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ASTRONOMY AND ASTROPHYSICS

# Identification of X-ray sources $< 1^\circ$ from Seyfert galaxies

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**Abstract.** Excess numbers of X-ray sources around bright Seyfert galaxies have been demonstrated with significances of association up to 7.4 sigma (Radecke, preceding paper). The optical identification of these sources is shown here to be predominantly blue stellar objects (BSO's) of which some are already catalogued as quasars.

Excluding the two brightest Seyferts, a subset of 24 with apparent magnitudes between $8.04 \leq B_T^{o,i} \leq 12.90 mag.$ show a minimum excess of $> 46$ bright X-ray sources. These excess X-ray sources are generally distributed between $10' < r < 40'$ and 12 of the Seyferts show conspicuous pairs of X-ray sources across their active nuclei. Additional pairing and alignment of sources is seen for the remaining Seyferts. Among the paired X-ray sources, 53 have been identified as BSO's.

Some double and multiple BSO's have been identified which are candidates for groups and associations of quasars. Some groups are well aligned and some centered on small blue galaxies.

Four previously known BL Lac objects fall close enough to the Seyferts in this sample to confirm, at a significance level of $1 - 2 \times 10^{-9}$, a previously reported association of BL Lac objects with bright, low redshift galaxies.

**Key words:** galaxies: Seyfert; BL Lac Objects – quasars: general – X-rays: galaxies

## 1. Introduction

The reason for undertaking this study was to test evidence going back to 1966 that quasars were in statistical excess around, and tended to be paired across, active galaxies. The study of this long perceived pattern recently received considerable impetus when W. Pietsch et al. (1994) published a pair of X-ray sources across the Seyfert galaxy NGC 4258 which they said "... may be bipolar ejecta from the nucleus". Subsequently E.M. Burbidge (1995) measured the blue stellar identifications (BSO's) as quasars of $z = .40$ and .65.

This finding supported earlier discoveries of radio sources paired across peculiar galaxies, some of which were quasars (Arp 1967), and later discoveries of active galaxies between pairs of radio quasars (Arp 1968). Statistical evidence continued to grow for such associations, and when X-ray quasars started to be discovered some extremely high probability examples of associations with active galaxies were found (Arp 1987; 1995a,b). It became clear that X-ray observations were a particularly efficient way to discover quasars in fields around galaxies and the work on NGC 4258 suggested that a class of active galaxies which would be available for analysis of a fairly complete sample were the Seyfert galaxies.

H.-D. Radecke has presented evidence in the preceding paper that there is a conspicuous and significant population of bright X-ray sources around a nearly complete sample of Seyfert galaxies. Fig. 1 here gives a graphical representation of the excess sources around the Seyferts which we will be mostly concerned with.

Examining the individual X-ray maps, however, produces another demonstration, in addition to the statistical one, of the association of these X-ray sources with the Seyferts: As in the case of NGC 4258, we find conspicuous pairs and alignments across the central Seyfert. Sources in these pairs are inspected here on schmidt survey plates in both the photographic red (103a-E) and blue (103a-o and IIIa-J). Most of them are identified with blue stellar objects (BSO's), the vast majority of which would be expected to turn out to be quasars of considerably higher redshift than the central Seyfert. Since most of these paired sources are X-ray emitting BSO's, the major result is to show that active galaxies *characteristically* have pairs and alignments of quasars across their nuclei.

## 2. Pairs of X-ray sources across Seyferts:

For each of the 26 Seyferts retrieved from the archives the events files gave the location of the detected photons as a function of $x$ and $y$. For each of these fields a map of the photons over the full field ($r \lesssim 58'$ or $x = y \leq 7000$ pixels) was plotted. In general these maps were not smoothed so that one can see the individual photons which make up the image. Toward the edge of the field the photons are spread over larger areas and one can only see brighter sources. Each map was inspected for patterns of pairs or alignments of sources across the central Seyfert. The sources which made up these patterns were then

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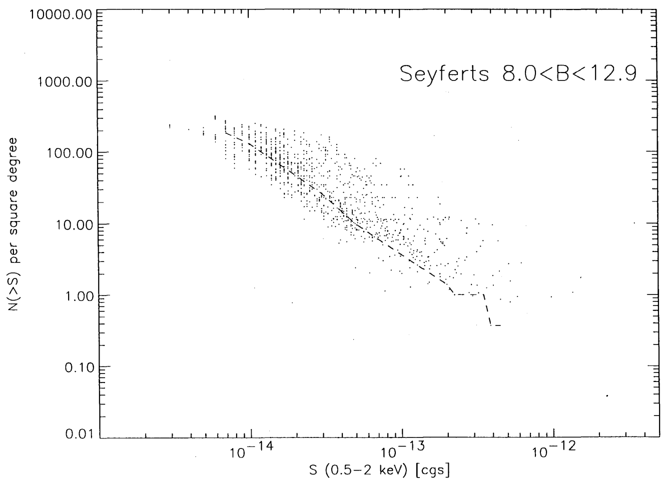


**Fig. 1.** The density of X-ray sources greater than a given flux S, in $ergcm^{-2}s^{-1}$, for ROSAT PSPC fields around 24 Seyfert galaxies with $8.04 < B_T^{0,i} < 12.90 mag$. The dashed line represents the average relation from 14 high latitude control fields (Radecke 1996).

identified by their $C = ctsks^{-1}$ values and are referred to by these numbers throughout this paper. In the statistical analysis of Radecke it was shown that the minimum excess of X-ray sources around the 24 Seyfert fields $8.04 \leq B_T^{o,i} \leq 12.90 mag.$ was > 46 excess sources. This is a minimum excess because we have not attempted to estimate the number of Seyfert sources $5 \leq C \leq 10$ at radii other than $10' \leq r \leq 20'$ or fainter than $C \leq 5$. Nevertheless it is an interesting number because it gives an excess of $\sim$ 2 strong X-ray sources per Seyfert field. That would be sufficient for every Seyfert to have a pair of strong X-ray sources across it and some to have more than one pair if we include X-ray sources outside the above areas of maximum contrast with the control fields.

This is approximately what we find. When looking at the maps of the PSPC fields it is apparent that many have conspicuous pairs of X-ray sources across the central Seyfert. The twelve best examples are shown here in Figs. 2-13.

In each map the sources are labeled with their $C = ctks^{-1}$ value by which most can be identified from the lists of $C \geq 5$ sources given by Radecke. Positions of all optical identifications are given in Table 3 of the appendix of the present paper including some with $C < 5$. Data on the pairs found in the present investigation and some optical information on the sources is summarized here in Table 1. The data in Table 1 is arranged in order of decreasing brightness of the central Seyfert. The distances and alignment angles are measured on the maps from the center of the Seyfert X-ray image, $r_1$ and $r_2$ are distances to the nearest and furthest of the pair and $C_1$ and $C_2$ are their counts.

At the bottom of Table 1 there are averages for each column which can be used to represent the parameters for an average pair across Seyferts in the sample. The latter average was obtained by choosing only pairs which contained opposite BSO's or QSO's. That yielded 12 Seyferts ($\bar{z} = .006$) with 21 pairs of BSO's. The average accuracy of alignment is $\overline{\Delta\theta} = 7\overset{\circ}{.}3$. This can be compared to the average alignment of radio sources across peculiar galaxies (Arp 1967) which was $\overline{\Delta\theta} = 12\overset{\circ}{.}7$. It is seen that the X-ray BSO pairs are better aligned across Seyferts on average, and generally closer in angular projection.

The average for the more distant count rates ($C_2$) was made without the C = 1213 BL Lac. If we further exclude the exceptionally strong $C_2 = 84.5$ and 91.3, then $\bar{C_2} = 13.0$, very close to the average $\bar{C_1} = 12.8$ count rate. This last calculation would indicate the BSO's in the pairs have very similar X-ray strength, on average about $F_x = 1.5 \times 10^{-13} erg\ cm^{-1} s^{-1}$ (for .5-2.0 keV).

Finally there are altogether 53 BSO's and QSO's optically identified in Table 1 as being associated with the pairing phenomenon. One must bear in mind that these sources can be strongly variable, some sources can be background and some associated sources may not be paired. Therefore this sum must be only indicative of the number of associated sources and its close agreement with the > 46 sources excess over control fields calculated in the beginning is to some extent fortuitously close.

In the same order of decreasing brightness each Seyfert field is now discussed individually. The first few are unrepresentatively nearby and then the bulk of the sample is encountered at distances comparable to the Virgo Cluster, around 16-20 Mpc.

**NGC5128** The 14.3 ks PSPC exposure of CenA in Fig. 14 shows two X-ray sources of $C = 28.5$ and 5.3 at p.a. 45°. The stronger source is at $r_1 = 30\overset{'}{.}2$. In the opposite direction there is a source $C = 10.8$ at p.a. = 232° and $r_2 = 32\overset{'}{.}2$. It is evident from Fig. 14 that the X-ray emission from the central regions of Cen A is elongated along this same line. The line drawn in Fig. 14 is the line of the X-ray jet from the center of the galaxy which is at p.a. = 53° and the X-ray counter jet at p.a. = 227° (Feigelson et al. 1981). These inner X-ray jets are in turn aligned with the inner radio jets in Cen A. The outer X-ray isophotes from the ROSAT Survey extends strongly to the NE for about 5° and less strongly to the SW for about 2° at p.a. = 53° and 227° (Arp 1994a). As described in that referenced paper the SW X-ray extension leads directly to the strong radio and X-ray galaxy NGC 5090.

It is clear that the major X-ray sources in this region lie fairly closely along the line of the X-ray and radio jets coming from the nucleus of the galaxy. The strongest X-ray source at C = 28.5 actually appears extended along this line.

Optically identifications have only been attempted for the three strongest sources in this field. The C = 28.5 and 10.8 source could not be identified, perhaps lending weight to the idea that they are actually extended. The C= 15.6 source is identified with an $m_J = 19.5 mag.$ BSO (see Table 3).

**NGC 3031** This Seyfert, M81, and the preceding Seyfert, Cen A, are so much closer in distance to us that the typical pairs evident around more distant Seyferts would be outside the field of the PSPC. This means that many of the sources are within the optical confines of the galaxy and, as Fig. 1b of Radecke shows, represent normal objects such as X-ray binaries and supernovae. Therefore we leave the discussion of the bulk of these sources to detailed analyses, e.g. in M81 to Fabbiano (1988) and Zimmerman (1996, in preparation).

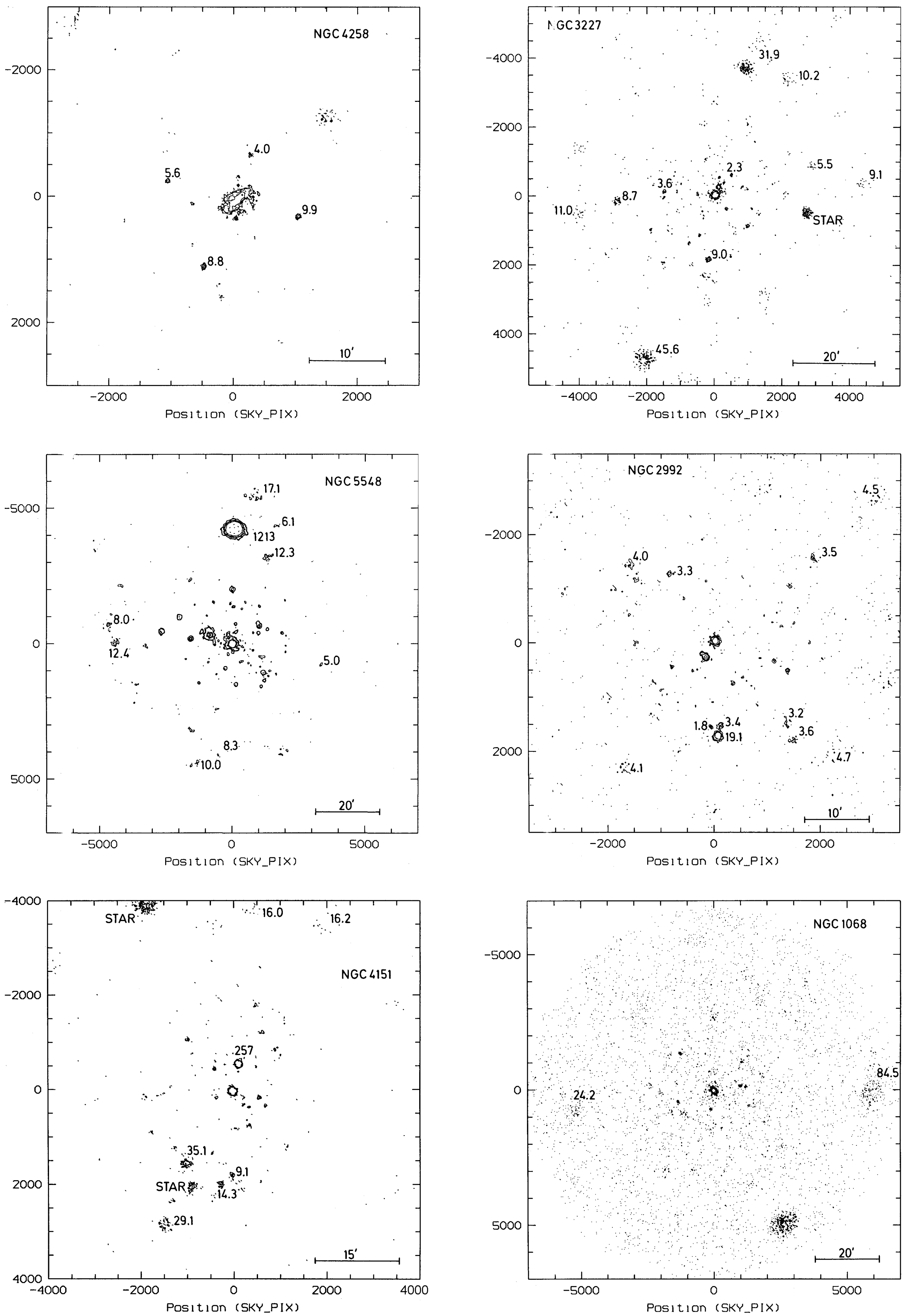


**Fig. 2–13.** PSPC maps of the 12 fields with most conspicuous pairing of X-ray sources across the central Seyfert. All are ROSAT PSPC observations and the $C = ctsks^{-1}$ in the .5-2.0 keV band are written next to those unsmoothed images which appear to be involved in the pairs. Coordinate scales are in pixels = 1/2 arc sec.

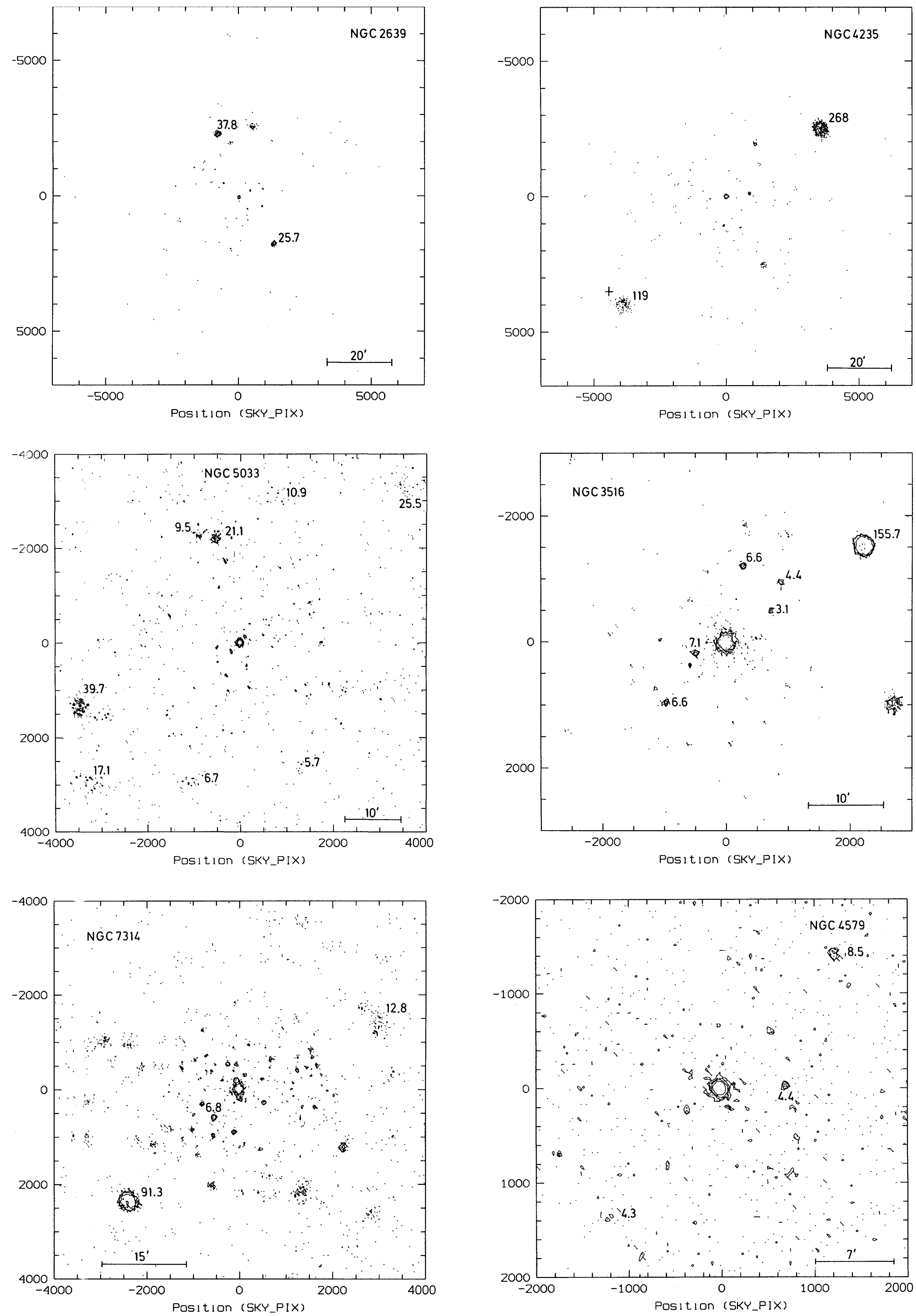


**Fig. 2–13.** (continued)

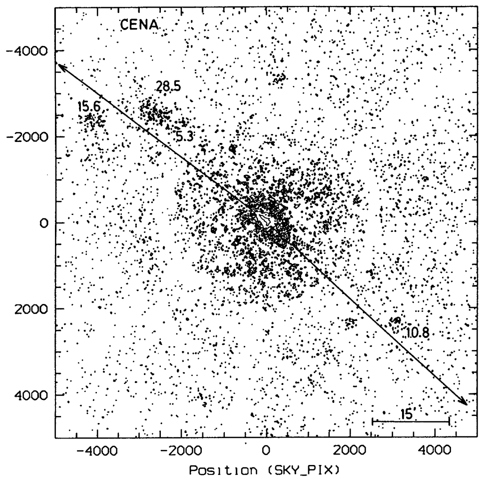


**Fig. 14.** In the nearest Seyfert, Cen A, X-ray emission can be seen extending along the direction of the X-ray and radio jet and counter jet (p.a. = 53° and 227°). Of the three brightest sources only C = 15.6 is identified, and that with a BSO.

For sources comparable in strength and separation to those shown in Figs. 2-13 it would be necessary to analyze ROSAT Survey fields. But we can mention three aspects of M81:

1) A source $C = 12.5$, at $6\rlap{.}'1N$ is paired with a source $C = 68.7, 33\rlap{.}'4S$. Both show radio emission and are optically identified with respectively, a stellar object and an HII region (Fabbiano 1988). They should be investigated spectroscopically.
2) M82, lying $37'N$ of the nucleus of M81 is a very srong X-ray source (C = 815). It is well known that this is an early spectral type, starburst galaxy with an excess redshift with respect to M81 of $\Delta cz = +286 kms^{-1}$ (Arp 1994b). In the following analyses of Seyfert neighborhoods we will see a number of examples of smaller companions in active phases with varying degrees of excess redshift.
3) There is a strong source, $C = 148$, about $12'E$ of the nucleus of M81. It lies near the edge of the dwarf galaxy Holmberg IX. The X-ray position falls close to a faint blue, partly nebulous object which should be checked spectroscopically. If this source is not a faint, powerful X-ray AGN then its nature is even more mysterious. (See Table 2 at end.)

**NGC 4258** (Fig. 2) The pair of X-ray sources with $C = 9.9$ and 5.6 were discovered by Pietsch et al. (1994) and identified as blue stellar objects. E.M. Burbidge (1995) later confirmed them as quasars of $z = .398$ and .653. The sources in the other pair with $C = 4.0$ and 8.8 fall on either end of the major spiral arms of NGC 4258. Blue sensitive plates with the 200-inch Palomar reflector which are available show three stellar objects, $mpg \sim 21$, within a $24''$ error circle for the northern X-ray source and four candidate objects, two $\sim 18 mag.$ and two $\sim 21 mag.$, near the southern X-ray source. It would require observations with a large aperture telescope to attempt their identifications. It can be seen from the table of Seyferts listed by Radecke in the preceding paper that the optical dimensions of the galaxy include these last discussed sources. This would make it even more important to investigate what relation, if any, these sources bear to the sources displaced outside the optical limits of the galaxy.

NGC 4258 shows a clear "cross" pattern of sources, with one pair oriented almost 90° with respect to the other. This configuration is seen frequently (e.g. NGC 4594) and several other examples are seen among the maps shown in Figs. 2-13. This cross pattern of sources has also been seen in PSPC maps around bright quasars (Arp 1995c). It should also be noted in the X-ray map of NGC 4258 that there are three fainter sources aligned nearly N-S through the nucleus.

**NGC 4945** The Seyfert is one of the bright galaxies along the line of the radio jets emerging from Cen A (Arp 1968b; 1994a). Since it is at the same distance as Cen A its X-ray sources give the same kind of log N-log S relation as shown in Fig. 1b of Radecke. There are no strong pairs within the PSPC field and the inner sources are strong and distributed along the projected major axis roughly NE-SW. Because these sources are in or near the optical extent of the galaxy, identifications have not been attempted here.

**NGC 4594** This Seyfert is the famous "sombrero galaxy" or M104. The most interesting sources are a pair aligned across the minor axis and another, crossed pair at about 90° angle, much like the two pairs in NGC 4258 (Pietsch et al. 1994), also see M51 (Ehle, Pietsch and Beck 1995, Fig. 2b) as well as some other cases shown here. Because these sources are in or near the optical image of the galaxy no identification is attempted here and no figure is shown. But it is provocative to note that there are BSO's identifiable on schmidt prints further out – a candidate closely along each of the four directions of X-ray sources from the center of NGC 4594.

**NGC 1068** Fig. 7 shows the wide pair across this relatively nearby Seyfert. The X-ray sources are strong and identified with a bright BSO ($C = 84.5$) and a very blue BSO ($C = 24.2$). The latter has two other BSO's at about equal distance NW and NE of the X-ray position and it is conceivable that there are a triplet of quasars contributing to this mean X-ray position (see appendix, Table 3).

Fig. 15 shows a more interior view of the NGC 1068 field. Table 2 shows that the wider pair, N-S at $C = 9.0$ and 15.7, are identified with faint BSO's. The $C = 15.7$ source actually has two very faint candidates about $14''S$ of a bright (E = 12.6 mag.) star. That star, which falls closest to the X-ray position, seems slightly misshapen. It should be checked with spectroscopy and higher resolution imaging. The source $C = 9.1$ on the E side of NGC 1068 falls on at the center of a chain of four, very faint red, non stellar objects. Opposite, on the W side, are at least two X-ray BSO's ($C = 4.2$ and 6.5) in a configuration that appears to be of importance to investigate further:

The automatic plate measuring (APM) finding chart in the Appendix shows the optical configuration in the field of the $C = 4.2$ and 6.5 sources. The sources with blue colors 0-E = .60 and 1.20 mag. are almost certainly quasars. Of the other blue sources the 0-E = .91 is probable and the .93 and .86 sources possible. The most outstanding feature, however is the blue (O-E = .67) galaxy about $32''$N of the C = 6.5 BSO. *There are*

**Table 1.** Paired X-ray sources

| Galaxy | $z_o(G)$ | $r_1$ | $r_2$ | $\Delta_\theta$ | $C_1$ | $C_2$ | identification |
|---|---|---|---|---|---|---|---|
| NGC4258 | .002 | 8.′4 | 9.′6 | 2° | 9.9 | 5.6 | 2 QSO, z = .40 and .65 |
| | | 6.3 | 9.8 | 10 | 4.0 | 8.8 | candidates |
| NGC4594 | .003 | 28.3 | 28.7 | 1 | 7.7 | 81.7 | prob.star, f. cl. |
| | | 2.2 | 2.5 | 19 | 8.5 | 26.6 | close to disk |
| NGC1068 | .004 | 43.9 | 49.7 | 8 | 24.2 | 84.5 | 2 BSO |
| | | 9.3 | 11.5 | 8 | $4.2 + 6.5$ | 9.1 | 1 BSO, ft.gals.,poss others |
| | | 5.9 | 22.6 | 9 | 15.7 | 9.0 | 2 BSO |
| NGC1556 | .004 | 26.1 | 29.7 | 4 | 13.6 | 21.8 | poss.gals. |
| NGC4579 | .006 | 15.1 | 15.7 | 1 | 4.3 | 8.5 | 2 BSO |
| NGC5033 | .003 | 9.4 | 12.3 | 12 | 21.1 | 5.7 | 2 BSO |
| | | 26.2 | 27.0 | 5 | 6.7 | 10.9 | 2 BSO |
| NGC4151 | .003 | 15.2 | 33.9 | 2 | 35.1 | 16.2 | 2 BSO |
| | | 15.7 | 33.1 | 1 | $14.3 + 9.1$ | 16.0 | 2 BSO |
| NGC4051 | .002 | 21.3 | 29.9 | 2 | 30.7 | 17.0 | star,false pair, see discuss. |
| NGC3227 | .004 | 31.5 | 43.3 | 10 | 31.9 | 45.6 | 1 Bcg, 1 QSO $z$ = .83 |
| | | 23.4 | 25.1 | 4 | 5.5 | 8.7 | 2 BSO |
| | | 33.9 | 35.9 | 4 | 11.0 | 9.1 | 1 BSO, 1S1 $z$ = .25 |
| NGC7314 | .005 | 15.7 | 15.9 | 21 | 12.8 | 91.3 | 2 BSO |
| NGC2992 | .007 | 33.0 | 37.0 | 2 | 10.0 | 9.3 | 1 gal., 1 BSO |
| | | 27.5 | 30.2 | 10 | 4.1 | $3.5 + 4.5$ | 2 BSO |
| | | 17.0 | 24.8 | $\sim 3$ | $4.0 + 3.3$ | 3.2, 3.6, 4.7 | 4 BSO |
| NGC2639 | .011 | 17.7 | 20.6 | 18 | 25.7 | 37.8 | 1 QSO, $z$ = .31, 1 BSO |
| NGC4235 | .008 | 35.9 | 46.1 | 10 | 267.6 | 119.4 | 1 gal, 1pec.obj. |
| NGC3516 | .009 | 10.7 | 11.2 | 1 | 4.4 | 6.6 | 2 BSO |
| | | 4.2 | 7.4 | 25 | 7.1 | 3.1 | 2 BSO |
| NGC5273 | .004 | 17.9 | 20.0 | 8 | 7.8 | 12.6 | 1 BSO, 1 v.f. NSO: |
| | | 14.6 | 16.7 | 0 | 18.2 | 39.2 | 2 BSO across C=4.1 source |
| NGC5548 | .017 | 36.3 | 41.3 | 7 | $8.3 + 10.0$ | $1213 + 17.1$ | 3 BSO, 1 BL Lac $z$ = .24 |
| | | 28.3 | 37.0 | 8 | 5.0 | $8.0 + 12.4$ | 2 BSO, 2c.g. |
| | | 13.1 | 18.2 | 14 | 4.8 | 6.3 | 1 QSO $z$ = 1.06, 2 BSO |
| | | 10.4 | 17.0 | 2 | $2.7 + 2.9$ | 8.7 | 1 QSO $z$ = 1.87, 2 BSO |
| | | 6.1 | 15.3 | 0 | 10.3 | 7.6 | 2 QSO $z$ = .67, .56 across C = 35.1 |
| average BSO pairs | .006 | 17.4 | 23.1 | 7.3 | 12.8 | 20.1 | ave *only* BSO, QSO pairs |

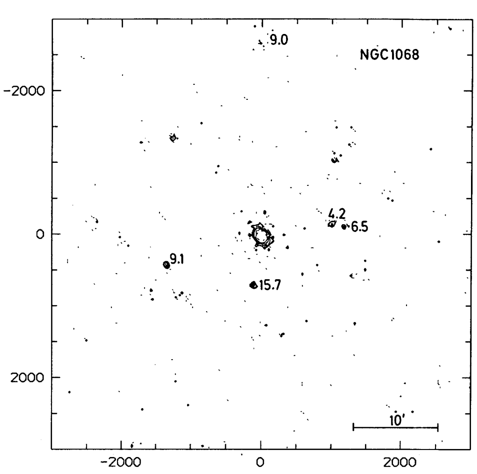


**Fig. 15.** The inner regions of NGC 1068 show an alignment of X-ray sources roughly E-W which is slightly rotated from the outer alignment in Fig. 7 and also an alignment N-S (C = 9.0 and 15.7).

*indications on both the E and O schmidt prints of luminous filaments from this galaxy toward the two X-ray quasars.*

**NGC 1365** In this PSPC exposure there are no conspicuous pairings or alignments. Fig. 16 shows a very conspicuous BL Lac object, however, located only 12.′3 from this SBb class Seyfert. The active, compact galaxy actually has a stronger flux at the time of the observation than the Seyfert. The catalogued apparent magnitude for the BL Lac object is V = 18.0 mag. and the redshift is $z = .308$. Active galaxies of this type falling near our sample of Seyferts are listed in Table 2 and discussed in the summary.

NGC 1365 was the brightest of six Seyfert galaxies analyzed by Turner, Urry and Mushotzky (1993). They reported 55 X-ray sources detected around 6 Seyferts in an annular ring area between $3' < r < 20'$ which totaled 8600 min$^2$. This gives an average density of 23 sources deg sq$^2$ to a flux of $\geq 3\times10^{-14} erg cm^{-2} s^{-1}$. The flux in their .1-2 keV band is about twice the flux in our .5-2 keV band and enables us to estimate a background expectation of sources of about 11-13 sources deg sq.$^{-2}$ (The factor two is supported by the fact that they measure

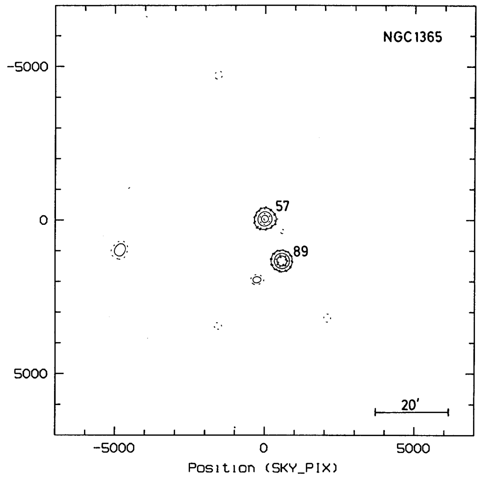


**Fig. 16.** The proximity to NGC 1365 of the strong (C = 89) X-ray BL Lac, MS 03313-36 is shown. See Table 2 and Summary for discussion.

for NGC 1365 C = 115 and we measure $56.6 ctsks^{-1}$) That would require about half their 55 sources to be associated, or an excess of 4.6 sources per Seyfert. That more than confirms our $\sim 2$ sources for Seyfert but their Seyferts were very X-ray strong for fainter optical apparent magnitudes. Moreover, excluding NGC 1365 their five Seyferts averaged $\bar{z} = .027$, or about 4.5 times our average $\bar{z} = .006$. On the redshift distance assumption their excess density of a factor of 8 inside $r = 3'$ would transform to an excess density inside our $r \leq 13'.6$ - well within the radius range where we find our excess density.

**NGC 1097** This powerful radio and X-ray Seyfert has the most extensive system of optical jets originating from it of any known galaxy. (Wolstencroft and Zealy 1975; Arp 1976; Lorre 1978). X-ray observations with the Einstein telescope revealed strong X-ray sources in the region of the strongest optical jets. Optical identifications were made and resulted in spectroscopic confirmation of six quasars (Wolstencroft et al. 1983). Later a $2.85 \times 2.85$ degree field around NGC 1097 was searched with objective prison schmidt plates and 31 quasars were confirmed with slit spectra (Arp, Wolstencroft and He 1984). The density of quasars was in excess of background, extended to about one degree radius from the galaxy and reached a factor of $> 20$ excess in a region centered between the two jets.

There are no conspicuous pairings of X-ray sources present in the newer ROSAT observations so no additional X-ray maps are shown here. (Although there is an alignment of X-ray sources over the larger ROSAT survey area – observations by Arp in preparation). But it is important to note that the previously published results (1983, 1984) had already established clearly that there are a number of quasars associated at $\lesssim 1°$ with this particularly active Seyfert galaxy. Hence, more than a decade earlier, an independent investigation on this one Seyfert had established the same association of quasars that we are finding here for Seyferts as a class.

**NGC 1566** No map is shown here although there is a strong pair of X-ray sources well aligned across the Seyfert having $C = 13.6$ and 21.8. The identification of these two sources is uncertain, the best possibilities are extended objects about $20^{th}$ and $18^{th}$ magnitude respectively. Other sources in the field are possibly identified with faint galaxies and BSO's, including a likely quasar candidate of $C = 2.2$ about $20^{th}$ magnitude, 7′.0 SE of the galaxy nucleus (04/20/34.4, -55/01/24 (2000)).

**NGC 5005** This Seyfert lies 41′ NW of the Seyfert NGC 5033 (discussed in the section after the following). NGC 5005 is smaller, has a much higher surface brightness than NGC 5033 and a redshift 145 kms$^{-1}$ higher. By the precepts of Arp (1994) we could consider NGC 5005 as a companion to NGC 5033 and a companion which is in a star bursting phase.

There are no strong pairs across NGC 5005 although there is an apparent line of sources, $C = 27.8, 10.0, 3.8, 2.2, 3.3$ and 3.5 coming through the Seyfert at p.a. $\approx 15°$. The two brighter sources are optically identified as a very compact, bluish gal $\sim 18 mag.$ and an E = 18.8 mag. BSO respectively. The fainter X-ray sources are not reliably identified. No figure is shown here.

**NGC 4579** A line of X-ray sources is shown in Fig. 13 running NW–SE through NGC 4579. The two end sources are the strongest at $C = 8.5$ and 4.3. The first is well identified with an E = 19.3 mag. BSO and the second with an E = 19.6 BSO. The $C = 4.4$ source, 5′.7W of NGC 4579 is closely identified with an E = 18.2 mag. BSO. Another BSO candidate lies exactly 53″ N of this latter position.

**NGC 5033** This Seyfert field, as shown in Fig. 10, contains a large number of strong X-ray sources. The source C = 25.5 represents the adjoining Seyfert NGC 5005 discussed previously. Table 3 lists optical identifications for most of the remaining sources.

Three of the X-ray sources, C = 10.9 and the pair C = 21.1 and 5.7, involve multiple BSO candidates. If confirmed as quasars they would represent the densest groupings of quasars yet discovered and continue the trend for such tight groupings to fall near active, low redshift galaxies (Arp 1987 p64; 1995c). Two of these three groups of BSO's are well aligned and one, C = 21.1, has a blue galaxy central to the line of BSO's!

**NGC 4395** This field contains a large number of strong X-ray sources. There seem to be no dominant pairings or alignments, however, so the field has not been pictured here. Detailed study of the individual sources might show pairing from secondary sources as seen later in the NGC 5273 and 5548 fields.

**NGC 4151** Fig. 6 shows many strong sources distributed generally along a line NNW to SSE through this well studied Seyfert. The most interesting optical identifications are listed in Table 3.

As Table 1 shows there are two well aligned pairs of BSO's across NGC 4151. Along this general direction is also found a very powerful X-ray BL Lac. C = 257 for the BL Lac compared to C = 570 for the central Seyfert even though the BL Lac is catalogued as V = 20.3 mag. The chance of finding a source as strong as $F_x = .114 \times 257 = 29.2 \times 10^{-13} erg cm^{-2} s^{-1}$ within 4′.5 arc minute of an arbitrary point in the sky can be measured from the Hasinger et al. (1993) log N-log S curves as $P_{4'.5} = 4 \times 10^{-4}$. Fig. 17 below shows that when an archival HRI observation is analyzed there appears an X-ray luminous connection between

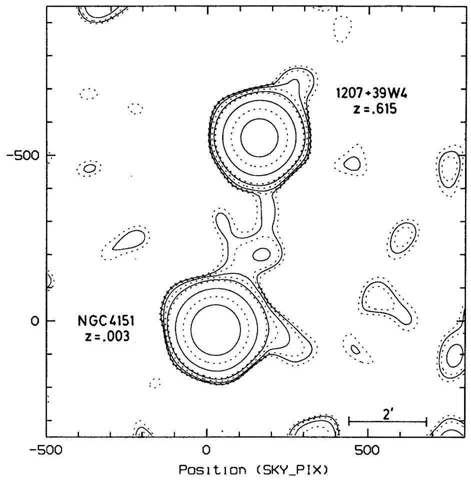


**Fig. 17.** The region between NGC 4151 and the BL Lac object is examined on a 9.6 ks HRI exposure. The 10″ pixel size is smoothed with a 5 sigma gaussian filter and the countours range from .21 to 10 cts. per image pixel.

the Seyfert and the BL Lac. This latter represents direct, as opposed to statistical, evidence for the associations of higher redshift BL Lac objects.

There are two X-ray sources 6.′8 NW of the BL Lac which can be seen in Fig. 6 and which are catalogued quasars of $z = 2.334$ and $z = 2.4$. Other sources in the interior can be identified with NGC 4156, a peculiar spiral with jet about 5.′0 NE of NGC 4151 and sources then leading SW to the other side of NGC 4151. Extensive photographic analysis of the NGC 4151 region may be referenced in Arp (1977).

**NGC 4051** A figure is not shown here but Table 1 indicates there is a strong pair of sources well aligned across this Seyfert. The pair is probably false, however, because the position of the C= 30.7 source falls on a bright star, E = 9.2 mag. It is, of course, always possible that some faint extragalactic objects could be masked by the bright star but the probability seems high that the source of the X-rays is the star. The other member of the pair at C = 17.0 has a good BSO candidate but it lies 88.″5 off the X-ray position, too far to be considered an identification.

There is one interesting source, very bright at C = 72.4, about 16.′7 NW of the Seyfert. As the identification chart in the appendix shows, there is a group of blue objects roughly surrounding a bluish, compact galaxy. Four of the five BSO's are accurately aligned in a cross pattern across the central blue galaxy. With so many candidates one has to consider the possibility that the red or blue schmidt plate might be miscalibrated in this region. If the colors are accurate, however, this would be an extrordinarily interesting group to investigate spectroscopically.

**NGC 7213** A figure is not shown here but there is a C = 4.9 and 6.8 sourcee on the NE and a C = 5.4 and 1.7 source on the SW quite well aligned through the Seyfert. The C = 4.9 source coincides closely with a B = 11.4 mag. star but 115″ NE of this is a B = 18.8 mag. BSO candidate which is aligned very well with the C = 5.4 source on the other side. The C = 6.8 source registers well with a $B \sim 21 mag$. BSO just N of the disk of the galaxy. The C = 5.4 source is well identified with a B = 19.8 mag. BSO. The C = 1.7 source has several possible identifications.

**NGC 3227** Fig. 3 shows the rich X-ray field around NGC 3227. The strongest pair is C = 31.9 and 45.6. As Table 3 shows, the former is identified with a blue galaxy which has BSO's at 43″ and 83″ distance from it, the latter is a catalogued quasar of $z = .828$. The C = 9.1 source is a possible double QSO.

The alignments include C = 31.9, 9.0 and 45.6 and also C = 9.1, 5.5, 3.6, 8.7 and 11.0, all BSO's plus one compact blue galaxy. The C = 3.6 source has nearby brighter BSO's -1.s8, -29″ and +3.s3, -68″ which could be worth checking.

It is often seen that pairs of X-ray sources are better aligned through smaller companion galaxies which are active. In the present case NGC 3226, in contact with NGC 3227 to the NW, is also a strong X-ray source (C = 15.0). The source C = 11.0 and 9.1 are almost exactly aligned through this companion.

The strongest sources at C = 31.9 and 45.6 along with the C = 9.0 source define a line just slightly rotated from N-S direction. It is interesting to note that there is actually neutral hydrogen from the central galaxies extending about 8′ N and 19′ S (Mundell et al. 1995). This line of hydrogen is quite straight and both sides are 100 kms$^{-1}$ higher redshift than the central NGC 3227. It would seem more natural to suppose that this was an ejection track rather than tidal tails.

**NGC 7314** As with seven other Seyferts in the present sample, NGC 7314 was pictured in the Atlas of Peculiar Galaxies (Arp 1966). The pecularity in this case was that the ends of the spiral, approximately N-S, showed detached segments suggestive of ejection. The map in Fig. 12 shows two X-ray blobs, close to the central source in roughly this alignment and might be profitably investigated as to their possible relation with the optical features.

There are numbers of X-ray sources in all directions from NGC 7314 but particularly in the direction along the line of the strong pair C = 12.8 and 91.3. The three strongest sources along this line are optically identified in Table 3.

**NGC 3998** Not shown in a figure here, this field is complicated because there is a galaxy cluster (A1436) in the NE corner (~ 50′). Near it is a source C = 115.6 which coincides with a bright red star (E = 9.83, 0-E = 1.98). More central to the field, the source C = 46.2 coincides with another red star (E = 8.67 mag., 0-E = 3.14). About 24′ SE of NGC 3998 is NGC 3982, a $B_T^{o,i} = 11.59 mag.$, Sey 2 at $cz_o = 1195 kms^{-1}$. NGC 3998 at $B_T^{i,o} = 11.50, czo = 1214 kms^{-1}$ is in the nature of a more active companion to NGC 3982. The latter is close to a weak X-ray source and there is a line of weak X-ray sources approximately across it. Stronger X-ray sources pair across the stronger X-ray Seyfert NGC 3998 at C = 8.9 and 11.9 and, in a slightly different direction, C = 8.7 and 6.7. Because of the confused nature of this field identification of these sources has not been attempted.

**NGC 4639** This is the shortest exposure Seyfert field considered here (6.6ks). The Seyfert is weak (C = 21.6) and there is only one other source registered in the field with $C > 5$. There

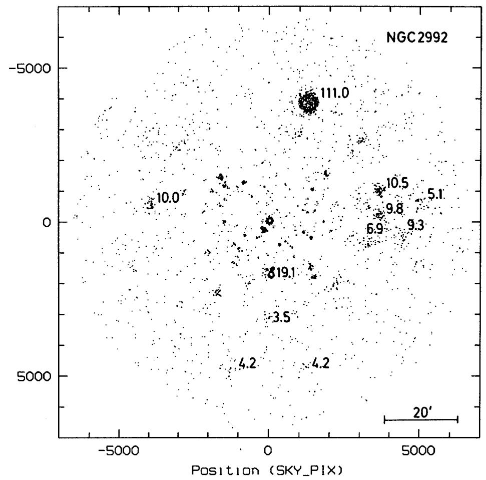


**Fig. 18.** This is the full field view of the NGC 2992 field, the inner region is shown in Fig. 5. Numerous identifications are listed in Table 3.

are a group of 8-9 sources, $1 < C < 4$, about 8′E of NGC 4639 for which identifications have not been attempted here.

**NGC 2992** This field is pictured in Fig. 5 on the same scale as NGC 4258 which is shown in Fig. 2. NGC 2992 has sources in the same kind of "X" pattern as in the NGC 4258 case but the NGC 2992 sources are fainter and at greater separation. However, there are more sources along the lines in NGC 2992, suggesting a connection back to the central active pair of galaxies (notice particularly the line of sources SW toward C = 3.2, 3.6 and C = 4.7).

An optical photograph of the disturbed pair of central galaxies can be seen in Atlas of Peculiar Galaxies #245 (Arp 1966). The sources in both the outer region (Fig. 18) and the inner region (Fig. 5) are identified in Table 3.

Some of the identifications are particularly interesting. The C = 111.0 source is a very blue compact galaxy in a group of red objects, a group which contains some other very blue objects. The 4.7 source is detected as 3 sources close together. Aside from the obvious BSO at this position there is also a BSO at $m_J$ = 18.3 mag. and 09/44/29.4 – 14/37/03.

**NGC 2639.** This is perhaps an even clearer case than NGC 4258 of a pair of X-ray sources across a Seyfert galaxy because there is only one pair and both sources are very strong (Fig. 8). The C = 25.7 source is a previously identified quasar, $z = .305$, (Arp 1980) and the C = 37.8 source is identified in Table 3 as being within a few arc sec from a very blue stellar object. [Note: The latter candidate has now been measured by E.M. Burbidge to be a quasar of $z = .325$. This represents the pair with closest matching redshifts so far found.]

To reinforce the similarity with NGC 4258, the discovery of an $H_2O$ megamaser in NGC 2639 has recently been announced (Wilson, Braatz and Henkel 1995). "The $H_2O$ features observed in NGC 2639 are remarkably similar to those of NGC 4258" and "… supports the existence of black hole powered activity in NGC 2639" are quotes from that paper.

For the $z = .305$ quasar it should be noted that the APM red magnitude (E) is much brighter than the previously measured $V_{5000}$ (continuum) = 18.1 mag. (U10 in Arp 1980). Whether this is a misestimate by the APM procedure or variability in the quasar is difficult to ascertain. The quasar is unusually bright, however, supporting the association with the bright Seyfert NGC 2639.

There are fainter X-ray sources roughly NE and SW of NGC 2639 of which optical identification is not attempted here.

**NGC 4235** This is the pair which involves the strongest pair of X-ray sources, C = 268 and 119 as shown in Fig. 9. The brighter source coincides almost exactly with a $V_{est} \sim 17mag.$, compact galaxy. This might, for example, turn out to be an object like the Seyfert 1 companion near NGC 3516 (See Fig. 11 and Table 2). There are apparent BSO'S about 1′ on either side of the brighter, C=268, X-ray source. The C = 119 source lies close to a BSO: ($V_{est} \sim 16.5mag.$) with apparent jet connection in the blue to a BSO: $\sim$ 45″NW. Both of these represent unusual configurations and should be investigated with deep, high resolution direct imaging and spectra. Finding charts are given in the Appendix.

One unresolved puzzle is that a Seyfert 1, MSS 12170 + 07, V = 16.29, Z = .080 is catalogued at the position of the + sign in Fig. 9. The Einstein, X-ray position is 36″ E of the optical object, a somewhat large disparity. But only 14″ SE of the MSS position is a faint BSO (only on the blue plate with 0 = 21.59 mag., 0-E < 1.59 mag.) which could be the source of the X-rays. The puzzle is that the ROSAT observation does not register the MSS source but does register a C = 119 source 5.′6 SE of the reported MSS source. The ROSAT source is completely free of web or detector support structure.

**NGC 3516** This is a strong X-ray Seyfert (C = 2582) with sources inside $\sim r = 11'$ aligned NW-SE. At $r = 22.'5$ along this line to the NW is encountered a very strong, $C = 155.7$ source which is a catalogued Sey. 1 of V = 16.40 mag., z = .089, or about 10 times the redshift of NGC 3516. Similar objects found in our Seyfert sample are listed in Table 2 and discussed in the Summary. The inner sources pictured in Fig. 11 are all identified accurately with BSO's as indicated in Table 3. Note the probability of a double quasar for C = 3.1

Also note the very similar BSO's, C = 6.6 N and 6.6S, extremely well aligned across the brighter BSO, C = 7.1. This could represent another case of a secondary alignment originating from a larger, active companion as in NGC 5273 and NGC 5548 following.

**NGC 5273** This Seyfert has one conspicuous pair across itself (C = 7.8 and 12.6). Originally it was thought that the pairs C = 39.2 and 18.2 were, in addition, a less well aligned pair across the Seyfert. However, there are better aligned possibilities as shown in Fig. 19.

Fig. 19 shows that there is exact alignment through the C = 4.1 source. But the optical identification of that source is not impressive. As Table 11 indicates, there is only a faintish, very red object within the X-ray error circle. Comparing the Palomar E and O plates to B and R plates taken with the same instrument

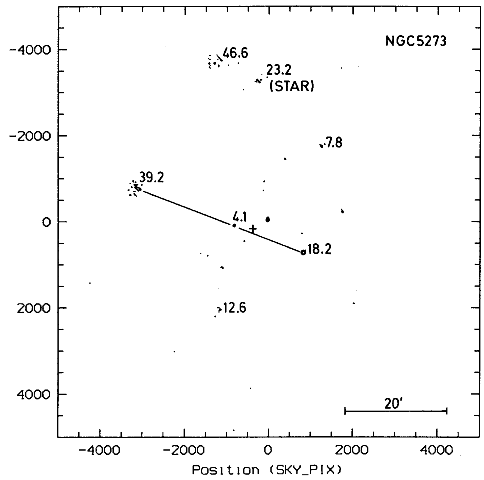


**Fig. 19.** The best alignment across NGC 5273 is the C = 7.8 and 12.6 pair. There is also an exact alignment across the C = 4.1 source. As discussed in the text, however, the companion galaxy NGC 5276, marked by a + sign, is probably a more likely origin for this pair.

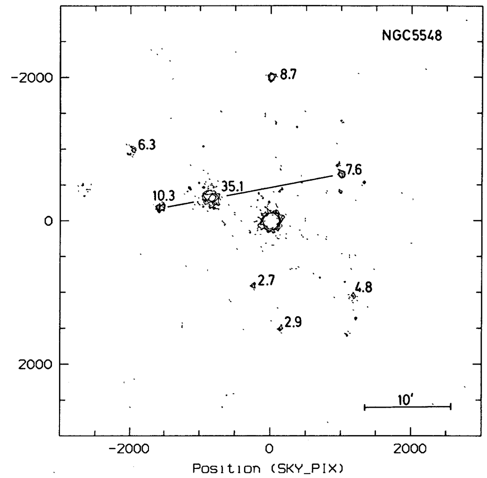


**Fig. 20.** The inner region of the NGC 5548 field is shown here, the outer is shown in Fig. 4. Numerous identifications are listed in Table 3.

about 40 years later suggests this object is variable. It may well be the correct X-ray identification albeit a very unusual one.

Actually, there is another, optically brighter, origin for this alignment as shown by the cross in Fig. 19. The cross represents the position of NGC 5276, a B = 14.6 mag., $cz = 5,548 kms^{-1}$ SBa galaxy. It is a typical, high redshift, active companion of the kind associated with large low redshift galaxies (Arp 1981; 1987). The alignment of the C = 39.2 and 18.2 sources across it is rather good ($\Delta\theta = 6°$) and the alignment is roughly in the minor axis direction. Moreover there are two BSO's (not registered as X-ray sources in the reduced PSPC exposure) between 1′ and 2′ of NGC 5276 and another further out along the direction to the C = 4.1 source. Although either is possible, it is felt that NGC 5276 is the most likely origin for these later objects.

**NGC 5548** Fig. 4 shows the disposition of the many strong sources around this strong X-ray Seyfert. Only the brighter, outer sources are labelled in Fig. 4. The inner sources are shown below in an enlargement of the X-ray map (Fig. 20). Identifications are given in Table 3.

The most noteworthy object in the field is the BL Lac object 1E 1415.6 + 2557 which in our .5-2.0 keV band has a flux of $F_X = 1213 \times .114 = 138 \times 10^{-13} ergcm^{-2}s^{-1}$. This corresponds well to the flux reported by Halpern et al. (1986) of $116 \times 10^{-13} cgs$ in the .3-3.5 keV band. X-ray sources this bright are very rare. Extrapolating the Hasinger et al. (1993) logN-logS curve we expect about 2 such sources per 1000 square degrees. At r = 35.′1 from NGC 5548 we are covering an area of about 1 square degree so the probability of accidentally finding an X-ray source this bright is only about $2 \times 10^{-3}$. Of course, the incidence of BL Lac objects among bright X-ray sources is about 4% (Stocke et al. 1991) so the probability of finding such a strong BL Lac this close to NGC 5548 is only about $2 \times 10^{-5}$ (See Table 2 in summary).

Like the BL Lac which was previously discussed as being so close to NGC 4151, the present one also seems to reside in an apparent extension of X-ray sources from the Seyfert galaxy. Fig. 4 shows the relatively strong sources C = 8.3 and 10.0 opposite the BL Lac object. There are also smaller sources at C = 8.7 and 2.7 and 2.9 along this line, closer in to NGC 5548.

It is evident in Fig. 4 that there is an excess of X-ray sources directly around the BL Lac, both strong sources and weaker sources. It is of course, an obvious interpretation that there are companion X-ray sources associated with the BL Lac just as there around the NGC 5548 Seyfert except that they are closer in angular separation around the BL Lac. Another noteworthy feature of this field is the number of double and multiple BSO identifications. There are two probable double QSO's, C = 2.7 and 4.8 in Fig. 20 and C = 8.3 in Fig. 4. Two other sources C = 12.3 and C = 10.0 are noted as having a number of BSO candidates nearby.

As for the interior sources shown in Fig. 20 we have mentioned the alignment N-S of the C = 8.7 and 2.7 and 2.9 sources in the direction of outer stronger sources. But the interior sources at C = 7.6 and 10.3 are exactly aligned across the strong source of C = 35.1 which is a companion to NGE 5548. Also the sources at C = 6.3 and 4.8 are much better aligned across this same C = 35.1 source. From Table 3 one sees the C = 6.3 and 4.8 sources involve highly probable QSO's. But the C = 7.6 and 10.6 sources are catalogued quasars at $z = .56$ and $z = .67$. This is remarkably similar to the pair of quasars across NGC 4258 at $Z = .40$ and .65 (Pietsch et al. 1994), the pair across Mark 205 at $z = .46$ and .64 (Arp 1995c) and the pair across IC 1767 at $z = .62$ and .67 (Arp 1968; 1980; 1995b).

In view of this apparent activity centered on the C = 35.1 source it would seem particularly important to identify and study the optical object associated with this strong source. As Table 3 reports, the X-ray source falls on a very faint, blue object which is not even recorded on the Palomar schmidt E plate. The E plate does record a group of faint red objects around the X-ray position. A faint, small, blue connection seems to lead to the

**Table 2.** Summary of BL Lac Type Objects in Seyfert Fields

| Seyfert | Object | C | $r_1$ | $Prob.(X)$ | $Prob.(BL)$ | V | $z$ |
|---|---|---|---|---|---|---|---|
| CenA | BL Lac | 285 | 114′ | $2 \times 10^{-1}$ | $8 \times 10^{-3}$ | 17.0 mag. | 0.108 |
| M81 | ? | 148 | 12 | $7 \times 10^{-3}$ | — | — | — |
| N1365 | BL Lac | 89 | 12 | $1 \times 10^{-2}$ | $4 \times 10^{-4}$ | 18.0 | .308 |
| N4151 | BL Lac | 257 | 4.5 | $4 \times 10^{-4}$ | $2 \times 10^{-5}$ | 20.3 | .615 |
| N3516 | S1 | 156 | 22 | $2 \times 10^{-2}$ | | 16.4 | .089 |
| N5548 | BL Lac | 1213 | 35 | $2 \times 10^{-3}$ | $8 \times 10^{-5}$ | 16 | .237 |

brightest red, non stellar object. This is clearly an important X-ray source to investigate with large, modern telescopes.

## 3. Summary

Analysis of PSPC observations show excess X-ray sources out to $\lesssim 1°$ around Seyfert galaxies. In the $8.0 < B_T^{0,i} < 12.9 mag.$ sample of 24 Seyferts investigated here it is estimated that a minimum of $>$ 46 sources, generally 10 to 100 times more luminous than X-ray objects found in our own galaxy, are physically associated with these active, central galaxies. What are these sources? Optical identifications of paired X-ray sources on schmidt survey plates yield $\approx$ 53 BSO's most of which must be quasars. Some of the stronger, more widely spaced X-ray sources are identified with compact galaxies which tend to be blue – i.e. objects whose properties are physically continuous with quasars.

Among the brightest X-ray sources in these fields are a number of the extreme non-thermal galaxies known as BL Lac objects. Table 13 lists the six most conspicuous objects of this type in the 26 Seyfert fields investigated. The column marked Prob (X) calculates the chance of accidentally finding an X-ray source of this strength within the observed distance to the Seyfert. But BL Lac's only comprise 4% of the X-ray sources in the Einstein Medium Sensitivity Survey (Stocke et al. 1991). Therefore the chance of finding any one of the four BL Lac's this X-ray bright and this close to the Seyferts is shown in the column marked Prob. (BL) to fall between $8 \times 10^{-3}$ and $2 \times 10^{-5}$. Since there are 26 Seyfert's in the sample the chance of finding all four is $P_{tot} = (26)^4 P_1 P_2 P_3 P_4 = 2 \times 10^{-9}$.

This is not an *a posteriori* calculation because already in 1979 it was reported that excess numbers of BL Lac objects were found at a mean radial separation of one degree ($\sim 1°$) around bright apparent magnitude Shapley-Ames galaxies (Sulentic et al. 1979). Nor is it a surprising result when one considers a quasar like the southern member of the pair across NGC 2639 (Fig. 8). That quasar has V = 18.1 mag., $z = .305$, $C = 25.7 ctsks^{-1}$. But the BL Lac associated with NGC 1365 in Table 2 has V = 18.0 mag., $z = .308$ and $C = 89 cts.ks^{-1}$. Only the X-ray flux from the latter is about 3.5 times greater, undoubtedly a signal of strong nonthermal continuum which reduces to low contrast the spectral lines which are characteristic of BL Lac objects. Of course quasars are notoriously variable, and BL Lac objects particularly so, and there are indications that one can change into another on a short time scale.

The upshot is that the evidence in this and previous papers shows quasars are associated with low redshift, active galaxies (e.g. Arp, Wolstencroft and He 1984 who showed a number of quasars associated with NGC 1097 out to $\lesssim 1°$). That evidence is supported by the evidence that BL Lac objects are associated with such galaxies out to this same $\lesssim 1°$ – and the BL Lac evidence in turn supports association of the quasars.

**Quantization** It is not possible to make an analysis with the limited number of redshifts currently available around the Seyferts, but we do wish to point out some provocative redshift values which have turned up so far. It is well known that quasar redshifts prefer certain values: .06, .30, .60, .96, 1.41, 1.96 (see for review, Arp et al. 1990). The BL Lac's in Table 2 at $z =$ .308 and .615 and the strong X-ray QSO south of NGC 2639 at $z = .305$ are examples. The closeness of these particularly strong X-ray objects to the preferred redshift values may suggest a resonance phenomenon at these redshifts.

In addition, the best examples of paired quasars mentioned at the end of the NGC 5548 section average, as seen below, to $\bar{z} = .58$

| | | | | |
|---|---|---|---|---|
| NGC 5548 : | $z =$ | .56 | and | .67 |
| NGC 4258 : | $z =$ | .40 | and | .65 |
| Mark 205 : | $z =$ | .46 | and | .64 |
| IC 1767 : | $z =$ | .62 | and | .67 |
| ave all $z$'s | | $\bar{z} =$ | .58 | |

The point of averaging these pairs is that it was calculated 28 years ago (Arp 1968) that the typical ejection velocity of quasars from the central galaxy was 0.1c. These new X-ray pairs would confirm this value by yielding an average projected ejection velocity = .086c or .12c corrected for average projection. After averaging out these receding and approaching ejection velocities, the intrinsic average redshift this group of quasars would be $\bar{z} = .58$ as shown above. This would be another confirmation of the preferred redshift of $z = .60$ and evidence that most of the dispersion around this preferred intrinsic value is due to approaching and receding velocities of ejection.

**Ejection Origin** Evidence for the ejection origin of quasars was first seen in the pairs of radio sources across active galaxies. Radio sources have always been accepted as ejected and a number of them were early identified as quasars (Arp 1967; 1968a). The advent of X-ray observations showed that X-rays often accompanied the radio ejections. The nearest example of this is NGC 5128 (Cen A) where the inner radio jets and X-ray jets are coincident. In this case also are seen filaments of gas and young stars stretching out along the path of ejection (Fosbury 1984 and Morganti, Robinson and Fosbury 1989). In the outer regions they can diverge but that may be due to the fact that the radio synchrotron electrons are longer lived than the X-ray synchrotron or bremstrahlung electrons. In any case the X-ray emission is indicative of recent energy generation and is a very efficient method of picking out high energy density quasars. That quasars selected by X-rays should show strong pairing characteristics due to recent ejection from a central active galaxy should be no surprise in view of all the examples which have accumulated dating back to 1966 (see Arp 1995b for most recent review). The evidence presented in the present paper that BSO's are *characteristically* paired across Seyfert galaxies should provoke a further intensive observational campaign directed specifically toward better empirical understanding of the nature and properties of this phenomenon.

## Appendix

Note: Table 3 is only available in electronic form via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html. Table 3 plus finding charts are also available on request from author.

In Table 3 are listed the optical properties of all the X-ray sources which have been labeled in Figs. 2-20 and discussed in the text. The columns are:

1) The NGC number of the central Seyfert, ordered in decreasing brightness. These Seyferts are at approximately position 0,0 in the maps.
2) C is counts per kilosecond of the source in the .5-20keV band. These are the numbers labeled on the maps in Figs. 2-20.
3) and 4) the position of the optical identification from schmidt telescope plates as reduced by automatic plate processing (APM). (Accurate to about 1 arc sec.)
5) E is the red apparent magnitude estimated by APM and O-E is the color, where the average color of faint stars is about O-E $\approx$ 2.0mag (Arp 1995a). South of Dec = -10° Palomar schmidt plates are not available via APM and the available schmidt plates have been visually estimated as to color of the identification.
6) and 7) $\Delta x$ and $\Delta y$ are the positions of the optical identifications with respect to the X-ray position. + is East and - West of the X-ray position, + is North and - South of the X-ray position. X-ray positions for sources with $C \geq 5.0$ can be obtained from Radecke in the preceding paper. These residuals can be averaged as desired by any user to obtain bore sight corrections for these fields. Then the average accuracy of the X-ray Positions can be calculated. For most count ranges and distances it is about $\pm 3$ arc sec.
8) When an object has an ambiguous identification or there are other BSO candidates which could be associated, reference to an appendix finding chart, A1 through A18, is given.

The finding charts A1 through A18 are given as printed out by the APM measuring program. The O-E colors are labelled next to all objects which are considered possible AGN candidates (i.e. bluer than about O-E $\simeq$ 1.50 mag.). The error circle drawn in each chart has a radius of $41''.1$. The APM program melds close optical images into one, usually elongated, shape so care must be exercised with images that have no color index label attached. In three cases of melded images A10, A12 and A13, the candidate optical object is indicated by an arrow. The most interesting cases are groups of BSO's or alignments of BSO's across X-ray identifications. BSO's which are not X-ray sources have less probability of being quasars, however, so spectroscopic checking is more necessary in these special cases. Measured values of the redshifts of these objects will be especially valuable to analyze.

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