Nuclear Activity of Galaxies Within Groups

K.J. Fricke and W. Kollatschny
Universitäts-Sternwarte Göttingen
Geismarlandstr. 11
D-3400 Göttingen
F.R.G.

ABSTRACT.
Results from a spectroscopic survey of groups around Seyfert galaxies and of an appropriate control sample are reported. The groups are $\lesssim$1 Mpc across. A nuclear spectroscopic "activity class" is assigned to each group member. The active types show a peaked distribution around the Seyfert galaxy and are confined to a critical radius ~300 kpc while the nonactive members are uniformly distributed over the whole extent of the groups. These results are briefly discussed.

INTRODUCTION.

Necessary and sufficient conditions for the development of the Seyfert and QSO phenomena are not known. Theoretically, the presence of a compact object (monster) in the nucleus, sufficient fuel supply (internal or external gas), and an effective feeding mechanism (e.g. an appropriate angular momentum distribution, the dynamical action of a central bar, or interactions with companions) seem to be required. Recently, much observational evidence for the operation of external or internal fuelling processes has been collected in the case of QSO's. High-resolution imaging shows a fraction of $\gtrsim$30% of nearby QSO's to occur in galaxies which are presently interacting with a close companion. Approximately the same fraction of such objects is located in compact groups of ~1 Mpc diameter (Hutchings et al. 1986). Similar evidence regarding the group environment of AGN's will be presented for Seyfert galaxies in this paper. Another objective of this investigation is the spectroscopic study of the group members around the AGN's. The investigation of the activity state in the group members around the AGN's is much easier for the nearby Seyfert groups than for the very faint companions of QSO's.

OBSERVATIONS.

An inspection of the Palomar and ESO/SRC survey plates shows many Seyfert galaxies to be located in compact groups of ~1 Mpc size (cf. Fig. 1). The neighbourhood of the Seyfert galaxies were searched for group members out to approx. 40 galaxy radii corresponding to ~600 kpc. Similarly, we selected comparison groups of about the same

E. Ye. Khachikian et al. (eds.), Observational Evidence of Activity in Galaxies, 371–376.

https://doi.org/10.1017/S0074180900155378 Published online by Cambridge University Press

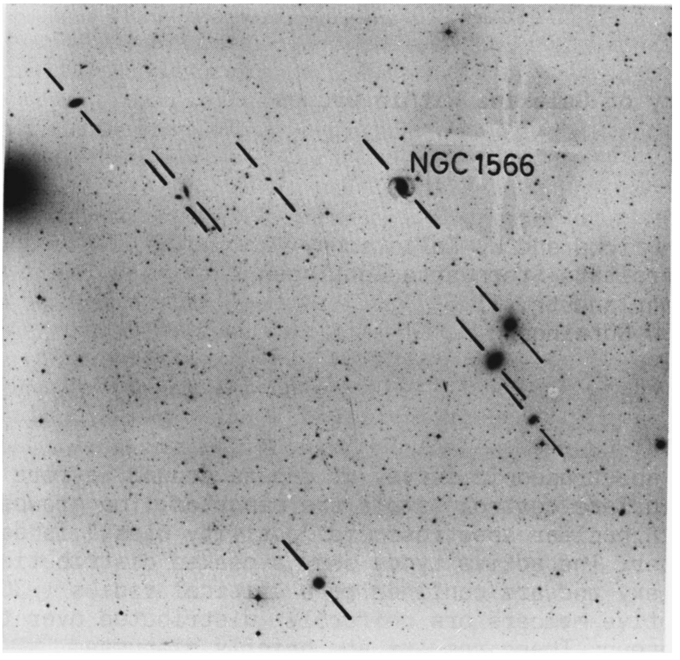

Fig. 1: The Seyfert galaxy NGC 1566 and its surrounding group.

size around non-Seyfert spirals. For further spectroscopic observations of such groups and their individual members we adopted the following selection criteria: we excluded all groups containing a Seyfert in close interaction with another galaxy. Among the group members we excluded interacting pairs of galaxies. Also strongly inclined galaxies ($i>30^{o}$), and galaxies with an obscuring dust lane have not been condidered since their activity level could not be determined securely. Spectroscopy of the selected sample galaxies was done using the ESO 1.5m, 2.2m, and 3.6m telescopes equipped with the Boller and Chivens spectrograph and an IDS or a CCD detector. The wavelength range of the spectra covered at least the region from 4500Å through 7000Å. The limiting magnitude of member galaxies taken into account was around m_V=16. From the radial velocity information we checked upon group membership and determined the velocity dispersion. Velocity differences within a group $\Delta v<1000$ km/s were considered to be internal.

Projected distances of the members to the Seyfert galaxy or to the central spiral galaxy (in the case of non-Seyfert groups) were measured on the POSS and ESO/SRC plates. Regarding the nuclear activity the galaxies were subdivided into two classes according to their emission line spectra: a galaxy is considered "active" if its nuclear spectrum has Seyfert, Liner, or starburst character; while all galaxies with nuclear spectra showing absorption only or just weak Hα and/or [NII] are considered "non-active".

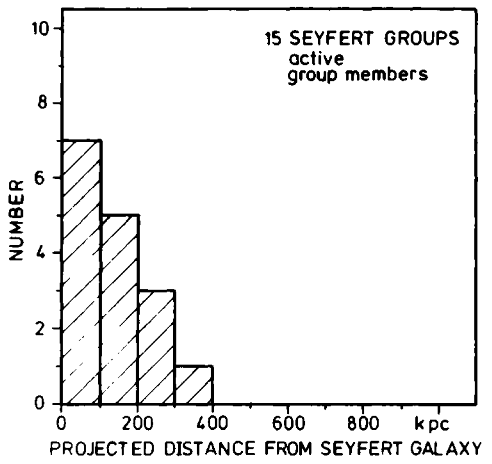

Fig. 2a: The distribution of the active members of the sample over projected distance from the Seyfert galaxy.

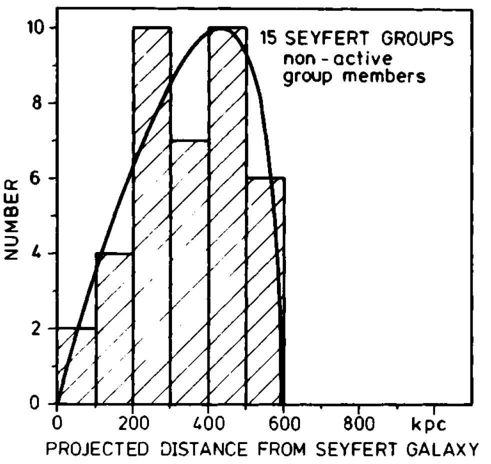

Fig. 2b: The distribution of the non-active members with respect to the projected distance from the Seyfert galaxy.

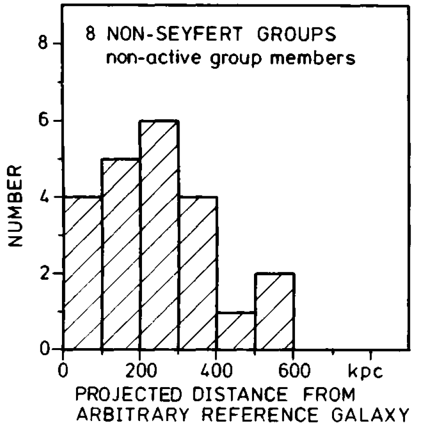

Fig. 3: The distribution of the members of the non-Seyfert groups with respect to the projected distance to the central spiral galaxy.

After selection and classification our sample consisted of 15 Seyfert-groups containing a total of 70 galaxies and 8 comparison groups containing 30 galaxies in total.
Morphologically, most of these galaxies are found to be spirals.

RESULTS

The results of this investigation are summarized in Figures 2a, 2b, and 3. We observed a strong spatial concentration of active group members around the Seyfert galaxies. Fig. 2a shows a centrally peaked distribution with respect to projected distance which implies a strong central condensation in space with a characteristic radius of 200-300 kpc. On the contrary, the non-active members appear to be nearly uniformly distributed in space with no indication of a central condensation. The full line in Fig. 2a represents the expected projected relative distribution of a homogeneous sphere of 600 kpc radius. The projected number distributions for the non-Seyfert comparison groups (Fig. 3) does not show any special properties resembling neither a strongly centrally condensed nor a uniform density distribution in space. Moreover, in such groups no "active" galaxies have been found so far.

DISCUSSION

The dependence of nuclear activity in group members from their distance to a Seyfert galaxy has been noted earlier by us in the NGC 4593 group (Kollatschny and Fricke 1985). The phenomenon of a characteristic radius for the distribution of active galaxies first showed up when a sub-sample of the present one comprising 7 groups with mostly spiral galaxies was investigated (Fricke et al. 1986). The observations reported here further support that the presence of a Seyfert galaxy in a group is accompanied by the occurrence of activity in nearby members and that the active members are distributed strongly towards the Seyfert galaxy.

For an interpretation of these facts a direct influence of the Seyfert galaxy on its neighbourhood via its ionizing flux and/or tidal forces out to distances of 200-300 kpc fails by several orders of magnitude and will therefore not be considered here. On the other hand, numerical simulations for the evolution of small groups with the inclusion of dissipative encounters (Schmutzler and Biermann 1985) offer an appropriate explanation of many aspects of our observational results. In such calculations collisions between the group members with gas exchange and its feedback on the dynamics were included. The dissipation of the kinetic energy by the gas increases the binding energy of the collision partners and speeds up the relaxation process, possibly leading to a central subsystem. Thereby, the formation of a merger - which could give rise to the development of Seyfert activity - is possible but not inevitable. During the collisions the galaxy nuclei always gain gas (at the expense of the outer regions), and starbursts will be initiated. Such starbursts last $\sim 4\times10^{8}$ yr according to theoretical calculations by Loose and Fricke (1982). A typical velocity dispersion of 300-500 km s^{-1} implies that starbursts resulting from an earlier interaction with the dominant galaxy (Seyfert) should be observable within a characteristic radius of ~200-300 kpc as is observed.

ACKNOWLEDGEMENTS

This work has been supported by the Deutsche Forschungsgemeinschaft through the grants Fr 325/21-4, Fr 325/15-2, as well as the travel grants 473/100/86. W.K. thanks the Armenian Academy of Sciences for generous support.

REFERENCES

Fricke, K.J., Kollatschny, W., 1986 in: Structure and Evolution of Active Galactic Nuclei, Giuricin, G. et al. (eds.), Reidel Publ. Comp. p. 551

Hutchings, J.B., Hickson, P., and De Robertis, M.N. 1986, Astron. J. 92, 279

Kollatschny, W., Fricke, K.J., 1985, Astron. Astrophys. 143, 393

Loose, H.H., Fricke, K.J., 1982, Proc. ESO Workshop "The Most Massive Stars (D'Odorico, S., Baade, D., Kjär, K., eds.), p. 269

Schmutzler, T., Biermann, P., 1985 Astron. Astrophys. 149, 383

DISCUSSION

PISMIS: Have you looked into the distribution of the total luminosity of the galaxies from the centre outwards in your groups? For it is conceivable that the power of the activity is in some way related to the total luminosity of a galaxy (and hence sensibly to its mass); that the more massive ones are closer to the centre and those may be the most active ones?

FRICKE: We have not looked specifically in the distribution of luminosities yet. However, your suggestion seems quite consistent with the model proposed by us to explain the concentration of active members towards the Seyfert galaxy.

ALLOIN: While you study 18 groups containing active galaxies, why do you consider only 9 control groups? This could bias your results.

FRICKE: I agree. We just have run out of observing time and shall increase the number of control groups soon.

OSTERBROCK: This is a very interesting result. Do you think that each apparently single Seyfert field galaxy can be traced back to some other galaxy with which it interacted at a distance of 300 kpc or less from their present position?

FRICKE: Theoretically, there are solutions in which one group member has eaten up all the others. This way, truly isolated Seyfert galaxies could originate. Observationally, deep imaging of the vicinity of Seyferts has not been done to the same extent as for quasars. Thus it might be that future deep imaging work of Seyferts will reveal signs of present or past interaction also in apparently isolated Seyferts.

https://doi.org/10.1017/S0074180900155378 Published online by Cambridge University Press