lens effect has to be invoked in order to make the case of HS 1543+5921 plausible. Assuming an amplification by 3 mag and a true amplification bias by about a factor of roughly 1.5 per mag – depending on the steepness of the QSO number counts N(<B)– (Refsdal, priv. comm.), the a posteriori probability might increase by to $\sim$ 0,03.

In summary: from the available data it is not clear whether the gravitational lens effect plays a role for HS 1543+5921. The statistical evidence is in favour of, the existing galaxy data are against the hypothesis of gravitational lensing. Only a deep direct image with better angular resolution (e.g. by HST) can decide whether the density distribution of the galaxy favours lensing and/or whether a second (faint) image is present. HS 1543+5921 is not a radio source. The closest known radio source is 7C 1543+5920 at a distance of 2.′2 (Visser et al., 1995).

Acknowledgements. This research has made use of the NASA/IPAC extragalactic database (NED) which is operated by the Jet Propulsion Laboratory, Caltech, under contract with the NASA (USA).

The Hamburg Quasar Survey has been supported by the Deutsche Forschungsgemeinschaft under Re 353/22/1-4. Spectroscopic observations have been funded with travel grants Ha 2070/1-10. We are indebted to S. Refsdal for discussions on the lensing properties of the galaxy.

References

Hagen H.-J., Engels D., Groote D., Reimers D., 1995, A&AS 111,1
Huchra J., Gorenstein M., Kent S. et al. 1985, AJ 90, 691
Köhler T., Groote D., Reimers D., Wisotzki L. 1997, A&A in press
Markaryan B.E., Stepanyan D.A., Erastova L.K. 1986, Astrophysics 25, 551
Martel A., Osterbrock D.E. 1994, AJ 107, 1283
Refsdal S., Surdej J. 1994, Ref. Progr. Phys. 56, 117
Schneider D.P., Turner E.L., Gunn J.E. et al. 1988, AJ 95, 1619
Subramanian K., Cowling S.A. 1986, M.N.R.A.S. 219, 333
Visser A.E.,Riley J.M., Rottgering H.J.A., Waldram E.M. 1995, A&AS 110, 419

This article was processed by the author using Springer-Verlag LaTeX A&A style file *L-AA* version 3.