# ASSOCIATION OF X-RAY QUASARS WITH ACTIVE GALAXIES

H. ARP
*Max-Planck-Institut für Astrophysik*
*Karl-Schwarzschild-Str. 1*
*85740 Garching, Germany*

**Abstract.** Analysis of ROSAT observations demonstrate that X-ray sources are associated with bright Seyfert galaxies up to distances of about 40 arc min. These X-ray sources are predominantly identified with blue stellar objects (BSO's) some of which are already catalogued as quasars.

The X-ray sources tend to pair and align across the nucleus of the active Seyfert. Enough redshifts are now available to indicate the similarities of the redshifts in the quasar pairs and to enable computation of ejection velocities of about 0.1c.

BL Lac objects are a conspicuous kind of strong X-ray source which are associated with Seyferts at a high level of probability. The BL Lac's appear to be a transition form between quasars and compact companion galaxies. Both quasars and companion galaxies tend to align along the minor axis of the ejecting galaxy and extend to the same maximum separation of $\sim 400$ kpc.

These observations require high redshift quasars to evolve into low redshift companion galaxies. The initially high intrinsic redshift of the quasars must then arise from the low particle masses in their relatively recently created matter.

## 1. Introduction

In 1966 it was discovered that radio quasars tended to pair across active galaxies. Evidence that these quasars were, like other radio sources, ejected from the energetic nuclei of the galaxies is reviewed by Arp (1987). In the past decade X-ray telescopes efficiently discovered point sources within fields of $\sim 1^\circ$ radius. When these fields were centered on the especially strong X-ray galaxies called Seyferts, it became obvious that there were



*K. Sato (ed.), Cosmological Parameters and the Evolution of the Universe,* 290–295.

physically associated, excess numbers of point X-ray sources out to about 40′ radius (Radecke 1997). These sources are overwhelmingly quasars and confirmed very strongly their pairing and alignment across the central, low redshift galaxies (Arp 1997a). An example is shown in Fig. 1.

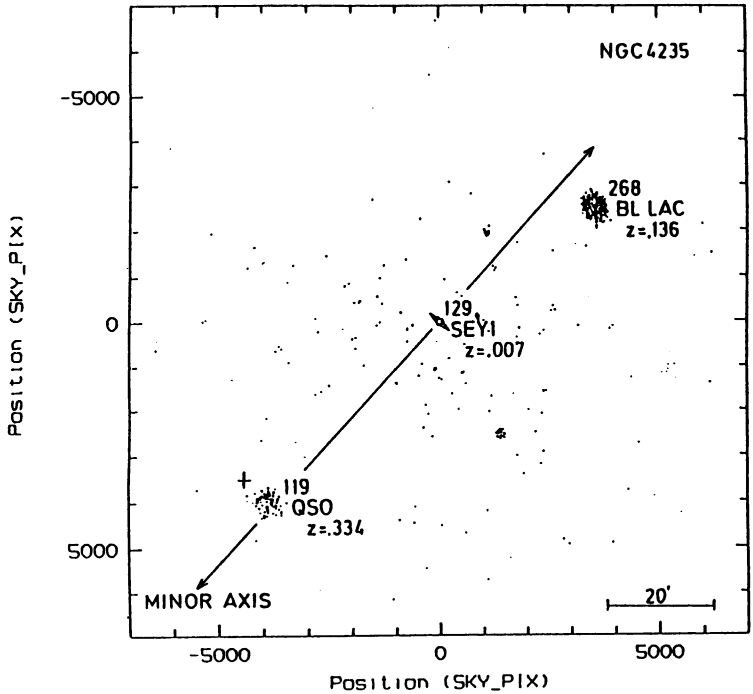



*Figure 1* The Sefyert 1 galaxy NGC 4235 with strong X-ray sources paired across it (268 and 119 counts/ksec). Redshifts of z=.334 for the quasar and z=.136 for the BL Lac object are much higher then the redshift of the central galaxy, z=.007 (From Arp 1997b).

## 2. Empirical Characteristics of the Associations

Fig. 2 incorporates in one schematic diagram the properties observed over the last 30 years for quasars associated with low redshift galaxies. Characteristically the quasars emerge close to the present galaxy with high redshift and low luminosity. As they travel outward they decrease their redshift and increase their luminosity. At maximum separation from their parent they tend to be relatively strong X-ray emitters and have redshift in the $.1 \lesssim z \lesssim .3$ range. This is the region where BL Lac objects (a rare, active kind of quasar in which energetic continuum outbursts swamp the usual quasar emission lines) are encountered. BL Lac objects themselves tend to eject new objects and they also show the first signs of underlying stellar population. They appear to be the transition phase between the quasars and the compact, young galaxies. Finally an empirical sequence of forms can be traced from the compact companions to increasingly normal companions as their intrinsic redshifts continue to drop.

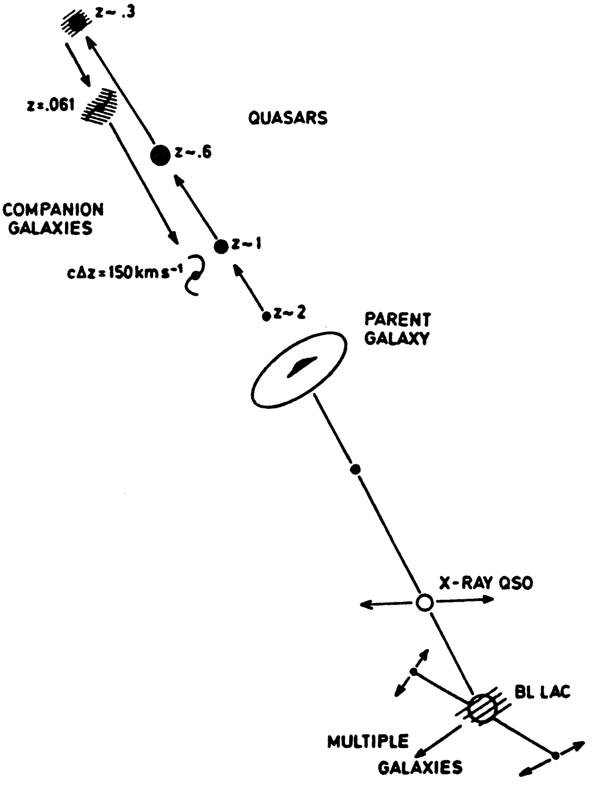



*Figure 2* Schematic representation of quasars and companion galaxies found associated with central galaxies from 1966 to present. The progression of characteristic is empirical but is also required by the variable particle mass theory of Narlikar and Arp (1993).

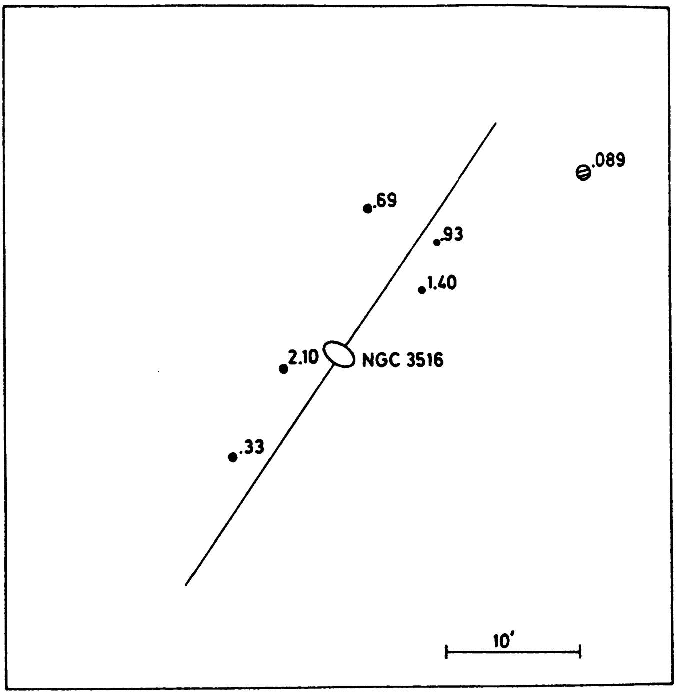
## 3. A Single, Striking Example, NGC 3516.

One of the particularly active Seyferts where associated X-ray BSO's were identified by Radecke and Arp was observed spectroscopically by Yaoquan Chu with the Beijing 2.2 meter telescope Fig. 3 shows the electrifying results of his quasar confirmations (Chu et al 1997). It can be readily seen how the quasars decrease in redshift as they extend away from the central Seyfert. They are aligned within $\pm 20$ degrees of the central galaxy's minor axis (a result by itself which has only $10^{-4}$ chance of being accidental).

Moreover the 5 quasars and the $6^{\mathrm{th}}$ BL Lac-type object all have redshifts very close to the quantized redshift values which quasars on average exhibit

https://doi.org/10.1017/S0074180900132966 Published online by Cambridge University Press

(Arp et al 1990). The importance of this result is that the peculiar velocity component of the redshift must be relatively small and the major portion of the redshift cannot be a recessional velocity.




Quantization

| | | | | | | |
|---|---|---|---|---|---|---|
| observed NGC3516: | z= .089 | .33 | .69 | .93 | 1.4 | 2.1 |
| Karlsson formula: | z= .061 | .30 | .60 | .96 | 1.41 | 1.96 |

*Figure 3* All bright X-ray objects around the very active Seyfert galaxy NGC 3516 which have had their redshifts measured by Chu et al (1997). Redshifts are written to the upper right of each quasar and quasar-like object.

## 4. Evolution of Quasars into Companion Galaxies.

As Fig. 2 shows, the empirical continuity of properties suggests very strongly that the quasars turn into normal companion galaxies as they age.

Among these properties are:

1) Intrinsic redshift. The quasars have high intrinsic redshift marking them as much younger than the parent galaxy. Companion galaxies as a class have small excess redshifts (Arp 1994) in consonance with their having reduced their intrinsic redshift as they aged from quasars. But if they were not slightly younger than the dominant galaxy in the group what could explain the systematic redshifts of the companion galaxies?

https://doi.org/10.1017/S0074180900132966 Published online by Cambridge University Press

2) Quantization of redshift. Quasar redshift are quantized in large steps. Galaxy redshifts are quantized in small steps (Tifft 1976; Guthrie and Napier 1996). It is unlikely that the quantization is caused by different effects in quasars and galaxies. Therefore the continuous change of this intrinsic property is strong evidence for an evolutionary process.

In addition to these arguments there is the direct evidence from their location with respect to the ejecting galaxy. As Fig. 4 shows, the QSO's are ejected within ±20 degrees of the minor axis whereas companion galaxies are found preferentially within ±35 degrees of the minor axis. Both distributions extend out to about 400 kpc (Arp 1998). As the companions age they apparently deviate somewhat from their initially plunging orbits back to their nucleus of origin. But to find both quasars and companions in this same unique volume of minor axis space is the most direct proof possible of their common origin.

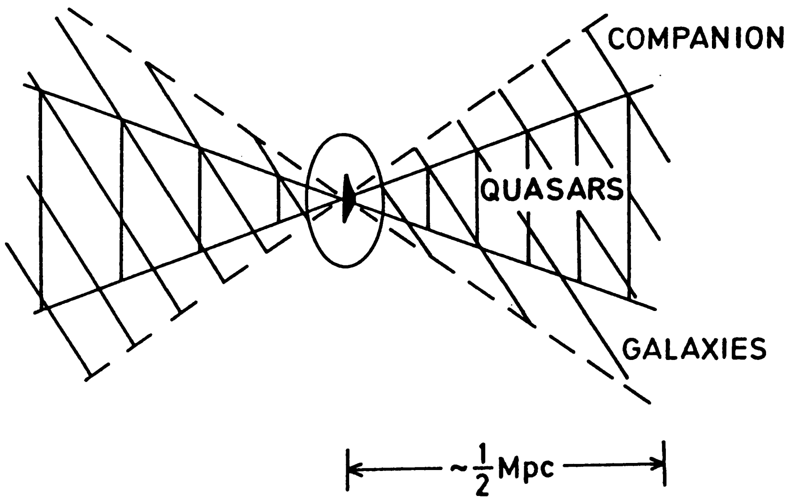



*Figure 4* Schematic representation of distribution of companion galaxies along minor axes of disk galaxies (±35 degrees from Holmberg 1969; Sulentic et al. 1978; Zaritsky et al. 1997). Quasars are observed ±20 degrees from minor axis (Arp 1998).

## 5. A Word about Theory.

The only explanation for intrinsic redshifts for stars and galaxies is that proposed by Narlikar and Arp (1993) where newly created matter has particle masses $m \gtrsim 0$ which grow with time. Since the newly created matter is in the form of energy it starts off travelling with the signal velocity, $c$. As particle masses increase with time the translational velocity slows to conserve momentum. This agrees with observation in that the small radio knots emerging from the innermost regions of galaxy nuclei are observed to travel with very nearly $c$. They could only represent the proto quasars which will subsequently evolve into quasars and then into companion galaxies. Calculations by Narlikar and Das (1980) with this theory yielded maximum excursions of about 400 kpc as are now observed.

The pairs of X-ray quasars now confirm results originally obtained 30 years ago, namely that by the time quasars have evolved to redshifts of $z \sim 1$ they are moving outward with about $0.1c$ (Arp 1968, 1996). As they move further out and evolve into companion galaxies their translational velocities must drop to less than about $\pm 20$ km/sec in order not to wash out their observed redshift quantizations of 37.5 and 72 km/sec.

The newly created plasma which is expelled from the ejecting nuclei must be composed of low mass, high cross section particles. This is closely analogous to the superfluid which Viktor Ambarzumian (1958) proposed to be responsible for the formation of new galaxies. He came to this conclusion by simply looking at photographs of galaxies which he judged to be showing formation of new galaxies by ejection.

The peculiar velocities of the particles in the plasma must also slow as they gain mass. That would produce cooling. So the plasma would cool and gain mass – certainly in the direction of forming self gravitating systems. After 40 years it seems likely that we will have to go back and recalculate all the analysis of ejected plasmoids, shock waves, magnetic fields, polarizations, etc., that have been made in connection with the famous active objects ejecting material in jets. The aim would be to see if this new kind of plasma naturally evolves into quasars and then into companion galaxies as empirically observed.

## References

Ambarzumian, V.A. 1958, Onzieme Conseil de Physique Solvay, ed. R. Stoops, Bruxelles.
Arp, H. 1968, Astrofizika **4**, 59.
Arp, H. 1987, "Quasars, Redshifts and Controversies" Interstellar Media, Berkeley
Arp, H. 1994, Ap.J. **430**, 74.
Arp, H. 1996, Astrophysics and Space Sciences **244**, 9.
Arp, H. 1997a, Astron. Astrophys. **319**, 33.
Arp, H. 1997b, "Pairs of X-ray Sources across Seyferts" Astron. Astrophys. Letters, in press.
Arp, H. 1998, "The Origin of Companion Galaxies" Ap.J., in press
Arp, H., Bi, H.G., Chu, Y. and Zhu, X. 1990, Astron. Astrophys. **239**, 33.
Chu, Y., Wei, J. Hu, J., Zhu, X. and Arp, H. 1997, Ap.J.Lett. submitted.
Guthrie, B.N.G. and Napier, W.M. 1996, Astron. Astrophys. **310**, 353.
Holmberg, E. 1969, Arkiv of Astron., Band 5, 305.
Narlikar, J.V. and Das, P.K. 1980, Ap.J. **240**, 401.
Narlikar, J.V. and Arp 1993, Ap.J. **405**, 51.
Radecke, H.-D. 1997, Astron. Astrophys. **319**, 18.
Sulentic, J.W., Arp, H. and Di Tullio, G.A. 1978, Ap.J. **220**, 47.
Tifft, W.G. 1976, Ap.J. **206**, 38.
Zaritsky, D., Smith, R., Frenk, C.S. and White, S.D.M. 1997, Ap.J. **478**, L53.