Rev. Mexicana Astron. Astrof., **14**, 108-119 (1987)

COMMENTS ON ACTIVITY IN GALACTIC NUCLEI AT ALL SCALES OF ENERGETICS

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RESUMEN. Se discuten algunas manifestaciones de la actividad de los núcleos galácticos como son los lóbulos y chorros los cuales parecen partir de los núcleos galácticos. Se hace énfasis en el papel que puedan jugar los parámetros globales iniciales de objetos con masas galácticas como; la masa total, concentración central de masa y energía, campos magnéticos y otros, aunque las interacciones de masas galácticas no son completamente ignorables.

ABSTRACT. Activity in galactic nuclei manifested in the form of lobes and jets are discussed. Emphasis is placed on the role that integral primeval parameters of bodies of galactic size may play in the problem of activity. These parameters are the total mass, central condensation of mass and energy, magnetic fields and others of minor importance although the effect of interactions between galactic masses may not be ruled out altogether.

A PROLOGUE. Research on activity of galactic nuclei has been extremely productive in the past years. The urge to inform the astronomical community about sensational findings as soon as possible is quite natural. As a result a large number of papers on the different aspects of AGN particularly from the radio range have appeared in the journal Nature.

The present report is an attempt towards a brief unified overview of some of the observational results, ideas expressed and hypotheses advanced on AGNs; I have put emphasis on the fact that activity in galactic nuclei extends to all scales of energy down to the mildest. I have freely expressed my personal views on this subject but have left out consideration on the onset of activity. Although I have striven towards objectivity I may not have succeeded; we all have our preconceived, pet ideas. I expect that my personal belief will be manifest through the following pages: I feel strongly that there is unity and coherence in Nature, a circumstance that has to be deciphered and brought to light despite the apparent diversities and complexities of the observational facts.

I am well aware that the present overview is only a summary of a vast problem. The filling in of the details, advertently left out necessitates further serious contemplation.

This report was prepared during my stay in the summer of 1985 at the Instituto de Astrofísica de Canarias. The hospitality received from Director F. Sánchez and his staff is greatly appreciated.

Key words: GALAXIES-NUCLEI — GALAXIES-SEYFERT

I. INTRODUCTION

Gleamings of activity in galactic nuclei had appeared in the early 40's through the work of Seyfert. He made spectral studies of galaxies with nuclei conspicuously bright with respect to the outer regions. The spectral lines were very wide; in some, wider than

5000 km s^{-1}. These widths interpreted as Doppler shifts meant that gas was being expelled from the nucleus at a high velocity.

Over a decade elapsed since Seyfert's findings before one became aware that the phenomenon might be more general than previously thought (and ignored). Research on galaxies, in general was scarce in the decade following Seyfert's work much more so on their nuclei. Seyfert himself did not pursue this line of study in his lifetime. Interest was aroused following the discovery of radio galaxies and quasars.

Some two decades ago Walker made a detailed kinematic study from high dispersion spectrograms of the nuclei of the Seyfert galaxies NGC 1068 and NGC 4151 (Walker 1968). He found that the profiles of the wide spectral lines could be explained by the motion of ionized gas clouds expanding away from the center of the galaxy while rotating. NGC 4151 was later observed by M.H. Ulrich (1973) who also found that the width of the emission lines were compatible with expanding motions (or perhaps contracting). Ulrich studied several other active galaxies and found in each case cloud structure with radial motions. These clouds may be likened to "hot spots". Were they closer or their nuclei less compact one whould probably pinpoint them as hot spots.

With the advent of sensitive radio telescopes and radio interferometers (WRST, VLA, VLBI MERLIN) as well as high sensitivity optical detectors, a great many galaxies, radio galaxies, quasars, etc. are shown to have active nuclei. At present objects of the kind go under the name "active galactic nuclei", with the acronym AGN. The study of such phenomena is in an extremely productive phase.

II. AGN and MAGN.

Under AGN are grouped, conventionally, QSO's, QSR's, radio galaxies, N galaxies, BL Lac objects, to name a few and finally Seyferts 1 and 2 being at the tail end of the group. It appears however that all galaxies have some kind of activity in their nuclei involving liberation of energy of more or less intensity, and thermal or non-thermal, with radial motions and other non-equilibrium manifestations. The energy involved may be as intense as in a quasar or as mild as in our Galaxy or in M31. The division line between the different active galaxies is becoming fuzzier as observational data increase in quantity and quality. I believe that the dividing line between the AGN and those galaxies not entering the AGN groups is also fuzzy. A classification of activity should therefore be considered only as a working convenience and not taken too hard and fast, the more so since the nuclei show variability and may at times pass on to a neighbouring group; I mention in this context the fact that NGC4151, which until lately was considered a prototype of the Seyfert 1 group has varied its spectrum such that at present it is a member of the Seyfert 2 class!

I propose the acronym MAGN (M for mildly) to designate the groups of all nuclei not energetic enough to be classified as AGN. (Pişmiş 1986).

It is reasonable to expect that the engine responsible for the activity in galactic nuclei is a universal one and that it is the difference in the energetics (also a function of time) of the phenomenon that distinguishes one type of object from others. As of to-day we still lack a convincing explanation for the origin and mechanism of the energy output observed in objects of galactic mass. Evidently the different classes of active nuclei are accessible to different means of observation depending on the dominance of the emission in some specific EM radiation range such as X ray, UV, optical, IR, radio, etc. Herein lies perhaps the distinction between the different types assigned to these objects. By the study in detail of specimens accessible to a scrutiny from all possible frequency ranges and confrontation of the physical properties, of objects at all degrees of activity may we be able to unravel the origin and mechanisms of the energy output of nuclei of galaxies.

Most of the information on nuclear activity in Seyfert 1 and 2 which fall at the lower end of the AGN sequence, are obtained through their optical spectra although, as will be mentioned later, radio continuum is also detected in these galaxies.

III. SEYFERT AND MAGN GALAXIES: FURTHER DETAILS.

The widths of the emission lines both permitted and forbidden, are the most common observational data and these are interpreted by introducing a model for its ionization structure, the morphology and in the best case an inferred kinematic structure. There are further indications confirming the earlier results of the sixties that the nuclei of Seyferts have a cloud structure (maybe "floating" within an amorphous nucleus). These clouds may resemble hot spots and may even be arranged in a coherent manner as ring-like structures. Wilson (1983) states that there are Seyferts with central S-shaped radio structure, adding that these maybe low thrust jets bent and disrupted by pressure of a rotating gas disk. I agree with Wilson that they may be low thrust jets but I disagree with his interpretation. An S-shaped structure also observed in the optical continuum and emission lines can be produced by a rotating and ejecting nucleus as will be shown later.

Overall investigation of nearby Seyferts and MAGN will doubtless contribute to an understanding of the general phenomenon of AGN.

Nuclear activity as a past event (or perhaps continuing) is detected particularly through the velocity fields and the morphology of the emitting regions. NGC 4258 is one example of such objects. Chincarini and Walker (1968) have found indications of velocity outflow from the center. Incidentally, NGC 4258 was considered a Seyfert object in the early days but it was later disqualified! Recently it is suggested that there is a collapsed object at its center. There are strong indications for explosive events in the nucleus of this galaxy.

Courtès and Cruvellier (1961) discovered, in Hα two symmetrical jet-like well defined and somewhat curved features extending from the nucleus of NGC 4258. I shall comment on symmetrical radio continuum features discovered lately which together with the Hα "jets" can be explained by the outflow of gas from the nucleus of this galaxy. It should be interesting to carry out a very detailed study of velocity field and morphology of this object which appears to be a link between AGN and MAGN. (Such a study is presumably being carried out by the Groningen team).

Incidentally, I do not take very seriously the separation of MAGN from AGN. My intention is not to add a new class of objects but to emphasize that outside the established classification there exist galaxies which show activity. This is like a protest that a classification should be flexible and not taken too hard and fast particularly if it lacks some theoretical background.

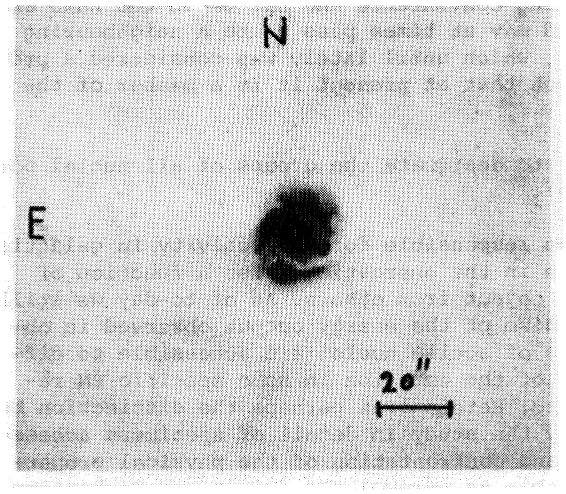

Fig. 1. The nucleus of the SBb galaxy NGC 1097: photograph taken by J.A. Graham with the 4-meter telescope at CTIO on emulsion 127-04 through a GG4945 filter. Exposure time, 2 min. The nuclear spots arranged in a tight spiral form are clearly seen. Kindness of J.A. Graham in providing the photograph is greatly appreciated.

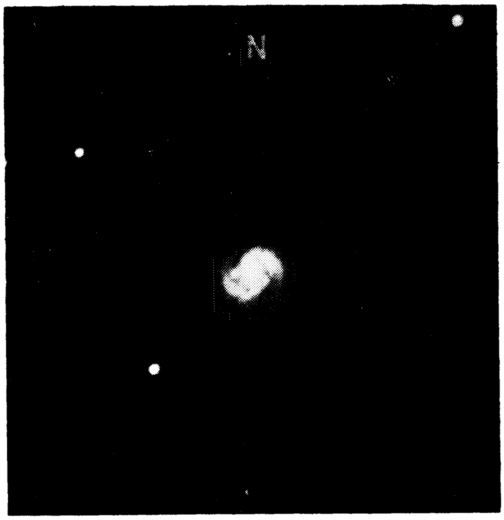

Fig. 2. The SBa galaxy, NGC 4314: a photograph taken on 103aE emulsion at the Cassegrain focus of the 2.1 meter reflector at San Pedro Mártir Observatory (Mexico). The tight nuclear spiral is clearly seen.

IV. TIGHT NUCLEAR SPIRALS IN MAGN GALAXIES.

Particularly interesting objects in the MAGN group are the barred galaxies of types SBa and SBb, like NGC 613, 1097, 4314, which have a bright nucleus at the center of the straight and faint bar. The "grand design" spiral arms start from the ends of this bar. However in the nucleus itself there is a pair of tightly wound spirals with a high degree of symmetry starting from two diametrically opposite regions of the nucleus. The configuration resembles an S. These tight spirals are usually delineated by bright HII knots "hot spots", and are referred to generally as rings; however, in no case are they closed curves but intertwined spirals. Such galaxies were classified as peculiar. But as better resolution images became available the existence of such tight, bright spirals, typically 1-2 kpc across seems to be rather the rule than the exception. Figures 1 and 2 show the nuclear spirals of NGC 1097 and 4314 respectively. High resolution imaging may reveal many more hot spot nuclei and in particular the arrangements of these namely: whether they show a tight spiral or not.

Also detailed velocity determinations of nuclear spirals would be very welcome to further progress in the deciphering phenomena in MAGN.

A very well defined central spiral is shown surrounding the nucleus of NGC 4736, a nearby Sb galaxy. The formulation given above of the origin of tight spirals will be directed to this object which offers the advantage that its nuclear spiral is large enough to be observed in detail. In fact, van der Kruit (1976) has given a detailed velocity field of the tight, central spiral.

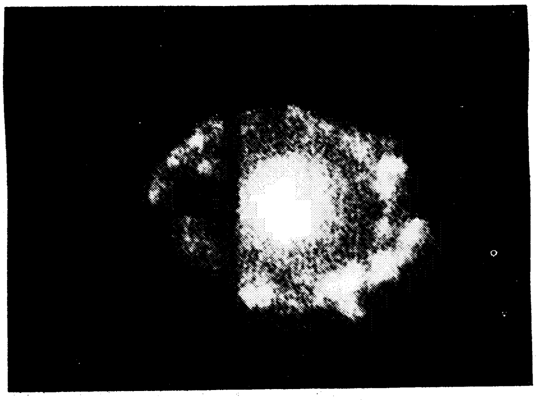

Fig. 3. The central spiral of NGC 4736 from an Hα interference filter (10 Å FWHM) photograph taken with a focal reducer attached to the 2.1 meter reflector at San Pedro Mártir Observatory (Mexico). Note the knotty nuclear spiral. The scale on the original plate is 49" mm^{-1}

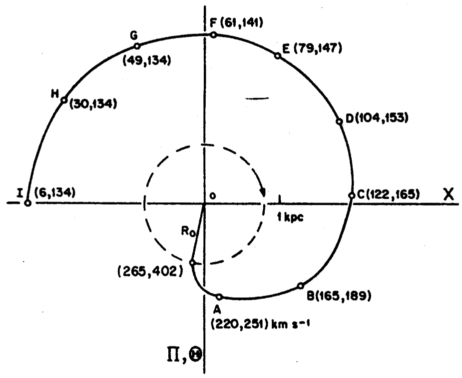

Fig. 4. Locus of matter ejected from a rotating nucleus with mass 3×10^9 $M_\odot$ and radius 0.8 kpc. See following pages.

Fig. 3 is an image of the central spiral of NGC 4736 taken at Hα (10A FWHM) with a focal reducer and a one stage Varo image intensifier attached to the Cassegrain focus of the 2.1 meter reflector at San Pedro Mártir Observatory (Mexico). The structure formed by the HII regions is loosely referred to as a ring, but clearly it is a rather tightly wound spiral similar to the many other "rings" which at better resolution exhibit a spiral form. I believe that it is more difficult for nature to produce rings than spirals, excepting perhaps at supernova explosions.

I shall present now a simple and straightforward way of generating a tight spiral by gas ejected symmetrically from a rotating nucleus. Symmetrical outflow of matter, as we shall discuss later, appears to be a common property of active nuclei.

In this connection, I like to stress once again, following the main line of my previous work, that the collimated outflow of plasma from zones located at the extremities of a diameter in the equatorial plane of the rotating nucleus (bipolar outflow) is presumed to be caused by the existence of a magnetic dipole-like field in the nucleus (Pişmiş 1961, see also Pişmiş and Moreno 1984).

V. FORMALISM: EQUATION OF A TIGHT SPIRAL.

I now present an analytic derivation of the spiral forms engendered by a rotating and ejecting nucleus where the ejection regions are symmetrically situated on the equatorial plane of the nucleus.

In a previous paper Pişmiş and Moreno (1984) have computed numerically the locus of the outflowing matter using the relevant physical parameters of the spiral galaxy NGC 4736 given by van der Kruit (1976). The results obtained have shown excellent agreement with the observed nuclear spiral as regards both the morphology and the kinematics. Comments on the effect of the effect of the ambient matter and the balistically obtained locus is given in Pişmiş and Moreno (1984). In what follows we derive analytically the locus of the ejecta based on the same assumptions as in the earlier paper.

Let V and $\Omega_o R_o$ be the velocities of ejection and rotation, respectively, where Ω_o is the angular velocity at R_o, the radius of the central body. Let the ejection velocity be orthogonal to the rotation velocity. One can now derive the trajectory described by the outflowing plasma. As earlier, we assume the force field of the nucleus to be only gravitation and that of a mass point. In this case the orbits of the ejecta will be conic sections (a two-body problem).

Let R and θ be the polar coordinates with origin at the mass point, V the velocity of ejection and Ω the angular velocity of rotation. R_o is the radiusvector of the ejection point and is assumed to be constant throughout the ejection.

The eccentricity of the orbit of the ejecta is

$$e = \frac{|V|}{\Omega R_o} \tag{1}$$

Let a be the major axis of the conic sections; then, clearly

$$\frac{a}{R_o} = \frac{1}{1-e^2} \tag{2}$$

we also note that the maximum distances reached by the ejecta will be $R_{max}=R_o/1-e)$ and $R_{min} = R_o/1+e)$ respectively. We now seek the locus of a point moving along an ellipse at the same time as the ellipse (or its major axis) describes a circular motion around one of its foci where the mass point is located.

After going through some lengthy algebra we obtain the expression of the locus of the ejecta produced after a period of time t, from the onset of ejection as follows:

$$\theta = \text{arc cos} \frac{1}{e} (1 - \frac{R_o}{R}) - (\frac{a}{R_o})^{3/2} (e|\cos\alpha| + \alpha + \frac{\pi}{2}) \tag{3}$$

where α satisfies the relation

$$\alpha = \text{arc sin} \frac{a-R}{ea} \tag{4}$$

The time t is defined by $t = \frac{\theta}{\Omega}$

The equation of the locus is applicable to any values of R_o, a and e.

VI. APPLICATION TO A CONCRETE CASE.

Observations available to date of tight spirals like that in NGC 4736 show that the presumed ejection must occur with velocity less than that of rotation for otherwise the observed spiral would not have a ring-like, tight form. Thus our model requires that the maximum distanes attained by the ejecta not exceed the maximum observed distance of the spiral structure from the center of attraction. This condition ensures that the orbits of the individual ejecta are ellipses.

A locus is computed from the expression (3) assuming that e=2/3 a = 1.44 kpc with R_o=0,8 kpc. The computed spiral is plotted in Figure 4 with the velocities of rotation and in the radial direction inscribed at several points.

To compare with the tight nuclear spiral of NGC 4736 we have taken two similar loci starting from diametrically opposite points on the nucleus at 0.8 kpc from the center. By inclining the double spiral by 40°, (the inclination of the galaxy NGC 4736), and presenting it only within a central angle of 180° we obtain Figure 5. Note the striking resemblance of this computed and projected image to that of the observed one in Figure 3. This gives support to the assumption that there has been a past activity in the nucleus of NGC 4736, and a ring-like spiral has thus been generated in the manner that we described.

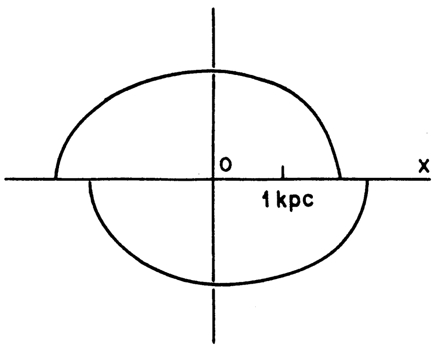

Fig. 5. The double spiral each one as in Fig. 5 placed symmetrically with respect to the nucleus and inclined by 40° to the plane of the sky, and covering Π radians. Note the resemblance of this sketch to the nuclear spiral of NGC 4736 in Figure 4.

Moreover, we can say in general that an S shape configuration which is like a tight spiral, symmetrical around a galactic nucleus, is highly suggestive that gas has been (or is being) ejected symmetrically from the nucleus. In such a picture, as Figure 4 of the plane spiral indicates, radial motions with respect to the nucleus will not be constant along the spiral but will vary with position angle. In NGC 4736 van der Kruit has indeed pointed out that the expansion velocity is position dependent (see also Peterson and Huntley 1980 for NGC 1300 and Jorsäter 1979 for NGC 1512). Detailed velocity field of nuclear features, hot spots, are almost non-existent. However overall values of radial motions have shown that in some galaxies there are inward motions while in others they are outward, expansional, motions. Table 1 shows a list of galaxies to support this statement.

TABLE 1. Radial Motions in Nuclear Regions

Galaxy	Type	Radial Motions	
M31	Sb	Outward	Rubin and Ford (1970)
NGC 253	Sc	Outward	Gottesman et al. (1976), Ulrich 1978
NGC 1068	Sb (Seyfert)	Outward	Walker (1968)
NGC 4151	Sa (Seyfert)	Outward	Walker (1968), Ulrich (1973)
NGC 4736	Sb	Outward	van der Kruit (1976)
NGC 2903	Sc	Inward	Simkin (1975)
NGC 3351	SBb	Inward	Rubin et al. (1975b)
NGC 3672	Sc	Inward	Rubin et al. (1977)
NGC 5383	SBb	Inward	Duval (1977)
NGC 6764	SBs (Seyfert)	Inward	Rubin et al. (1975a)

Application of expression (1) shows that after reaching their apogalacticum the ejecta, if they still hold together (10^7 years), will be returning towards the nucleus on their elliptical orbits. At that stage we will still obtain a spiral formation but it will be curling inwards and the velocities will be of approach towards the center. Of the galaxies listed in the Table 1, 5 show outward while 5 exhibit inward motions. So far as my knowledge goes inward motions are not taken seriously; they are overlooked (in one instance, with respect to the motions in radio jets, it is asked with surprise whether inward motions can be explained). I also want to call attention to the fact that according to our model both inward and outward motions may coexist in the same galaxy; for it is clear that expansion will be shown by ejecta that have not yet attained the apogalacticum of their elliptical orbits while inward motions will be shown by ejecta returning towards the perigalacticum.

As mentioned earlier, the symmetrical collimated outflow in our model is assumed to be due to the funneling effect of magnetic field lines (Pişmiş 1961, Pişmiş and Moreno 1984). Polarization observed in the nuclear spiral of NGC 4314 gives support to the existence of magnetic fields usually along the spiral arms.

It is interesting to mention in this connection results recently obtained with the VLA in the 6 cm continuum emission of the barred galaxies NGC 613, 1300 and 4314 (García-Barreto and Pişmiş, 1986). The bright tightly wound spirals in all three barred spirals show essentially non-thermal continuum with $\alpha \cong 0.9$. Furthermore in NGC 4314 the non-thermal radiation is plane polarized. We are now attempting to look for polarization in several similar nuclei where there is a tight spiral or an S shaped feature. Polarization of non-thermal radiation attests to the existence of mangetic fields; this is consistant with magnetic fields postulated earlier which ensures the bipolar collimation of the outflows.

VII. AN ASSESSMENT OF OBSERVED PROPERTIES ALONG THE SEQUENCE OF ACTIVE GALAXIES.

I shall review some of the salient characteristics of activity in masses of galactic size and which, to my taste and judgment, are of relevance in pointing towards a link between the different "classes" of nuclear activity. In doing so I adopt the premise that the phenomenon underlying activity in galaxies is a universal one, the differences being due to global initial conditions with which a galactic mass gets started and the changes it undergoes during its evolution as an isolated system. I consider here galaxies as they appear at present, irrespective of their evolutionary histories which are still in a speculative stage at best. I believe strongly that the evolutionary paths followed are expected to vary according to the initial physical parameters of a galaxy, and depending to a minor extent on the environment where they originated or perhaps the environment is also a factor in determining the initial parameters.

A. Compactness of the nucleus

QSO's, the most intrinsically luminous objects, are also the most compact, judging from their "characteristic" period of variability. Coming down along the sequence of activity the objects become on the average less compact; the decrease of compactness is accompanied by the gradual prominence of the outlying regions; appendages are very seldom noticeable around quasars, even with the use of modern sensitive detectors, while they are prominent in Seyferts and in MAGN. At the less energetic end of the AGN sequence our information becomes better founded and less speculative. As such objects are relatively nearby and can be studied in detail, it is important to emphasize, based on their morphology, that Seyfert 1 galaxies have more compact nuclei, of smaller size than Seyfert 2 galaxies where the compactness is less and the nucleus larger (Brecher 1977). Further statistics to check the above statements as regards Seyferts would be desirable. A similar trend continues as well along the sequence of "common" spirals: the bulge becomes less compact (and less massive) as one goes along the Hubble sequence from Sa to Sb, Sc and to irregulars. In fact this property is a criterion of the Hubble sequence of spirals.

B. Cloud Structure.

Cloud structure of several Seyfert nuclei is rather well known through the Doppler interpretation of the line profiles of their spectra. In "ordinary" galaxies such as NGC 4736, NGC 1097 and others, clouds (hot spots) are directly observed.

As we go up the scale in the energies of the nuclei there may also exist cloud structure but they become very compact closely packed and not directly observable by optical means. Observations with the VLBI have revealed the small scale structure in the compact cores of QSO's in the form of discrete condensations. How far up the scale towards QSO's can the VLBI pinpoint the different blobs is hard to guess at present. In the less energetic cases like NGC 4736 or NGC 4314 the hot spots are symmetrically arranged with respect to the center from which they were probably ejected. Are hot spots more symmetrically ordered as the outflow energy decreases? It should be interesting to know whether symmetry is in some way correlated with energy involved in nuclear activity.

In summary nuclei may be composed of discrete condensations all along the sequence of galactic masses. This may be considered as a working hypothesis. The space telescope and interferometric arrangements in space of optical telescopes may shed more light on the structural details of nuclei and their hot spots.

C. Radio Lobes and Jets

QSR's (radio loud quasars) and radio galaxies radiate tremendous amounts of energy, as much as 10^{38}W between 10 MHz and 100 MHz. No line radiation is as yet observed and except in very few cases our information is based on the radio continuum. Such radiation is not isotropic but is collimated usually in a bi-polar fashion.

Extended radio sources clearly show structure in the form of "lobes", which are symmetrial with respect to the parent galaxy; the lobes are, usually, of comparable power and size on each side of the central object. In well studied cases a jet may usually be observed (of more or less instensity) starting from the nucleus and extending through the middle of the lobes. Spatially as well as physically the jets are related to the lobes and quite certainly are the agents feeding energy to the lobe. (Bridle and Perley 1984).

Direct information of motions in jets is not available. Superluminal transverse motion of the nuclear condensation in some quasars obtained with the VLBI technique may afford circumstancial evidence that jets may be expanding. Based on indirect arguments it appears that the velocity of expansion in the jet may be from $\sim$300 km s^{-1} up to the speed of light.

One or two sided jet structure may well be a property intrinsic to the galaxy although it may also be due to Doppler favoritism. The latter phenomenon will arise if the inclination of the jet to the line of sight is $\lesssim 60°$ (see for example Begelman, Blandford and Rees, 1984). In some cases the jet may be one sided to a certain distance from the nucleus but from there on both sides of the jet become observable. This may mean that the velocity of the jet is high near the nucleus but diminishes at larger distances such that Doppler "boosting" ceases to be operative farther out.

Less energetic sources have essentially two sided jets. This circumstance also gives support to the Doppler Favoritism interpretation of sidedness since the velocities of expansion in jets are not expected to be high enough for the apparent boosting of the nearer side and the diminution or absence of the receding side.

D. Morphology of Radio Lobes and Jets

I shall not discuss all the different shapes of radio lobes, nor of jets observed and discussed so far in the literature, but consider only the general properties of jet morphology -a rather simplistic overall outlook which may apply to lobes as well.

Two sided bi-symmetry of jets means that such jets would reasonably superpose if one side is rotated by pi radians around the central object. This is not a rotational symmetry.

The straightness of a considerable number of jets and lobes is indeed striking, it may be due to the following circumstances:

If jets (and lobes) are ejected from a rotating source the direction of outflow should be along or close to the rotation axis.

It is highly probable that the source rotates since it is difficult to accept that the compact core of a stellar system will not have angular momentum. Although elliptical galaxies where jets and lobes are observed rotate slowly, if at all, the ejecting core is most likely a collapsed object. It is inconceivable, at least to me, that such an object would not rotate.

If we accept that the central object rotates, then the overall straightness of the lobes and jets requires that the direction of ejection be coincident or very close to the rotation axis. In this picture the slight wiggles are then produced when the ejection axis makes a very small angle with the rotation axis. (At present this process is called precession!). Furthermore the outflow may be variable in velocity, in brightness and/or intermittent, causing thus more irregularities in jets.

The expression (3) enables one to compute the locus of the ejecta, i.e. of the jets, with variable velocity of ejection, offering thus one more freedom to simulate the observed morphology of jets. The rotation velocity will remain reasonably constant unless mass loss from the nucleus is appreciable which is not probable given the short lifetime (≈ 10 years) of the jets and lobes. The loss of angular momentum will be faster if the outflow is along the magnetic lines of force. Our interpretation requires that irregularities also be symmetrical. Any other irregularity left over may be caused by the ambient matter.

A gravitational interpretation of jet morphology assumes implicitly that the outgoing plasma has dragged along sufficient mass. This situation may well be true such that gravitational forces may compete with magnetic forces evidently present in the jets.

If the ejection axis is not along, or close, to the rotation axis -if rotation does exist- then the magnetic forces along the plasma beam must be extremely large (or the mass extremely small) to give a straight shape to the lobe or jet (rather to their projection on the plane of sky). For one-sided jets the arguments given above for the straightness, wiggles or irregularities apply equally well.

The next important type of structure is the so-called head-tail jet. Some show symmetry which Ekers calls "mirror symmetry". It appears that the relative motion of the otherwise symmetrical and straight jets through an intergalactic medium may explain the bow shaped or head-tail structures. Ekers also calls attention to two sided jets which do show mirror symmetry. Less energetic cases tendency of jets within or very close to the plane of symmetry NGC 4258 is a case in point.

VIII. LOBE AND JET PHENOMENA RELATED TO OVERALL GALACTIC PARAMETERS.

Excepting very few cases, all lobes and jets observed so far, occur in quasars and elliptical as well as in SO's, we may venture to say, in massive ellipticals. For instance, the apparently "dwarf" ellipticals, companions to M31 are not observed to have lobes or jets. It may be argued that the massive M31 may have stripped them of their gas (I am not a partisan of such an interpretation). I think that it will be interesting to search for radio radiation in faint and hence less massive ellipticals now that modern powerful radio telescopes have increased detection limits (Sadler 1986). There is however the question of their mass: how well can we determine the mass of an elliptical at present?

Search for jets in Seyfert galaxies has shown that the jets appear in an S-shape configuration in quite a few. More often these are two radio continuum "lumps" staddling (to use the currently favored expression) the central continuum source (Wilson 1981). In general the distance of the radio lumps from the nucleus of Seyferts is from a few hundred parsecs to a few kiloparsecs. NGC 4736 discussed earlier in this report, though not a Seyfert, also shows a 3-blob radio continuum structure. The two outer ones fall at two symmetrical zones on the nuclear spiral (van der Kruit 1971).

Optical detection of jets has fallen behind the radio observations either because they are intrinsically faint in the optical region or, if they are prominent, to detect them optically in spiral galaxies may not be straightforward given the confusion of such features with the bright background. In any case a systematic survey for optical counterparts of radio jets in all types of galaxies particularly in early spirals, (where one expects to find such structures) should be rewarding. This kind of study may provide some clues to the possible evolutionary history of lobes and jets.

The question may be asked: Do radio jets considered as high energy particle beams -with magnetic fields- evolve into less energetic optical jets? In which class of objects can we observe both radio and their associated optical jets if the latter do exist? Intuitively one would expect the radio jet phenomenon to precede the optical jet. Is this true? To tackle such questions the overall evolutionary history of galaxies must also be invoked.

IX. CENTRAL CONDENSATION AND FREQUENCY OF JETS.

In their review article Bridle and Perley (1984) give a list of 125 known radio jets in their Table 1. A second list gives 73 "possible" jets.

Even though the main list is not up-to-date, general statistical trends can be noted. Of the 125 well observed jets, 40 are in galaxies -mostly ellipticals- and the rest are QSR's (which may also be ellipticals).

We designate by $S^{5}{}_{core}$ and $S^{1.4}{}_{total}$ the fluxes at 5 MHz and 1.4 MHz of the core and of the total galaxy respectively and the ratio of $S^{5}{}_{core}$ to $S^{1.4}{}_{total}$ by f_c.

BP (1984) state that "among extended 3CR[2] QSR's, the jet detection rate increases with the relative prominence of f_c, "apparently regardless of redshift". Extrapolating from this result we may expect Power of core/Power of total to be a possible (or perhaps relevant) criterion for the detectability of jets (projection effects are not taken into account). Thus an energetic core favors the formation of jets. Concentration of energy and mass at the center of the galaxy, on the other hand, may well be related to the total mass although such correlation is probably not very tight. To give support to this statement, I shall draw a parallel between the relative importance of the nuclear mass versus total mass of radio galaxies and a similar relative importance of nuclear mass to total mass in the spirals that fall within the Hubble sequence.

To that effect I shall recall briefly the main conclusions reached in a recent review of mine (Pişmiş 1985). I have argued that the Hubble sequence, an empirical morphology sequence, which has not been interpreted so far appears to be basically function of two independent initial integral parameters; perhaps the most important parameter is the total mass with which a galaxy got started as a dynamical entity (incidentally, the mass determined today may be the initial mass with a high degree of certainty, hence the importance of mass determination of galaxies). The second independent parameter may be the central condensation of mass (in general the mass distribution within the galaxy), or any other parameter, for instance angular momentum and its distribution; magnetic field and its configuration and others of more local importance. These remaining parameters are not independent of one another and are probably derivable from the two main initial parameters. It is reasonable to expect that any two parameters can be taken as the independent ones and the others may be derived from them provided we know the dynamical state of the system.

X. TOTAL MASS AND ITS CONCENTRATION.

A) Brosche (1973) has shown statistically that the maximum rotation velocity of a spiral occurs closer to the center in an early type galaxy; the relative distance at which the maximum velocity occurs decreases from Sa on to Sb, and Sc types. This implies that the concentration of mass (and hence reasonably of the energy too) decreases along the Hubble sequence. This relation is valid in a statistical context.

B) On the other hand the total mass of spirals from Sa down to Sc and irregulars is shown to decrease (Pişmiş and Maupomé 1978). As a consequence of these two relations,mass concentration along the Hubble sequence accompanies the decrease of the total mass. Thus one expects that at least in the spiral sequence, the mass concentration will be a decreasing function of total galactic mass.

If the relation of mass concentration to total mass holds also for elliptical galaxies where radio lobes are produced, we could expect that it would be the massive ellipticals that possess radio-lobes; observations do indeed support this.

An indication that the masses of active galaxies diminish from QSO's down to

Seyferts and all the way down to field galaxies is implicit in a conclusion to which Osterbrock has reached although he takes great care to emphasize the uncertainties involved, (IAU Symp. 97 p. 369); his Table 1 shows that the number densities decrease from field galaxies ($\sim 10^{-1}$Mpc^{-3}) down to quasars ($\sim 10^{-9}$Mpc^{-3}). The tendency of decrease in space number density is consistent with the existence of a mass function in objects of galactic size just as it is for objects of stellar size. Quasars, the brightest and possibly the most massive assemblies are thus at the lowest end of the distribution function similar to the stellar case where the number density of massive stars is the smallest in a given volume.

XI. MAGNETIC FIELD.

So far I have not mentioned magnetic fields and their relevance in AGNs. I believe magnetic forces are very important in space but rather unpopular among astronomers. In the past I have attempted to explain the origin of spiral structure by appealing to magnetic force lines to funnel the plasma. In particular, lately we have renewed the emphasis on the role magnetic lines of force to account for the bi-polar structure of nuclear spirals. (Pişmiş and Moreno 1984).

The assumption of a magnetic field appears to be a sure way of alienating the referees and causing their rejection for publication. But in the case of jets there is no doubt that magnetic fields do play an important role; observations of radio continua have shown that linear polarization up to 40% is common in radio jets; with local values going up to 50%. Jets with low polarization (<5%) are exceptional (Bridle and Perley, 1984). High degrees of polarization imply ordered magnetic fields. As yet information on magnetic fields is not too abundant (only 40 jets reasonably well observed).

The magnetic field can be discussed in two of its projected components, namely in B and B_ (parallel and perpendicular to the jet respectively). Most one sided jets (which are related to energetic nuclei) show B while most two-sided jets have either $B_{\perp}$ or $B_{\perp}$ - B , In less powerful sources -presumably the two sided- the field changes from B to B_ in the first 10% of the jets; less powerful jets may also show predominently $B_{\perp}$. A correlation of magnetic configuration with the energy of the nuclear source appears to exist. However more observations of polarization of jets with differing morphologies, MAGN's included, will be needed before definite patterns emerge.

XII. EPILOGUE.

The present overview, a personal approach to the vast problem of non-equilibrium processes in the nuclei of galaxies, is intended to stress that aside from the necessity of detailed research on spectacular phenomena in different "classes" of active nuclei it evidently is a healthy practice to look also into the problem of activity in the large, in a unified manner. Fundamental properties of matter and energy in the universe are expected to underlie the manifestations observed so far, however varied they may present themselves. What are, then, those fundamental properties?

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DISCUSSION

AGUILAR: ¿Sugiere que la estructura espiral en gran escala se puede explicar como material eyectado del núcleo galáctico?

PIŞMIŞ: Para explicar el "grand design" de las galaxias espirales al que usted se refiere he propuesto en 1963 una modificación al modelo que describí aquí. Los brazos exteriores pueden formarse aún sin eyección. El plasma sale de manera bipolar de un esferoide aplanado (¿o una barra? a medida que contrae éste último paulatinamente. De esta manera he mostrado (Bol. Obs. Tonantzintla y Tacubaya, 1963) que los brazos formados simulan muy bien los de M31. En la parte central domina la eyección del material mientras que en las partes exteriores es despreciable.

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