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JET MODELS AND OBSERVED JETS IN A SAMPLE OF SUPERLUMINAL ACTIVE GALACTIC NUCLEI

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RESUMEN

Se presenta una muestra de 33 fuentes extragalácticas con radio jets y movimientos superlumínicos, que incluye diferentes tipos de núcleos activos de galaxias: 22 cuasares, 6 blazares, 1 galaxia Seyfert, 3 radiogalaxias y 1 radio fuente de campo. Los parámetros observados de las fuentes y sus jets (velocidad del jet, corrimiento al rojo, flujos y tamaños) se han introducido en las predicciones de los modelos de jet relativista para derivar los siguientes parámetros teóricos: la luminosidad de la fuente, la temperatura de brillo máxima, la frecuencia característica de la radiación sincrotrónica y el campo magnético. Los parámetros globales de los jets y sus fuentes centrales se comparan, para estudiar la relación entre las propiedades cinemáticas y radiativas de los jets. Los resultados importantes son: (1) La luminosidad observada (L_{ob}) y la luminosidad predicha por los modelos de jet relativista (L_{th}) están correlacionadas. (2) Las temperaturas de brillo máximas T_b están en el rango 10^{11} - 10^{13} K. (4) El factor de Lorentz, γ_{jet}, y las luminosidades teórica y observada, son comparadas y se discute evidencia de dos clases de jets relativistas, aquellos producidos por alta y baja luminosidad. Para fuentes de alta luminosidad, una posible correlación entre el factor de Lorentz y la luminosidad, implica que las fuentes más luminosas producen los jets más potentes. (5) El campo magnético, la frecuencia característica y la luminosidad en radio se encontraron correlacionadas con las luminosidades de IRAS y rayos-X. Estos resultados son indicativos de una posible relación entre los mecanismos de emisión que están produciendo las propiedades en radio de los radio jets y su emisión en lejano IR y rayos-X.

ABSTRACT

We present a sample of 33 extragalactic sources with radio jets and superluminal motions, that includes different types of AGNs: 22 quasars, 6 blazars, 1 Seyfert galaxy, 3 radiogalaxies, and 1 empty field radio source. The observed parameters of the sources and their jets (jet velocity, redshift, fluxes and jet sizes) have been used as input to the relativistic jet model predictions to derive the following model parameters: the source luminosity, the maximum brightness temperature, the characteristic frequency of the synchrotron radiation and the magnetic field. The global parameters of the jets and central sources have been compared, to study the relations between the kinematic and radiative properties of the jets. The important results are: (1) The observed luminosities (L_{ob}) and the relativistic jet model luminosities (L_{th}) follow a correlation. (2) The maximum brightness temperatures T_b predicted by the models are in the range 10^{11} - 10^{13} K. (3) The Lorentz factor, γ_{jet}, and the luminosities are compared and evidence is discussed for two types of relativistic jets, those produced by high and low luminosities. For the high luminosity sources, a possible correlation between the Lorentz factor and the luminosity, implies that more luminous sources produce more powerful jets. (4) The magnetic field, the characteristic frequency and the radio luminosity were found to be correlated with the IRAS and X-ray luminosities. These results are indicative of a possible relation between the emission mechanisms that are producing the radio properties of the jet sources and their FIR and X-ray emission.

Key words: **RADIO JETS – ACTIVE GALACTIC NUCLEI**

I. INTRODUCTION

Relativistic jet models (eg., Blandford, McKee and Rees 1977; Marscher 1978; Blandford and Königl 1979; Königl 1981; Ghisellini, Maraschi and Treves 1985) have been proposed to describe the observed properties of variable extragalactic radio sources associated with the nuclei of galaxies, quasars and blazars. In this work we have used the jet models, assuming that they are correct, and used the observational data available in the literature for a large sample of jets in AGNs as input parameters to the models. As a model test, we compared the observational parameters of several jets and the predictions of the relativistic jet models, i.e., using the observational parameters of the jets as input to the models, we deduced the parameters predicted by the models for each source jet. The model+observed parameters for the jets were then compared in an attempt to predict trends in a large sample of superluminal extragalactic sources with observed jets that includes various types of AGNs: quasars, blazars, radiogalaxies and Seyfert galaxies. Although the models are idealizations of the emission of radio jets, and are based on assumptions and simplifications, it is necessary to test them with a large sample of AGNs. Previous work has focused on the model application to very few individual sources. In the last few years several groups have worked on the small and large structure of the radio jets, and a crucial parameter has been derived for the jets: **the velocity of the jet**, by means of proper motion determinations. These observations have made possible the application and test of the relativistic jet models.

In this work we study the global characteristics of a sample of 33 AGNs with radio jets that have the necessary parameters for model testing. Understanding the physics of extragalactic jets, needs testing of the available models, and the only way is to use observational data. Our motivation to choose the relativistic jet models is mainly because the physics involved is rather beautiful. The results of this paper are summarized in §V, where we present evidence that favour the models as plausible. Under the light of this models we found indications of a close link between the central source and the jet. The contents of the remaining sections are the following: In §II, the equations of the relativistic jet model assumed and used throughout, are presented, together with the references to the theoretical work. In §III, the sample of AGNs studied, the observed and derived jet parameters for each source in the sample, and the references to the observational work, are presented. The results are presented and discussed in §IV. Obviously, future work needs to be done since more observations will be available and new problems will arise. One of these, is the relation of the radio jets with the extended conical narrow line emitting regions of AGNs.

II. THE MODEL

Extragalactic jets and proposed models are described in an excellent review paper by Begelman, Blandford and Rees (1984). The relativistic jet models started with the proposal by Blandford and Rees (1974) of relativistic beams in radio sources in order to explain the continuous supply of energy from the nucleus of a radio galaxy to its outer lobes. The relativistic jet model was later developed by Blandford and Königl (1979) in a fundamental paper. The testing of this model requires the acquisition of observational data for a reasonable number of sources and thus several years of observations by many groups were needed.

Our aim in this paper is to test the relativistic jet models using available observational data of AGN sources. The required parameters of each source are obtained and used in the expressions given by Blandford and Königl (1979), hereafter BK. In what follows we present a brief description of the BK model which includes the kinematics, the jet properties and the radiative properties of superluminal sources. We have transformed the equations given by BK to obtain expressions in terms of observable parameters of the sources.

a) *Kinematics*

In order to explain superluminal motion, Rees (1966) proposed that extragalactic jets move with relativistic velocities and assumed that one of the jets is projected almost parallel to the line of sight. The geometrical effect on the apparent velocity of a source moving almost in the observed direction is given by

$$\beta_{ob} = \frac{\beta_j \sin\theta}{1-\beta_j \cos\theta} \ , \qquad (1)$$

where β_j is the real jet velocity in units of c, and θ is the angle between the emitting source and the line of sight. From (1) it is easy to see that for the counter-jet: $\beta_j \cos\theta < 0$, so that the velocity of the counter-jet is never superluminal, while the jet velocity can be superluminal.

For a real source β_j and θ are unknown, and one needs to use maximum critical values of θ_c, obtained taking the derivative of equation (1). The critical angle, i.e., maximum apparent velocity, is given by

$$\theta_c = arccot\ \beta_{ob} \ . \qquad (2)$$

With this assumption, the jet parameters related to the velocity are modified in such a way that the Lorentz factor and the Doppler factor can be expressed in terms of the observed velocity and θ_c by the following expression:

$$\gamma_j \approx \delta_j \approx \csc\theta_c \approx \beta_{ob} \ , \qquad (3)$$

where γ_j is the Lorentz factor $\gamma_j = (1 - \beta_j^2)^{-1/2}$ and δ_j is the Doppler factor $\delta_j = \gamma_j^{-1}\,(1-\beta_j \cos\theta)^{-1}$.

These expressions are applicable to sources moving with any velocity in different directions of the observer, but the apparent velocity is superluminal only if the velocity is relativistic and the jet points almost in the direction of the observer.

b) *Jet Properties*

The steady jet model proposed by BK is based on the following assumptions:

(i). A narrow conical jet of small semiangle ϕ whose axis makes an angle θ with the direction of the observer, the observed opening angle is $\phi_{ob} = \phi \csc\theta$.

(ii). The jets are supersonic and free so that the external pressure does not confine the material in the direction perpendicular to the jet axis. From this, the jet opening semiangle is given approximately by the inverse of the Lorentz factor, i.e., $\phi \leq \gamma_{jet}^{-1}$.

(iii). The relativistic electrons responsible of the synchrotron emission are continuously accelerated along the jet. The usual energy distribution function is assumed: $N(E) = KE^{-(2\alpha+1)}$ where α is the spectral index ($F_\nu \propto \nu^\alpha$) and $E_{min} < E < E_{max}$ (or $N(\gamma_e) = K\gamma_e^{-(2\alpha+1)}$ where $\gamma_{min} < \gamma_e < \gamma_{max}$). Here N is the relativistic electron density, $E = \gamma_e m_e c^2$, where m_e is the electron rest mass and K is a constant (electron number density). Furthermore, the electron energy density $u_e = K\Lambda m_e c^2$, with $\Lambda = \ln(\gamma_{max}/\gamma_{min})$, is insensitive to the exact values of γ_{min} and γ_{max}, and we assume equipartition with the magnetic energy density, i.e., $u_e = k_e \Lambda B^2/8\pi$, where k_e is a constant ≤ 1.

(iv). The the jet velocity, β_{jet}, is almost constant over an extended region.

c) *Radiative Properties*

From these assumptions and the observable kinematic consequences described previously, the radiative properties of superluminal sources were derived by BK: source luminosity, maximum brightness temperature, characteristic frequency of the synchrotron spectrum and magnetic field. In this paper we used their results to derive the expressions for these parameters in terms of the observable quantities: the redshift z, the luminosity distance to the source D_l, the observed opening semiangle of the jet ϕ_{ob}, the apparent velocity of the jet β_{ob}, and the observed flux density S_{ob} where the continuum distribution is almost flat. To derive the radiative properties we adopted $\Lambda = \ln(\gamma_{max}/\gamma_{min}) \approx 3$ and $k_e = 0.5$, as suggested by BK. The simplified expressions presented in this paper, based on those of BK are presented below.

1. *Luminosity*. The theoretical luminosity of the source, i.e., the total power carried by the jet in the form of relativistic electrons and magnetic field is given by equation (29) of BK. It can be expressed also in the following form (in units of 10^{44} erg/s)

$$L_{th} \approx [0.105 S_{ob}^{-1}(1+z)\beta_{ob}^{1/6} D_l^{-2} \phi_{ob}^{-1}]^{-12/17}\Delta\,, \qquad (4)$$

where $\Delta = \ln(R_{max}/R_{min})$ (the maximum and minimum length of the jet are R_{max} and R_{min}, respectively), S_{ob} is in Jy and D_l is in Gpc. This equation predicts the dependence of the monochromatic luminosity of a superluminal jet source on the jet parameters (β_{ob}, ϕ_{ob} and Δ).

2. *Maximum Brightness Temperature*. The effect of the jet on the brightness temperature of a superluminal source can be studied using the maximum value of the brightness temperature given by equation (27) of BK. In terms of the observable jet parameters it can be expressed by:

$$T_b \approx 2.88 \times 10^{11}[(1+z)^{-18}\beta_{ob}^{101/6}\phi_{ob}^{-11/6} S_{ob} D_l^2]^{1/17}\,, \qquad (5)$$

where T_b is in K, S_{ob} is in Jy and D_l is in Gpc.

3. *Characteristic Frequency of Synchrotron Spectrum*. The characteristic frequency of the synchrotron spectrum, i.e., the frequency at maximum of the spectral energy distribution (where the transition between optically thick and optically thin emission of the syncrotron source occurs, $\tau = 1$) is given by equation (30) of BK, it can be obtained (in units of 10^9 Hz):

$$\nu_{b_9} \approx 36.77[(1+z)^{-12} S_{ob}^{-5}\beta_{ob}^{32} D_l^{10}\phi_{ob}^{12}]^{1/17}\,, \qquad (6)$$

where S_{ob} is in Jy and D_l is in Gpc.

4. *Magnetic Field*. The magnetic field at a distance of 1pc from the central source is given by equation (23) of BK; it can be written as:

$$B_1 \approx 0.06[(1+z)^6 S_{ob}^{-6} \beta_{ob} D_l^{-12} \phi_{ob}^{11}]^{-1/17} \ , \qquad (7)$$

where B_1 is in Gauss, S_{ob} is in Jy and D_l is in Gpc.

III. APPLICATION TO OBSERVED SUPERLUMINAL RADIO SOURCES

In order to compare the BK models for observed AGNs, sources with observed jets are required;

TABLE 1

PARAMETERS OF SUPERLUMINAL JETS SOURCES

Source (1)	ID (2)	z (3)	D_l (Gpc) (4)	References[a] z (5)	References[a] D_l (6)
0106+013 4C 01.02	QSO	2.107	24.1	49	50
0108+388 OC 314	EF	1*	8.7	1	2
0212+735	BL	2.367	28.5	3	4
0235+164 AO	BL	0.851	7.1	5	6
0333+321 NRAO 140	QSO	1.258	11.8	7	7
0415+379 3C 111	RG	0.049	0.3	8	8
0430+052 3C 120	GS	0.033	0.2	9,10	9,10,11
0711+356 OI 318	QSO	1.62	16.6	12	13
0723+679 3C 179	QSO	0.846	7.0	14	15
0735+178	BL	0.424	3.1	14	16
0742+318 4C 31.30	QSO	0.462	3.4	17	15
0836+710 S5	QSO	2.16	25.0	18	19
0850+581 4C 58.17	QSO	1.322	12.6	20	18
0851+202 OJ 287	BL	0.306	2.1	14	21
0906+430 3C 216	QSO	0.669	5.2	22	23
0923+392 4C 39.25	QSO	0.699	5.5	24	25
1039+811 S5	QSO	1.26	11.8	26	27
1040+123 3C 245	QSO	1.029	9.1	22	28
1137+660 3C 263	QSO	0.652	5.1	29	30
1150+812	QSO	1.25	11.7	26	27
1226+023 3C 273	QSO	0.158	1.0	31	31
1253-055 3C 279	QSO	0.538	4.0	32	33
1641+399 3C 345	QSO	0.595	4.6	34	35
1642+690 4C 69.21	QSO	0.751	6.1	36	37
1721+343 4C 34.47	QSO	0.206	1.4	17	15
1845+797 3C 390.3	RG	0.0569	0.4	38	39
1901+319 3C 395	QSO	0.635	4.9	40	41
1928+738 4C 73.18	QSO	0.302	2.1	18	42,37
1951+498	QSO	0.466	3.4	36	43
2007+777 S5	BL	0.342	2.4	18	44
2200+420 BL Lac	BL	0.07	0.4	45	21
2230+114 CTA 102	QSO	1.037	9.1	32	28
2251+158 3C 454.3	QSO	0.859	7.2	46	47,48

* Indicates z assumed.

a. References: 1) Pauliny-Toth and Kellermann 1972; 2) Readhead *et al.* 1984; 3) Argue and Sullivan 1980; 4) Lawrence *et al.* 1986; 5) Argue *et al.* 1973; 6) Cohen *et al.* 1986; 7) Kristian and Sandage 1970; 8) Longair and Gunn 1975; 9) Kinman 1967; 10) Burbidge 1967; 11) Sargen 1967; 12) Blake 1970; 13) Burbidge and Strittmatter 1972; 14) Veron 1971; 15) Wills and Wills 1976; 16) Wampler 1968; 17) Grueff and Vigotti 1972; 18) Kuhr 1980; 19) Eckart *et al.* 1982; 20) Kuhr 1977; 21) Miller *et al.* 1978; 22) Ryle and Sandage 1964; 23) Smith and Spinrad 1980; 24) Wills 1967; 25) Lynds *et al.* 1966; 26) Kuhr *et al.* 1981; 27) Eckart *et al.* 1986; 28) Schmidt 1965; 29) Sandage *et al.* 1965; 30) Phillips 1977; 31) Greenstein and Schmidt 1964; 32) Sandage and Wyndham 1980; 33) Burbidge and Rosenberg 1965; 34) Goldsmith and Kinman 1965; 35) Burbidge 1965; 36) Cohen *et al.* 1977; 37) Lawrence *et al.* 1986; 38) Wyndham 1966; 39) Sandage 1966b; 40) Veron, 1972; 41) Phillips and Mutel 1980; 42) Bierman *et al.* 1981; 43) Walsh *et al.* 1984; 44) Worrall and Wilkes 1990; 45) Macleod and Andrew 1968; 46) Sandage 1966a; 47) Lynds 1967; 48) Schmidt 1968; 49. Bolton *et al.* 1965; 50) Burbidge 1966.

which limits the sample of known AGNs to a small number. Furthermore, the comparison requires sources with measurements of proper motions, i.e., superluminal motions. So this paper is restricted to AGNs with jets and superluminal components, which unfortunately limits the sample even further.

From the available data in the literature we selected 33 extragalactic sources with jets. In this group the following AGNs are included: 22 quasars, 6 blazars, 1 Seyfert galaxy, 3 radiogalaxies, and 1 empty field radio source.

The relativistic jet model application to real sources is not simple, as several parameters required by the models are difficult to derive. The superluminal velocity, β_{ob}, can only be obtained from VLBI multitemporal observations and thus the number of extragalactic sources with jets is reduced considerably. In the sample considered in this paper we encountered the following problems:

a). The redshifts for quasars, Seyfert galaxies and radiogalaxies are well known, but for blazars they are more uncertain. An additional assumption was necessary: that the redshift to the central source is that of the ambient galaxy. Since this assumption might not be valid, it may just be an approximation to the real velocity. The redshift corrections and distance determinations are thus more uncertain for some blazars than for the other sources in the sample.

b). The minimum and maximum sizes of the jets, crucial for the parameter $\Delta = \ln(R_{max}/R_{min})$, require observations for each source both on small scales (e.g., VLBI) and on large scales (e.g., VLA).

c). The models require the value of the flux density when the continuum distribution is almost flat. But, for several sources the simultaneous and multifrequency continuum data required were not available. For the sake of uniformity in the radio data we have assumed that the continuum becomes flat above 10 GHz (in few cases we adopted 5 GHz), instead of using the largest observed frequency.

d). The cone angle of the jet can either be estimated from VLBI data or from the assumption that the jet is free and thus $\phi_{ob} \leq 1$.

The sample of superluminal sources studied in this paper is presented in Table 1. The source name is given in col. 1, col. 2 is the source identification as quasar (QSO), radiogalaxy (RG), BL Lac objects (BL), Seyfert galaxy (SG) and empty field radio source (EF); col. 3 is the redshift; col. 4 is the distance (assuming H_0 = 50 km s^{-1} Mpc^{-1} and q_0 = 0.05). The references are in col. 5 and 6 which is corresponding to the source identification and redshift.

The observed parameters of the jet and the central source are presented in Table 2. Col. 1 is the source name. Col. 2 is the observed velocity in units of c, β_{ob}, with the error below, between parentheses. If the source has multiple components the observed velocity of each component is given together with the name of the component; an average value of β_{ob} was used and its value is given at the end of the individual values. Col. 3 contains the observed proper motions when available, the error is below between parentheses. Col. 4 is the flux density in Jy observed at 10 GHz. Col. 5 is the calculated monochromatic luminosity at 10 GHz using the distances given in Table 1. Col. 6 is the IRAS 60 μm flux densities in mJy. Col. 7 is the calculated 60 μm monochromatic FIR luminosity; the 60 μm band was used only because more sources of our sample had detections. Col. 8 contains the parameter $\Delta = \ln(R_{max}/R_{min})$ where R_{max} and R_{min} are the maximum and minimum jet sizes obtained from the published large and small scale radio maps found in the literature. Col. 9 is the Einstein Observatory 1 keV flux density in μJy. Col. 10 is the calculated 1 keV monochromatic luminosity. The references to each parameter are indicated in cols. (11) to (16).

In this paper, instead of deriving the cone angle of the jet from VLBI data, we assumed that the jet is free, so that $\phi_{ob} \approx 1$ was substituted in equations (4), (5), (6) and (7). The dependence on ϕ_{ob} is weak, and the available data proved that this assumption did not affect our results. Using the data for each individual source in our sample of superluminal sources we applied the relativistic jet model expressions of BK to derive for the sample the resulting model parameters presented in Table 3: col. 1 is the source name, col. 2 is the theoretical luminosity, L_{th}, from equation (4), col. 3 is the maximum brightness temperature, T_b, from equation (5), col. 4 is the characteristic frequency of the synchrotron spectral energy distribution, ν_b, from equation (6), and col. 5 is the magnetic field at 1 pc, B_1, from equation (7).

IV. DISCUSSION

Using the observational and theoretical parameters for a sample of 33 superluminal AGNs that include quasars, blazars, radio galaxies and Seyfert galaxies, we decided to look for global characteristics, trends or correlations that may give some insight of the physics that may be useful for future models. The only parameters that can be compared directly are the observational and theoretical luminosities and, as we show below, they are correlated giving an indication that the model predictions may be correct. The rest of the model parameters are difficult to derive observationally and a direct comparison is not possible at present. In our work we have attempted to link in some way the kinematical parameters of the jets with the radiative parameters

TABLE 2

JET PARAMETERS AND SOURCE OBSERVED PARAMETERS

Source (1)	Comp.	Observed velocity β_{obs} (2)	μ^a $(\frac{mas}{yr})$ (3)	S_b^b (Jy) (4)	L_{ob}^b $(10^{44}\frac{erg}{seg})$ (5)	$S_{60\mu m}$ (mJy) (6)	L_{IRAS} $(10^{44}\frac{erg}{seg})$ (7)	Δ^c (8)	S_{1KeV} (μJy) (9)	L $(10^{44}\frac{erg}{seg})$ (10)	References[g] $\beta_{ob,\mu}$ (11)	S_b (12)	$S_{60\mu}$ (13)	R_{min} (14)	R_{max} (15)	S_{1KeV} (16)
0106+013		24.5 (6.13)	0.20 (0.05)	3.1[d]	107.45[d]	209	7244.2	...	0.04	67.05	42	42	4	...	...	44
0108+388		1.65 (1.24)	$\frac{0.08}{3.42}$ $(\frac{0.06}{3.42})$	...	...	...	...	...	...	...	1	...	...	1	...	...
0212+735	C_2	12.0 (6.67)	0.09 (0.05)	2.3	223.02	<64	<3102.9	...	...	...	2	3	4	5	...	...
0235+164		49.5	1-1.5	7.4	44.30	249[f]	745.3	...	0.55	79.62	6	3	4	6	...	43
0333+321	B	12.4 (0.83)	0.15 (0.01)	2.9	48.10	<97	<804.4	2.5	2.32	930.77	7	3	8	9	10	43
0415+379		>3	3.3/5	5.0	0.05	321	1.7	9.4	...	...	11	11	12	11	11	...
0430+052	A	4.2	1.35													
	B	7.8	2.53													
	C	7.6	2.47													
	D	8.2	2.66													
	E	7.8	2.54													
		7.12[e]	...	16.8	0.08	1310	3.2	4.3	...	...	13	3	14	15	10	...
0711+356		−5.5 (0.85)	$\frac{-0.13}{2.42}$ $(\frac{0.02}{2.42})$	...	...	28	462.6	...	...	...	1	8	...	...	1	...
0723+679		8.5 (1.21)	0.14 (0.02)	0.3	1.77	...	...	8.7	...	...	16	3	17	17	...	...
0735+178		14.9 (1.35)	0.44 (0.04)	2.7	2.99	306.7[f]	169.6	...	0.33	8.82	6,47	3	4	...	43	...
0742+343		<5.5	<0.15	0.9[d]	0.61[d]	112	75.7	9.2	...	...	18	...	8	18	18	...

TABLE 2 (CONTINUED)

Source (1)	Comp.	Observed velocity β_{obs} (2)	μ^a ($\frac{mas}{yr}$) (3)	S_b^b (Jy) (4)	L_{ob}^b ($10^{44}\frac{erg}{seg}$) (5)	$S_{60\mu m}$ (mJy) (6)	L_{IRAS} ($10^{44}\frac{erg}{seg}$) (7)	Δ^c (8)	S1KeV (μJy) (9)	L ($10^{44}\frac{erg}{seg}$) (10)	References[g] $\beta_{ob,\mu}$ (11)	S_b (12)	$S_{60\mu}$ (13)	R_{min} (14)	R_{max} (15)	S_{1KeV} (16)
0836+710	C4	29.7	0.25													
		(16.63)	(0.14)													
	C3	15.4	0.13													
		(9.48)	(0.08)													
	C2	<7.1	<0.01													
		...	(0.05)													
		22.6[e]	...	2.5	186.11	...	...	...	...	...	2	5	...	2	...	...
		(13.06)	...													
0850+581		10.3	0.12	1.2	22.74	...	...	5	...	...	19	3	...	19	19	...
		(1.63)	(0.019)													
0851+202	K1	5.1	0.20													
		(0.76)	(0.03)													
	K2	6.8	0.27													
		(0.76)	(0.03)													
		6.0[e]	...	3.5	1.84	926.5[f]	243.3	...	...	...	20	3	4	20	20	...
		(0.76)	...													
0906+430		5.4	0.11	1.4	4.60	<140	<229.9	5.9	...	...	21	3	4	17	17	...
		(0.98)	(0.02)													
0923+392		9.3	0.18	11.9	43.54	< 27	< 49.4	7.4	0.39	34.50	22	3	8	17	17	43
		(0.52)	(0.01)													
1039+811		≤ 8.2	≤0.1	...	...	...	...	...	...	...	23	...	...	...	...	...
1040+123		7.8	0.11	1.0	9.75	...	...	7.8	0.10	23.59	24	3	...	24	25	43
		(3.55)	(0.05)													
1137+660		3.0	0.06	0.6	1.85	< 64	< 98.7	8.3	0.22	16.40	26	3	8	26	27	44
		(1.0)	(0.02)													
1150+812	C2	9.8	0.12	1.1	17.93	...	...	...	...	...	5	3	...	5	...	...
		(3.27)	(0.04)													

TABLE 2 (CONTINUED)

Source (1)	Comp.	Observed velocity β_{obs} (2)	μ^a $(\frac{mas}{yr})$ (3)	S_b^b (Jy) (4)	L_{ob}^b $(10^{44}\frac{erg}{seg})$ (5)	$S_{60\mu m}$ (mJy) (6)	L_{IRAS} $(10^{44}\frac{erg}{seg})$ (7)	Δ^c (8)	S_{1KeV} (μJy) (9)	L $(10^{44}\frac{erg}{seg})$ (10)	References[g] $\beta_{ob,\mu}$ (11)	S_b (12)	$S_{60\mu}$ (13)	R_{min} (14)	R_{max} (15)	S_{1KeV} (16)
1226+023	C3	11.0	0.79													
		(0.42)	(0.03)													
	C4	13.8	0.99													
		(0.42)	(0.03)													
	C5	16.6	1.2													
		(0.42)	(0.03)													
	C7a	10.6	0.76													
		(0.70)	(0.05)													
		13.0[e]	...	60	7.42	1805	111.6	8.4	12.05	36.04	28,26	3	8	17	17	43
		(0.49)	...													
1253-055	?	20.8	0.5													
		(4.16)	(0.1)													
	B2	7.0	0.11													
		(1.27)	(0.02)													
		13.9[e]	...	20.3	39.33	...	...	7	0.61	28.58	29,30	3	...	31	10	43
		(2.72)	...													
1641+399	C2	18.9	0.42													
		(2.25)	(0.05)													
	C3	19.3	0.43													
		(2.24)	(0.05)													
	C4	7.7	0.17													
		(2.26)	(0.05)													
	C5	4.9	0.11													
		(0.89)	(0.02)													
	C6	9.4	0.21													
		(2.24)	(0.05)													
		12.0[e]	...	16.3	40.23	766	945.2	8.2	11	656.42	28,32	3	8	17	17	43
		(1.98)	...													
1642+690		18.6	0.34	3.1	13.55	...	...	7.8	...	...	33	3	...	33	33	...
		(2.19)	(0.04)													

TABLE 2 (CONTINUED)

Source	Comp.	Observed velocity β_{obs}	μ^a $(\frac{mas}{yr})$	S_b^b (Jy)	L_{ob}^b $(10^{44}\frac{erg}{seg})$	$S_{60\mu m}$ (mJy)	L_{IRAS} $(10^{44}\frac{erg}{seg})$	Δ^c	S_{1KeV} (μJy)	L $(10^{44}\frac{erg}{seg})$	References[g] $\beta_{ob,\mu}$	S_b	$S_{60\mu}$	R_{min}	R_{max}	S_{1KeV}
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1721+343	M_B	2.7	0.15													
		(0.72)	(0.04)													
	M_C	5.1	0.29													
		(0.35)	(0.02)													
		3.9[e]	...	0.8	0.18	...	...	10	1.99	10.54	34	3	...	18	18	43
		(0.54)														
1845+797		3.8	0.74	0.4[d]	0.003	250	1.8	9.8	...	...	35	...	12	35	35	...
1901+319		30.4	0.64	1.7	4.91	...	...	5.8	...	...	36	3	...	36	17	...
		(4.75)	(0.1)													
1928+738	C2	12.8	0.51													
		(2.51)	(0.10)													
	C3	14.3	0.57													
		(1.25)	(0.05)													
	C4	10.0	0.40													
		(1.25)	(0.05)													
	C6	10.0	0.40													
		(2.5)	(0.10)													
	C7	15.0	0.60													
		(2.5)	(0.10)													
	C9	7.8	0.31													
		(13.84)	(0.55)													
		11.7[e]	...	3	1.53	...	...	0.5	...	...	2,46	3	...	5	17	...
		(3.98)	...													
1951+498		2.6	0.07	0.2	0.28	...	...	...	...	...	37	3	...	...	...	...
2007+777		7.26	0.26	1.55	1.05	<38	<12.8	...	0.36	5.88	5	23	...	4	5	43
		(2.23)	(0.08)													
2200+420		4.8	0.76	2.4	0.05	458[f]	5.1	9.4	3.18	1.73	38	3	4	17	17	43
		(0.19)	(0.03)													

TABLE 2 (CONTINUED)

Source (1)	Comp.	Observed velocity β_{obs} (2)	μ^a $(\frac{mas}{yr})$ (3)	S_b^b (Jy) (4)	L_{ob}^b $(10^{44}\frac{erg}{seg})$ (5)	$S_{60\mu m}$ (mJy) (6)	L_{IRAS} $(10^{44}\frac{erg}{seg})$ (7)	Δ^c (8)	S_{1KeV} (μJy) (9)	L $(10^{44}\frac{erg}{seg})$ (10)	References[g] $\beta_{ob,\mu}$ (11)	S_b (12)	$S_{60\mu}$ (13)	R_{min} (14)	R_{max} (15)	S_{1KeV} (16)
2230+114		46.3 (10.68)	0.65 (0.15)	2.6	25.89	192	955.5	...	0.14	33.69	39	3	4	39	...	44
2251+158	4	21.4	0.35	27.4	167.98	179	548.7	6	0.98	145.27	40	3	8	41	17	43

a. A ratio indicates the proper motion measured over the observed period. b. S_b and L_{ob} at 10 GHz. c. $\Delta = ln(R_{max}/R_{min})$ d. Data at 5 GHz. e. Average value for multiple component source. f. Average value for flux densities. g. References: 1) Readhead *et al.* 1984; 2) Witzel *et al.* 1988; 3) Impey, 1987; 4) Impey and Neugebauer 1988; 5) Eckart *et al.* 1986; 6) Baath, 1984; 7) Marscher and Broderick 1985; 8) Neugebauer *et al.* 1986; 9) Marscher *et al.* 1987; 10) Pilbratt *et al.* 1987; 11) Gotz *et al.* 1987; 12) Golombek *et al.* 1988; 13) Walker 1986; 14) IRAS Point Sources Catalog 1985; 15) Walker *et al.* 1984; 16) Porcas 1981; 17) Porcas 1986; 18) Barthel *et al.* 1985; 19) Barthel *et al.* 1986; 20) Gabuzda *et al.* 1989; 21) Pearson *et al.* 1986b; 22) Schalinski *et al.* 1988; 23) Schalinski *et al.* 1987; 24) Hough and Readhead 1987; 25) Hough, 1986; 26) Zensus *et al.* 1987; 27) Pooley and Henbest 1974; 28) Cohen and Unwin, 1984; 29) Cotton *et al.* 1979; 30) Unwin 1987; 31) Unwin *et al.* 1989; 32) Tang *et al.* 1989; 33) Pearson *et al.* 1986a; 34) Barthel *et al.* 1989; 35) Alef *et al.* 1988; 36) Waak *et al.* 1985; 37) Zensus and Porcas 1987; 38) Mutel and Phillips 1984; 39) Baath 1987; 40) Pauliny-Toth 1987; 41) Pauliny-Toth *et al.* 1984; 42) Wehrle *et al.* 1990. 43) Worral and Wilkes 1990; 44) Worral *et al.* 1987; 45) Wehrle and Cohen 1989; 46) Johnston *et al.* 1987; 47) Zhang and Baath 1991.

TABLE 3

DERIVED PARAMETERS FROM THE RELATIVISTIC JET MODEL

Source	L_{th}	T_b	ν	B_1	Source	L_{th}	T_b	ν	B_1
	(10^{44} erg s^{-1})	(10^{12}°K)	(10^{12}Hz)	(Gauss)		(10^{44} erg s^{-1})	(10^{12}°K)	(10^{12}Hz)	(Gauss)
(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
0106+013	...	3.2	31.717	0.47	1040+123	41220	1.35	3.908	0.20
0108+388	...	...	...	...	1137+660	17471	0.59	0.618	0.13
0212+735	...	1.45	9.422	0.49	1150+812	...	1.57	6.294	0.23
0235+168	...	10.13	64.813	0.31	1226+023	49471	3.98	1.243	0.21
0333+321	35496	2.09	7.388	0.32	1253-055	11028	3.48	3.587	0.34
0415+379	22.31	0.78	0.086	0.04	1641+399	13351	2.90	3.070	0.35
0430+052	12.37	1.90	0.245	0.05	1642+690	52177	3.80	12.615	0.22
0711+356	...	...	...	...	1721+343	50.33	0.93	0.543	0.06
0723+679	14360	1.47	5.997	0.11	1845+797	5.68	0.87	0.333	0.02
0735+178	...	3.48	6.724	0.14	1901+319	18461	6.26	35.018	0.15
0742+343	14764	1.20	1.475	0.11	1928+738	9.44	2.90	3.504	0.12
0836+73	...	2.88	29.306	0.45	1951+498	...	0.52	0.559	0.07
0850+581	41864	1.62	6.883	0.25	2007+777	...	1.71	1.835	0.11
0851+202	...	1.50	0.950	0.13	2200+420	18.61	1.20	0.303	0.04
0906+430	21506	1.10	1.463	0.16	2230+114	...	8.24	83.056	0.25
0923+392	12206	2.11	2.214	0.35	2251+158	2220	4.75	9.145	0.52
1039+811	...	...	...	...					

of the central sources, and also the radio emission with the emission at other frequencies (FIR and X-ray).

Note that for all the correlations discussed below we have taken the harmonic mean of the direct and inverse regressions following the precepts of Deeming (1968), in order to obtain unbiased regressions.

a) *Observed Luminosity vs. Theoretical Luminosity*

In Figure 1 we have compared the observed luminosities at 10 GHz (L_{ob}), i.e., the radio luminosity of the core source, and the relativistic jet model luminosities (L_{th}), i.e., the total power carried by the jet in the form of relativistic electrons and magnetic field. We found that these luminosities are indeed correlated: $L_{th} = 2.0 \times 10^{17} L_{ob}^{0.65}$, with correlation coefficient $r^2 = 0.85$. This result strongly favours BK models and supports the interpretation that superluminal sources are the byproduct of relativistic jets.

The source 1928+738 is an exception as the observed luminosity lies significantly below the line; this source has 8 components (6 of them superluminal), the observed flux corresponds to most of these core components and thus, it is difficult to separate into individual fluxes. Due to this, we decided to exclude this source from the calculation.

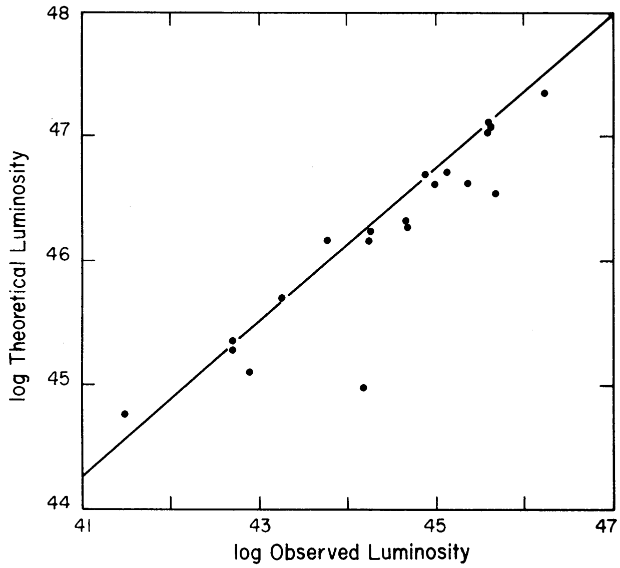

Fig. 1. Correlation between the relativistic jet model and observed luminosities at 10 GHz. The line represents the predicted correlation: $L_{th} = 2 \times 10^{17} L_{ob}^{0.65}$.

b) *Redshift*

In Figure 2 we plot the redshift of the sources and the observed velocity β_{ob}; as can be seen we found no dependence on distance for the observed

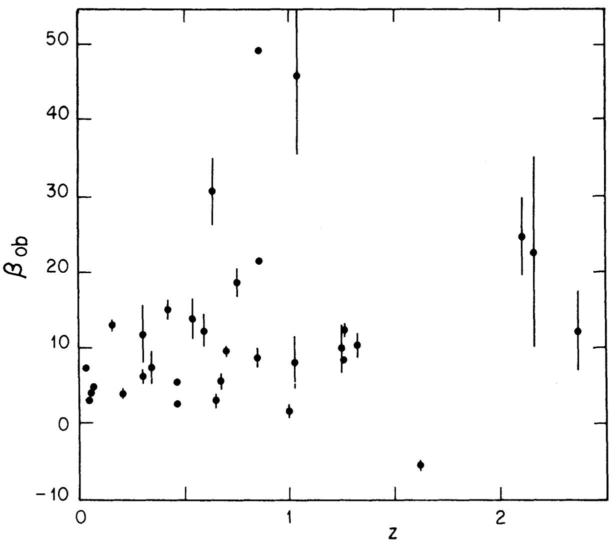

Fig. 2. Comparison of the source redshift z and the observed velocity β_{ob} showing no indication of correlation or evolutionary effects.

velocity, and thus, no evidence for evolutionary effects. As mentioned above the velocity was calculated from the observed proper motions, using $H_0 = 50$ km s^{-1} Mpc^{-1} and $q_0 = 0.05$. We note that a larger dispersion in velocity is found for $z > 0.6$.

We also compared the redshift of the sources with other model parameters: L_{th}, T_b, ν_b, B_1, and found no strong relation of these parameters on distance to the sources, even though the redshift interval of the sources is 0.03 – 2.4.

c) *Ratio of Maximum and Minimum Jet Sizes*

The parameter Δ given by the ratio of the maximum and minimum length of the jet ($\Delta = \ln R_{max}/R_{min}$), which relates the small scale structure and the large scale structure of the jets, was compared with the model parameters: L_{th}, T_b, ν_b, B_1. We found no strong dependence of L_{th} on Δ, as expected (c.f. Eq. (4)). Also, there is no dependence on Δ of the remaining model parameters.

d) *Jet Velocity*

The expressions (4), (5), (6) and (7) of BK depend both on pure jet parameters (β_{ob}, ϕ_{ob}) and pure central source parameters (flux and distance). Looking for the strongest dependence on the jet parameters, we compared the velocity of the jet β_{ob} with the model parameters: L_{th}, T_b, ν_b, B_1, and found, no strong dependence on the jet velocity for the magnetic field and the luminosity. We think that this result causes a problem to the model since the magnetic field and the luminosity produced by the synchrotron central source, crucial radiative parameters, apparently do not depend strongly on the jet kinematics.

For the brightness temperature and the characteristic frequency we found that an apparent correlation exists, which means that these parameters are strongly dependent on the jet velocity. This may be a direct reflection of equations (5) and (6) for objects with a comparatively narrow range of S_{ob}, ϕ_{ob} and D_l, rather than a true correlation. If in equation (5) the dominant parameter is the observed velocity, then the higher the jet velocity the higher the predicted temperature. This is interpreted as follows: for jets pointing towards the observer, those with high β_{ob}, the contribution to T_b comes from the central source and the jet components and so T_b is higher; while for jets pointing perpendicular to the observer, those with low β_{ob}, the contribution to T_b comes mainly from the central source and thus is lower. For the characteristic frequency (c.f. equation (6)), the strong dependence on β_{ob} can be interpreted as follows: the more compact sources, i.e., those with higher ν_b, correspond to higher jet velocities. The higher the frequency the higher T_b will be. Both parameters are derived from the relativistic jet models, but the value of ν_b can be obtained from multiple frequency simultaneous observations and compared with the theoretical values.

e) *Brightness Temperature*

The maximum brightness temperatures predicted by the models for the sources studied in this paper (cf. Table 3, col. 3) are between 10^{11} and 10^{13} K, which means that all the sources have temperatures close to the *Compton catastrophe* limiting value near 10^{12} K (eg., Kellermann and Pauliny-Toth 1969). As other authors have shown from variability studies (eg., Condon and Dennison 1978) the temperatures derived can be as high as 10^{15} K. It seems that the relativistic jet models predict much lower temperatures and may solve a long standing problem on the physics of these sources.

f) *Lorentz Factor vs. Luminosity*

The Lorentz factor for each source in our sample was calculated using the approximation $\gamma_{jet} \approx \beta_{ob}$ given in §II above. The values of β_{ob} are given in col. 2 of Table 2.

(i). Theoretical Luminosity. In Figure 3a we plot L_{th} vs. γ_{jet}, which shows no clear indication of a relation. One can see that low luminosity sources have a small range of Lorentz factors, $1 < \gamma_{jet} < 12$ for $L_{th} \leq 10^{46}$ erg/s, while for $L_{th} > 10^{46}$ erg/s (all sources are quasars) the Lorentz factors cover a wider range $2 < \gamma_{jet} < 23$.

(ii). Observed Radio Luminosity. In Figure

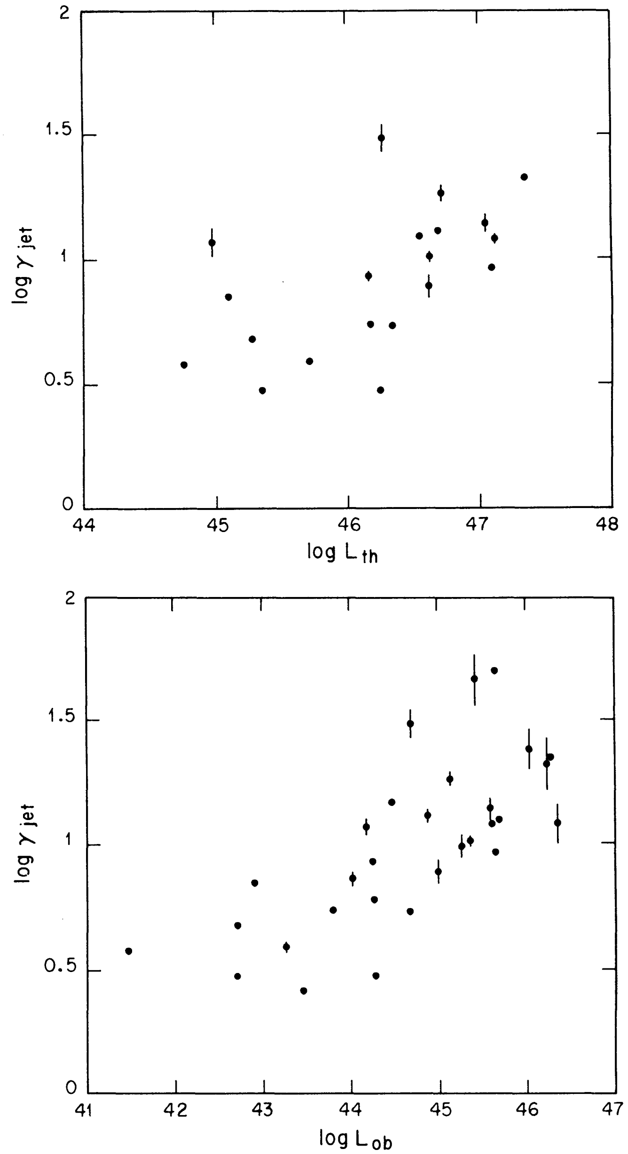

Fig. 3. Comparison between the Lorentz factor γ_{jet} and the 10 GHz theoretical (Fig. 3a) and observed (Fig. 3b) luminosities. The line in Fig. 3b represents the correlation $\gamma_{jet} = 6.27 \times 10^{-13} L_{ob}^{0.3}$.

3b we plot the observed radio luminosity at 10 GHz vs. γ_{jet}. One can see that low luminosity sources have a small range of Lorentz factors, $1 < \gamma_{jet} < 12$ for $L_{ob} \leq 10^{44}$ erg/s, while for $L > 10^{44}$ erg/s (all sources are quasars) the Lorentz factors cover a wider range $2 < \gamma_{jet} < 23$. This may indicate that there are two families of relativistic jets. We found a weak correlation ($r^2 = 0.45$) in the sense that lower luminosity sources have smaller values of γ_{jet} while larger γ_{jet} corresponds to more luminous sources, i.e., $\gamma_{jet} = 6.27 \times 10^{-13} L_{ob}^{0.3}$. Although, this trend needs confirmation, if true it indicates that more luminous sources produce more powerful jets. Furthermore, it links the emission processes with the kinematics of the jets.

As is known Seyfert galaxies are weak radio sources and few radio jets have been observed. Our result, indicates that jets in Seyfert galaxies are much weaker than those in other AGNs due to a less powerful central source.

g) *Comparison with Observations from IRAS Satellite and Einstein Observatory*

a). The observed velocity β_{ob} was compared with the luminosities at 1 keV, L_X, and 60 μm, L_{IRAS}, and no correlations were apparent.

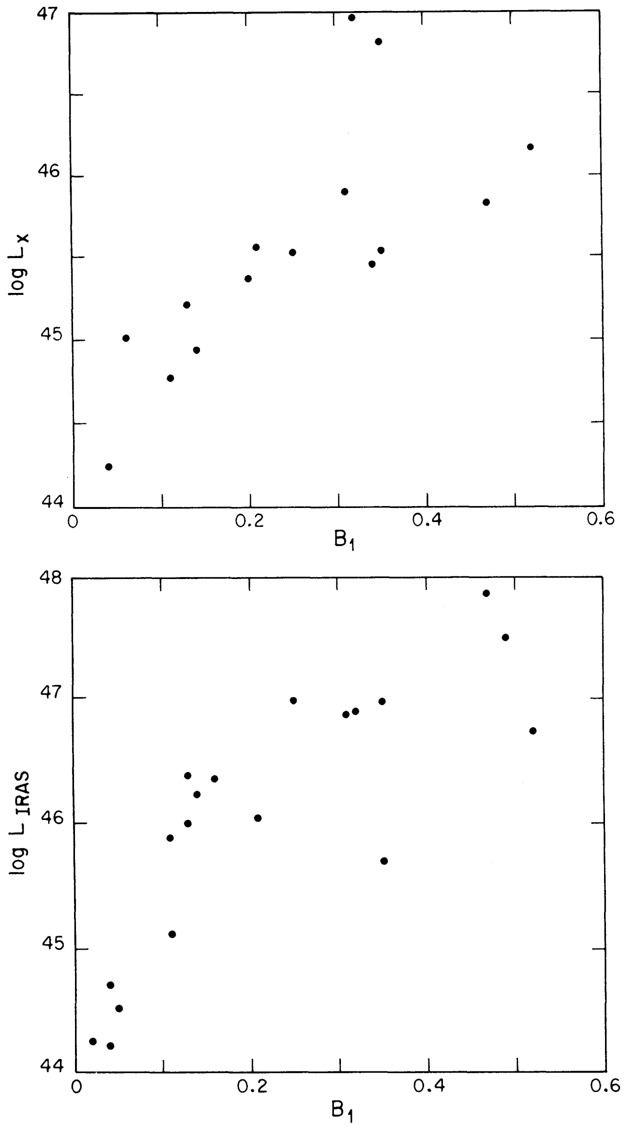

Fig. 4. Comparison between the magnetic field at 1 pc of the central source and the observed X-ray (Fig. 4a) and IRAS (Fig. 4b) luminosities.

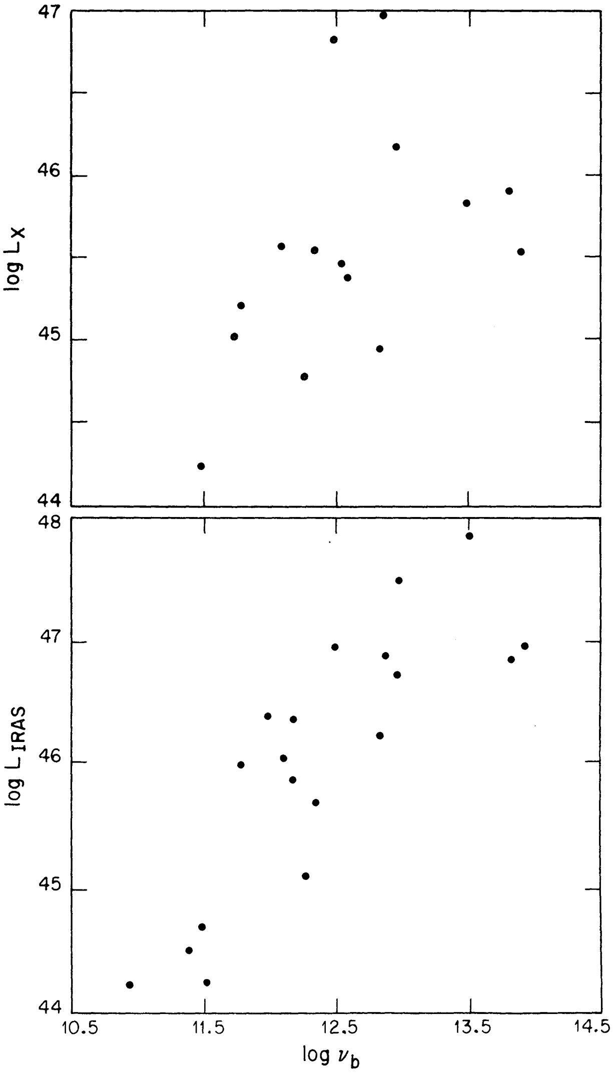

Fig. 5. Comparison between the characteristic frequency of the synchrotron source and the observed X-ray (Fig. 5a) and IRAS (Fig. 5b) luminosities.

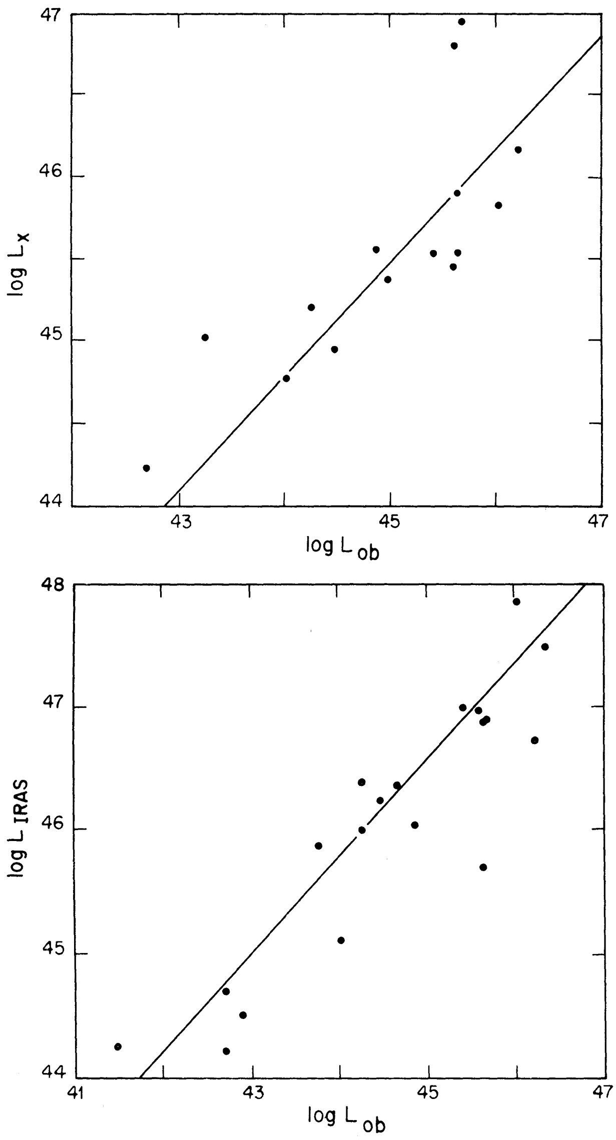

Fig. 6. Comparison between the observed radio luminosity at 10 GHz (L_{ob}) and the observed X-ray (Fig. 6a) and IRAS (Fig. 6b) luminosities. The lines represent the correlations: $L_X = 5 \times 10^{13} L_{ob}^{0.71}$ and $L_{IRAS} = 1 \times 10^{11} L_{ob}^{0.79}$, in Fig. 6a and Fig. 6b, respectively.

b). The maximum brightness temperature T_b was compared with the above luminosities and no correlations were found.

c). The magnetic field at 1 pc of the central source, B_1, when compared to the above luminosities shows an indication of possible correlations in the sense that, stronger magnetic fields correspond to larger X-ray and IRAS observed luminosities, as is shown in Figures 4a and 4b, but the data is scarce and need confirmation.

d). The characteristic frequency ν_b when compared with the above luminosities also shows an indication of possible correlation, in the sense that larger characteristic frequencies correspond to larger X-ray and IRAS luminosities, as is indicated in Figures 5a and 5b, and also needs confirmation when more data become available.

e). The radio luminosity at 10 GHz, L_{ob}, when compared with the other bands' luminosities shows the correlations: $L_X = 5.0 \times 10^{13} L_{ob}^{0.71}$, with $r^2 = 0.83$, and $L_{IRAS} = 1.07 \times 10^{11} L_{ob}^{0.79}$, with $r^2 = 0.83$. These results are shown in Figures 6a and 6b. We find these results rather interesting since they indicate a possible relation between the emission mechanisms that are producing the radio properties of the superluminal jet sources and their

TABLE 4

SUMMARY OF RELATIONS AND CORRELATION COEFFICIENTS FOR AGN SUPERLUMINAL JET SOURCES

$L_{th} = 2.0 \times 10^{17} L_{ob}^{0.65}$	$(r^2 = 0.85)$
$\gamma_{jet} = 6.27 \times 10^{-13} L_{ob}^{0.3}$	$(r^2 = 0.46)$
$L_X = 5.0 \times 10^{13} L_{ob}^{0.71}$	$(r^2 = 0.83)$
$L_{IRAS} = 1.07 \times 10^{11} L_{ob}^{0.79}$	$(r^2 = 0.83)$

X-ray and FIR observed luminosities. The available data are scarce and thus these results have to be confirmed in future work.

The overall spectral continuum distributions produced by relativistic jets are obtained by Königl (1981) and Ghisellini *et al.* (1985) and a direct comparison of these model predictions to the observed energy distributions requires simultaneous multiple frequency data for each source. This comparison should be done in future work for a number of superluminal jet sources in order to explore the possible geometries presented by these authors. Another aspect of jets that should be studied is their relation to the narrow line extended emitting regions that have recently been detected in a number of AGNs (eg., Meurs and Fosbury 1989). The data presented in this paper contain observational material that could be used to test alternative models of jets.

A summary of the correlations found in this paper and discussed in this section is presented in Table 4.

V. CONCLUSIONS

The relativistic jet models of Blandford and Königl (1979) have been applied to extragalactic sources with observed jets. The models require sources with measurements of proper motions, i.e., superluminal motions, and so we selected sources with jets and superluminal components. This restriction unfortunately limits the sample of known AGNs to a small number. From the available data in the literature we selected 33 extragalactic sources with jets; in this group the following AGNs are included: 22 quasars, 6 blazars, 1 Seyfert galaxy, 3 radiogalaxies, and 1 empty field radio source. We looked for global characteristics, trends or correlations in the AGN sample that may give some insight of the physics that may be useful for future models. The results are the following:

1. The only parameters that can be compared directly are the observed luminosities at 10 GHz (L_{ob}), the radio luminosity of the core source, and the relativistic jet model luminosities (L_{th}), the total power carried by the jet in the form of relativistic electrons and magnetic field. The comparison showed the following correlation: $L_{th} = 2.0 \times 10^{17} L_{ob}^{0.65}$. The sample of 33 AGNs covers different types of objects with the common properties of jets and superluminal motions, the correlation found strongly favours the relativistic jet model and the interpretation that superluminal motions are the byproduct of relativistic jets for a wide range of activity classes.
2. By comparing the redshift of the sources, for the sample in the interval (0.03, 2.4), and the observed velocity β_{ob}, calculated from the observed proper motions, we found no dependence on distance and no evidence for evolutionary effects. The comparison of z with the model parameters (L_{th}, T_b, ν_b, B_1) showed no indication of strong dependence on distance.
3. The maximum brightness temperatures predicted by the models are in the range $10^{11}-10^{13}$ K. All the sources have temperatures close to the inverse *Compton catastrophe* values (e.g., Kellermann and Pauliny-Toth 1969); indeed most sources have $T_b < 10^{13}$ K. As other authors have shown from variability studies (e.g., Condon and Dennison 1978) the temperatures derived are as high as 10^{15} K. It seems that the relativistic jet models predict lower temperatures and may solve a long standing problem on the physics of this sources.
4. The brightness temperature and the characteristic frequency have a strong dependence on the jet velocity, in the sense that the higher the velocity the higher the predicted temperature and frequency. This may indicate, that for jets pointing towards the observer, higher β_{ob}, the contribution to T_b arises from the central source and the jet components, while for sources with lower jet velocity, pointing perpendicular to the observer, the contribution to T_b arises mainly from the central source. In the case of the frequency, a possible interpretation is that the more compact sources those of higher ν_b present higher velocities.
5. The Lorentz factor, γ_{jet}, for each source in our sample was calculated using the approximation $\gamma_{jet} \approx \beta_{ob}$, and is compared with the theoretical and observed luminosities.

(i). Theoretical Luminosity. Low luminosity sources have a small range of Lorentz factors, $1 < \gamma_{jet} < 12$ for $L_{th} \leq 10^{46}$ erg/s, while for $L_{th} > 10^{46}$ erg/s (all sources are quasars) the Lorentz factors cover a wider range $2 < \gamma_{jet} < 23$.

(ii). Observed Radio Luminosity. Low luminosity sources have a small range of Lorentz factors, $1 < \gamma_{jet} < 12$ for $L_{ob} \leq 10^{44}$ erg/s, while for $L > 10^{44}$ erg/s (all sources are quasars) the Lorentz

factors cover a wider range $2 < \gamma_{jet} < 23$. This may indicate that there are possibly two families of relativistic jets. We notice that most high luminosity sources seem to follow a trend, in the sense that lower luminosity sources have smaller γ_{jet}, while larger γ_{jet} corresponds to more luminous sources, i.e., $\gamma_{jet} = 6.27 \times 10^{-13} L_{ob}^{0.3}$ ($r^2 = 0.45$). Although, this trend needs confirmation, this tentative result suggests that more luminous sources produce more powerful jets, in such a way that the jets in Seyfert galaxies are much weaker than in other AGNs due to a less powerful central source. Furthermore, it links the emission processes with the kinematics of the jets.

6. The observed velocity and the maximum brightness temperature as compared to the luminosities at 1 keV, L_X, and 60 μm, L_{IRAS}, show no correlations.

7. The magnetic field when compared to the above luminosities shows an indication of a possible correlation in the sense that, stronger magnetic fields correspond to larger X-ray and IRAS observed luminosities.

8. The characteristic frequency when compared with the above luminosities also shows an indication of a possible correlation, in the sense that larger characteristic frequencies correspond to larger X-ray and IRAS luminosities.

9. The radio luminosity at 10 GHz, L_{ob}, when compared with the other bands' luminosities (L_X and L_{IRAS}) shows a correlation. The last results indicate a possible relation between the emission mechanisms that are producing the radio properties of the superluminal jet sources and their X-ray and FIR observed luminosities.

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