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Letter to the Editor

Spectra of two quasars possibly ejected from NGC 4258

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Abstract. Spectroscopic observations made at Lick Observatory are presented for two X-ray-emitting optical objects identified, from ROSAT PSPC data, by Pietsch et al. (1994). The X-ray data suggested that these objects were ejected from the nearby galaxy NGC 4258. It is shown that they are both quasi-stellar objects with redshifts of 0.398 and 0.653 respectively.

Key words: galaxies: active — galaxies: individual (NGC 4258) — quasars: redshifts — X-rays: quasars

1. Introduction

NGC 4258 (M 106) is a nearby spiral galaxy classified by Sandage & Bedke (1988, 1994) as Sb(s)II which has an active nucleus and considerable evidence for ejection from the center. Its distance is uncertain and values from 3.3 - 7 Mpc have been used in the literature. It is not strictly speaking a classical Seyfert galaxy (Burbidge & Burbidge 1962) but shows evidence for large deviations from circular motions (Burbidge et al. 1963, Chincarini & Walker 1967, van der Kruit 1974). "Anomalous arms" (or jets) were detected in Hα emission (but not in optical continuum) by Courtès & Cruvellier (1961), and these have been detected in radio continuum by van der Kruit et al. 1972 (cf. van Albada & van der Hulst 1982; note especially their fig 4) and in CO (Martin et al. 1989, Krause et al. 1990, Plante et al. 1991). NGC 4258 was also detected as an X-ray source (Fabbiano et al. 1992), and Cecil et al. (1992) discussed the relation of the X-ray emission to the anomalous arms. NGC 4258 was detected in the ROSAT (Trümper 1983) All Sky Survey (Voges 1992) as an extended X-ray source.

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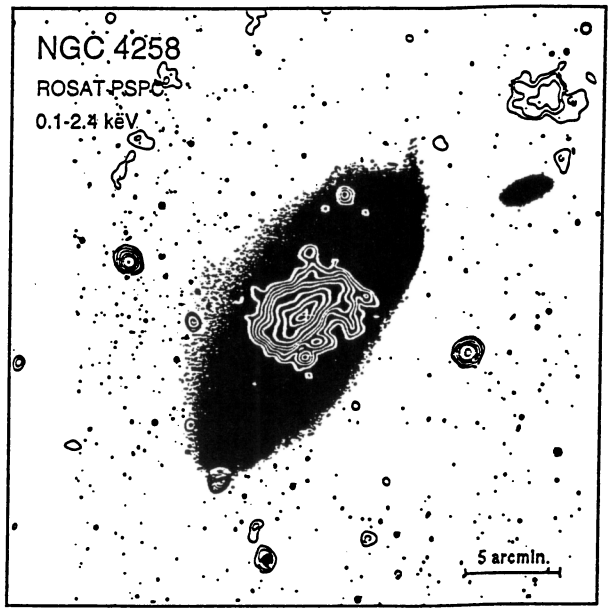

Fig. 1. Reproduction of Fig 2 of Pietsch et al. (1994), showing locations of broad-band ROSAT PSPC images of their nos. 8 and 26 relative to the galaxy NGC 4258. N is up, E. to the left. The separations from the nucleus are 8′.5 for no. 8 and 9′.5 for no. 26.

A detailed X-ray study by Pietsch et al. (1994) with the ROSAT PSPC detected an extended X-ray source centered on the nucleus of NGC 4258 and also a number of individual X-ray sources around the extended source. Pietsch et al. listed coordinates of 28 sources (see their Fig 1 and Table 2), and drew attention to two (their nos. 8 at $\alpha_{2000} = 12^h18^m08\overset{s}{.}3$, $\delta_{2000} = 47°16'15''$ and 26 at $\alpha_{2000} = 12^h19^m52\overset{s}{.}1$, $\delta_{2000} = 47°21'01''$) which are aligned symmetrically, each ~9 arc min from the galaxy nucleus in position angles $72\overset{°}{.}4$ and $256\overset{°}{.}4$ with respect

to the nucleus (the P.A. of the minor axis of NGC 4258 is 67°). They used a distance 3.3 Mpc for NGC 4258 in discussing the X-ray data quantitatively.

In their table of proposed identifications of the individual X-ray sources, Pietsch et al. (1994) found blue stellar objects with $m \sim 20$ at the positions of nos. 8 and 26, which are very compact with high net count rates. Their Fig 2 showing these is reproduced here as Fig 1. They described these sources as follows: "Two of the X-ray sources for which faint blue stellar objects are proposed as counterparts are outstanding in terms of their X-ray brightness and symmetrical and equidistant position with respect to the nucleus of NGC 4258 .... The line connecting the two X-ray sources touches the ends of the anomalous arms ... [Courtès et al. 1993] .... If the connection of these sources with the galaxy is real they may be bipolar ejecta from the nucleus". The centroid position of the two sources given by Pietsch et al. ($\alpha_{2000} = 12^h19^m00^s.2$, $\delta_{2000} = 47°18'38''$) is not coincident with the nucleus of NGC 4258, but they point out that it agrees with the position of the nucleus to within 36″. Pietsch et al. also drew attention to a study by Valtonen (1977) of radio source pairs around spiral galaxies; Valtonen had reported an outstanding pair aligned symmetrically about the nucleus of NGC 4258 (not coincident with the X-ray pair), which Valtonen had suggested might be supermassive objects ejected from the nucleus.

We have obtained spectra of the X-ray point sources 8 and 26. Results are presented in §2 and are discussed in §3.

2. Results

Spectra of no. 8 (the W object,) and no. 26 (the E object), were obtained on 4 February 1995 with the Kast double spectrograph on the 3-m Shane telescope at Lick Observatory, using the 300 $l\ mm^{-1}$ grating blazed at 7500 Å and the grism 2 with the dichroic D55 giving total coverage 3200-10000 Å and spectral resolution $\sim$ 12Å. Integration times for each were 3600s. Both objects were found to be faint QSOs, hereafter named Q1218+472 and Q1219+473 respectively, using 2000 coordinates for these designations. Q1218+472 has a redshift z = 0.398, from emission lines of MgII λ 2800, Hβ, [0III] $\lambda\lambda$ 4959, 5007, and Hα. Q1219+473 has z = 0.653 from Mg II λ 2800, Hβ, [0III] $\lambda\lambda$ 4959, 5007. The spectra are shown in Figs 2 and 3, with line identifications marked. Photometric large-aperture observations were not obtained (the slit width used for each spectrum was 2 arc sec), but the seeing was good ($\sim 1 - 1.5$ arc sec) and the approximate magnitudes m_{5500} read from the flux in the continua, 20.4 for Q1218+472 and 19.4 for Q1219+473, indicate that the latter is brighter than the former. Other spectral features detected were [Ne V], [Ne III], [O II] λ 3727, and the Fe II bump near Mg II. These results are given in Table 1. A full discussion of the emission line intensities and the X-ray to optical to radio fluxes is in preparation.

Table 1. Emission Lines and Redshifts in the Two QSOs

	X-R W Q1218+472	X-R E Q1219+473
Line	z	z
MgII λ 2798	0.3971	0.6528
[NeV]λ 3426	0.3980	0.6548
[OII]λ 3727	0.3985	–
[NeIII]λ 3869	–	0.6535
Hβ	0.3974	0.6528
[OIII]λ 4959	0.3979	0.6536
[OIII]λ 5007	0.3978	0.6534
Hα	0.3989	–
Mean	0.3979± 0.0006	0.6535±0.0007

3. Discussion

For more than twenty years there have been many reports that the close pairs of bright galaxies and QSOs with very different redshifts indicated that at least some QSOs have large non-cosmological redshift components (Arp 1967, 1987; Burbidge et al. 1971, Burbidge 1979, 1981, Burbidge et al. 1990; Hoyle & Burbidge 1966). The symmetry of these QSOs with respect to the galaxy nucleus, and the evidence for activity in the galaxy make it very hard to argue that this is an accidental configuration.

We therefore conclude that in this system the X-ray astronomers have pointed the way for the discovery of two faint QSOs with intrinsic redshifts close to the measured redshifts. The redshift of the galaxy is small ($cz = +465 km\ sec^{-1}$) so that the observed redshifts must be made up of the shifts due to the velocities of ejection and the intrinsic component, i.e.

$$(1 + z_{obs}) = (1 + z_{doppler})(1 + z_{intrinsic})$$

In a recent paper Hoyle & Burbidge (1995) have developed a theory for intrinsic redshifts.

As was pointed out in the introduction, NGC 4258 is clearly a galaxy with an active nucleus which is emitting high velocity gas and is a source of energy not of stellar origin. Recently it has been shown that the center possesses a maser (or megamaser) emitting at the H_2O 1.35 cm transition with a range of velocities $\pm 1000 km\ sec^{-1}$ from a disk of only about 0.13 pc in radius. The velocities appear to be Keplerian and give a central mass of $3.6 \times 10^7 M_\odot$ (Miyoshi et al. 1995; also see Greenhill et al. 1995). The major axis of the disk is aligned in P.A. 83° ± 2° (Greenhill et al. 1995).

In many of the other close pairs of bright galaxies and QSOs which statistical arguments have suggested are physically associated, the galaxy is active and shows evidence for ejection, e.g. NGC 3067 in the pair NGC 3067-3C 232 (Burbidge et al. 1971, Carilli et al. 1989, Carilli & van Gorkom 1992), and NGC 3079 and UB4 (Arp 1981,

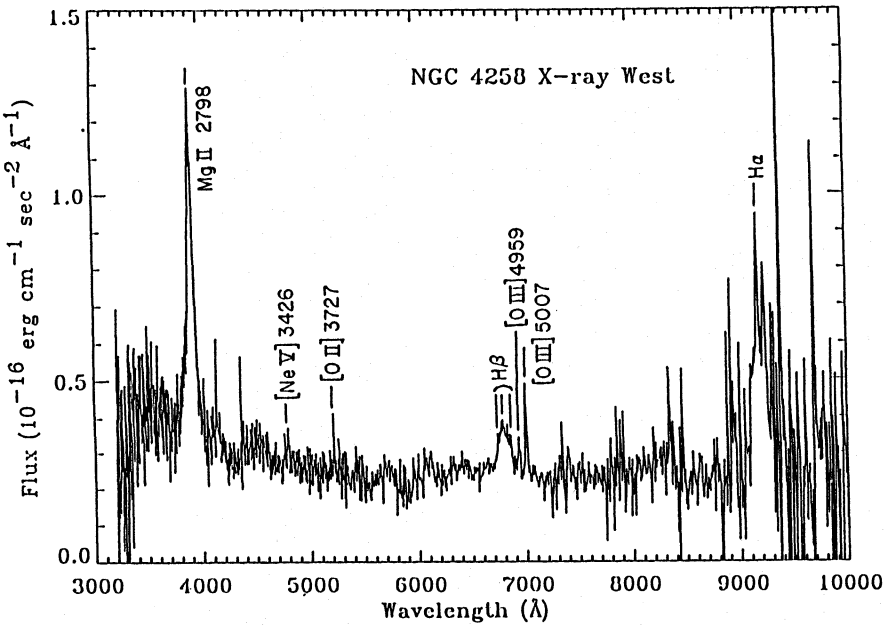

Fig. 2. Lick Observatory spectrum of Q 1218+472, flux vs observed wavelength. Noise from 9000-10000 Å, around Hα, is due to flat-fielding. The atmospheric A and B bands have been removed by using the star SAO 044145 observed near the same sky position. The grism and grating overlap occurs at 5250-5350 Å.

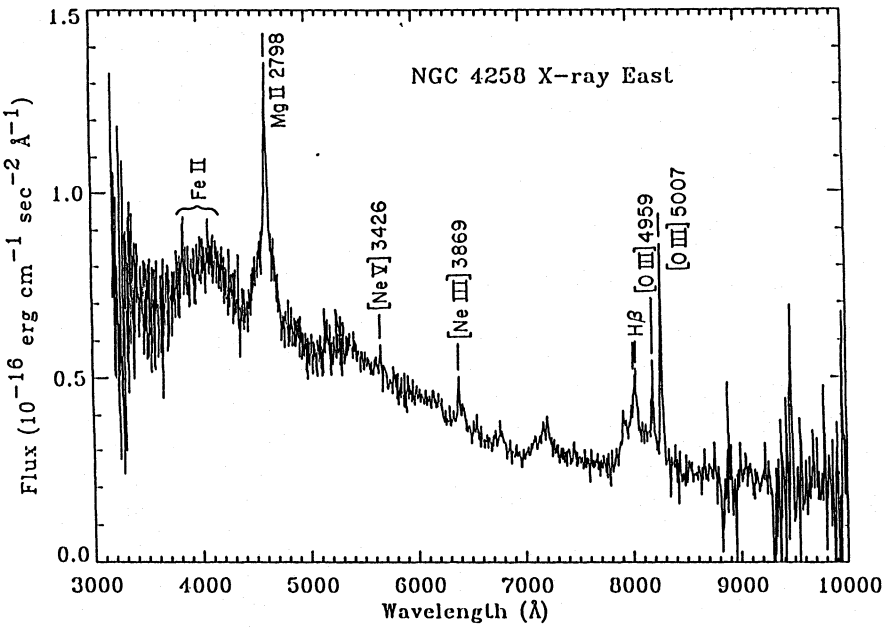

Fig. 3. Lick Observatory spectrum of Q 1219+473; details as in Fig 2.

Hummel et al. 1983, Filippenko & Sargent 1992, Womble 1993, Womble et al. 1992).

If the QSOs Q1218+472 and Q1219+473 were ejected from NGC 4258, they have $M \approx -8.8$, -9.8 respectively and they each lie at a projected distance of about 18 Kpc from the center of NGC 4258 ($\sim 9'$ at D = 7 Mpc, just over twice the distance of NGC 4258 used in the X-ray study.) The ratios of X-ray luminosity to optical luminosity are 1.03, 0.29 respectively. There are no significant differences between their optical spectra and those of QSOs with similar redshifts. Compared with the QSOs in many other QSO-galaxy pairs these QSOs are optically fainter. This is because in most of the other cases the QSOs have first been identified as bright radio or bright optical QSOs. Here we have two QSOs whose dominant mode of emission is in the X-ray band. However, optically there is some similarity between these two QSOs and the four faint ones

which were found serendipitously to lie close ($\leq 10'$) to M82 (NGC 3034)(Burbidge et al. 1980, Arp 1983).

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References

Arp, H. 1967, ApJ, 148, 321
Arp, H. 1981, ApJ, 250, 31
Arp, H. 1983, ApJ, 271, 479
Arp, H. 1987, "Quasars, Redshifts, and Controversies" (Berkeley: Interstellar Media)
Burbidge, E.M. & Burbidge, G. 1962, ApJ, 135, 694
Burbidge, E.M., Burbidge, G. & Prendergast, K.H. 1963, ApJ, 138, 375
Burbidge, E.M., Burbidge, G., Solomon, P.M. & Strittmatter, P.A. 1971, ApJ, 170, 233
Burbidge, E.M., Junkkarinen, V.T., Koski, A.T., Smith, H.E. & Hoag, A.A. 1980, ApJL, 242, L55
Burbidge, G. 1979, Nature, 282, 451
Burbidge, G., Hewitt, A., Narlikar, J.V. & Das Gupta, P. 1990, ApJS, 74, 675
Carilli, C.L. & van Gorkom, J.H. 1992, ApJ, 399, 375
Carilli, C.L., van Gorkom, J.H. & Stocke, J.T. 1989, Nature, 338, 134
Cecil, G., Wilson, A.S. & Tully, R.B. 1992, ApJ, 390, 365
Chincarini, G. & Walker, M.F. 1967, ApJ, 149, 487
Courtès, G. & Cruvellier, P. 1961, Compt. Rend. Acad. Sci. Paris, 253, 218
Courtès, G., Petit, H., Hua, C.T., Martin, P., Blecha, A., Huguenin, D. & Golay, M. 1993, A&A, 268, 419
Fabbiano, G., Kim, D.-W. & Trinchieri, G. 1992, ApJS, 80, 531
Filippenko, A.V. & Sargent, W.L.W. 1992, AJ, 103, 28
Greenhill, L.J., Jiang, D.R., Moran, J.M., Reid, M.J., Lo, K.Y., & Claussen, M.J. 1995, ApJ, 440, 619
Hoyle, F. & Burbidge, G.R. 1966, ApJ, 144, 534
Hoyle, F. & Burbidge, G. 1995, A&A submitted
Hummel, E., van Gorkom, J.H. & Kotanyi, C.G. 1983, ApJL, 267, L5
Krause, M., Cox, P., Garcia-Barreto, J.A. & Downes, D. 1990, A&A, 233, L1
Martin, P., Roy, J.-R., Noreau, L., & Lo, K.Y. 1989, ApJ, 345, 707
Miyoshi, M., Moran, J., Herrnstein, J., Greenhill, L., Nakai, N., Diamond, P. & Inoue, M. 1995, Nature, 373, 127
Pietsch, W., Vogler, A., Kahabka, P., Jain, A. & Klein, V. 1994, A&A, 284, 386
Plante, R.L., Lo, K.Y., Roy, J.-R.., Martin, P. & Noreau, L. 1991, ApJ, 381, 110
Sandage, A. & Bedke, J. 1988, Atlas of Galaxies, NASA SP-496
_____ 1994, Carnegie Atlas of Galaxies (Carnegie Inst. of Washington Pub) 638
Trümper, J. 1983, Adv. Space Res. 2, 241
Valtonen, M.J. 1977, ApJL, 211, L111
van Albada, G.D. & van der Hulst, J.M. 1982, A&A, 115, 263
van der Kruit, P.C. 1974, ApJ, 192, 1
van der Kruit, P.C., Oort, J.H. & Mathewson, D.S. 1972, A&A, 21, 169
Voges, W. 1992, The ROSAT All-Sky X-ray Survey, in Proc. European ISY meeting, Symposium 'Space Sciences with particular emphasis on High Energy Astrophysics', p. 9
Womble, D.S. 1993, Ph.D. Thesis, University of California, San Diego
Womble, D.S., Junkkarinen, V.T. & Burbidge, E.M. 1992, ApJ, 388, 55

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