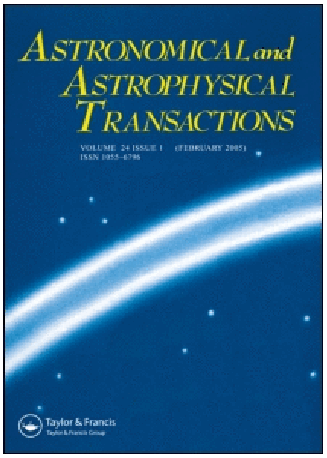

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THE EFFECTIVE ROTATION MOMENTUM AS A CHARACTERISTIC OF THE HUBBLE'S TYPE OF GALAXIES

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The dependence of the momentum on mass was derived from observational data for 127 galaxies. For each of the Hubble's types an effective specific momentum $S\alpha M^k$ was found which does not depend on the mass for the given type thus parameterizing it. The exponent k changes slightly and is close to $\frac{5}{3}$ for E and S_0 and to $\frac{7}{4}$ for S galaxies. The density (radius) dependence on mass is in correspondence with Faber–Jackson relation for E galaxies and with Tully–Fisher rélation for spirals. The statistical dependence of the momentum and radius (density) on mass can be mutually related to the slight dependence of the mass-luminosity ratio on mass or to slight deviations from Faber–Jackson's law for E & S_0 galaxies. The great scatter for E & S_0 galaxies may evidence for sample heterogeneity due to observational selection: the effective momentum can be derived only for the later E types.

KEY WORDS Galaxies, angular momentum, Hubble's sequence

1 INTRODUCTION. INITIAL DATA

Quite successful research into the physical parameters of galaxies corresponding to Hubble's classification (see reviews by Djorgovski, 1991, 1992) refers separately to elliptical and spiral galaxies while the morphological idea underlying the classification allows to search for a general characteristic of a morphological type as a quantity connected with rotation though, as known, it presents certain difficulties. Attention towards rotation of galaxies and its role in their formation never slackened since the works of Crampin and Hoyle, Peebles, Doroshkevich.

Simple considerations favoring the dependence of the momentum on mass $S \propto M^{5/3}$ and confirmations of this dependence have been long circulating in astronomical literature beginning with the works by Ozernoy (1967) and Heidmann (see the following discussion and references: Mineva (1988), Carrasco *et al.* (1982), Fall (1983), and also Zasov and Ozernoy (1966), I. & L. Genkins (1973), Nordsieck

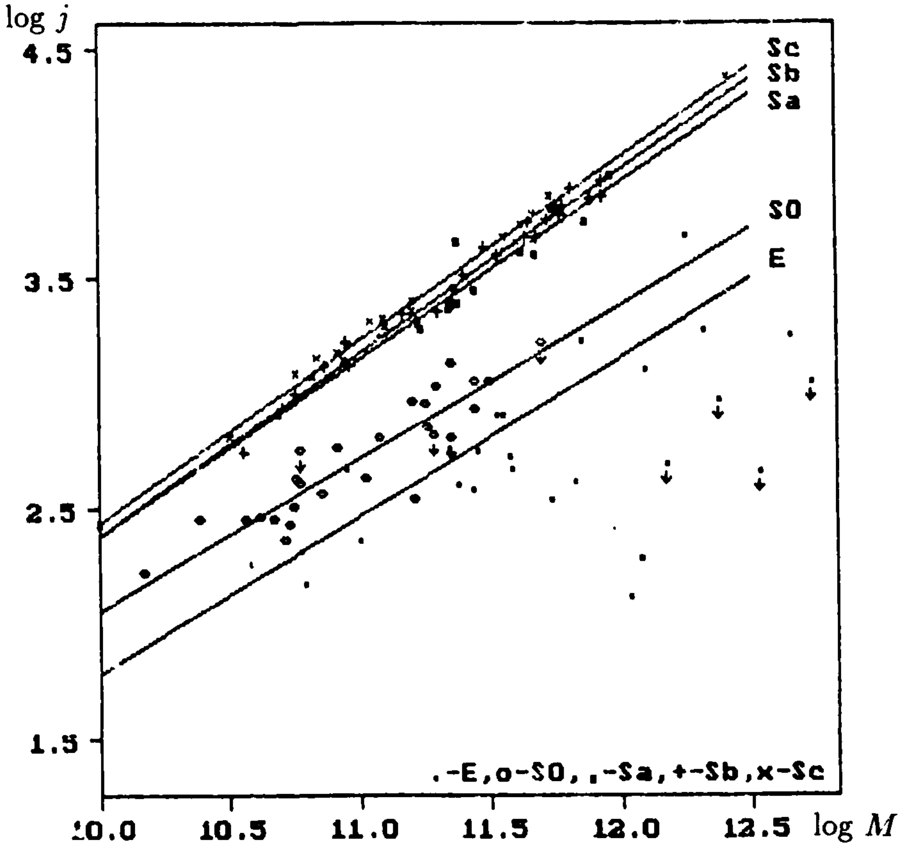

Figure 1 The statistical dependence of the effective momentum on mass for different Hubble's types. The similar slope of the straight lines means the possibility of introducing the common specific effective momentum not depending on mass for a given morphological type.

(1973), Efstathiou and Jones (1979)). However, the data gained for each Hubble's type were insufficient to use the effective momentum $S/M^{5/3}$ as a parameter having its definite value for each type. But namely that is of interest for the theory of the formation of massive galaxies (and active objects like quasars and radio galaxies) through merging considering mass and rotation momentum conservation (Kats, Kontorovich, 1990, 1992). On the other hand, the exponent 5/3 corresponds to density ρ not depending on mass (within a type). Or, in other words, $R \propto M^{1/3}$. The Faber–Jackson (FJ) or Tully–Fisher (TF) relations ($L \propto V^4$) realizing viral relations (at least for constant M/L ratio and correspondingly $S \propto M^{7/4}$) lead to $R \propto M^{1/2}$, while the initial data of density constancy did not find confirmation either.

Starting from this point, we undertook an attempt to derive both the effective specific momentum S/M^k, not depending on mass inside a given type, and the dependence $R \propto M^{kr}$ (Freeman, 1970) directly from the observational data, which

Table 1.

n	T	N	$log(j_0)$	k	$log(R_0)$	k_R	$k(k_R)$
1	E	40	1.78 ± 0.07	1.69 ± 0.08	-0.26 ± 0.02	0.52 ± 0.05	1.76 ± 0.02
2	SO	32	2.06 ± 0.02	1.66 ± 0.07	0.23 ± 0.04	0.49 ± 0.10	1.75 ± 0.05
3	Sa	11	2.37 ± 0.05	1.77 ± 0.08	0.52 ± 0.06	0.54 ± 0.17	1.77 ± 0.08
4	Sb	23	2.38 ± 0.01	1.79 ± 0.03	0.52 ± 0.02	0.59 ± 0.05	1.79 ± 0.03
5	Sc	21	2.44 ± 0.01	1.80 ± 0.02	0.61 ± 0.02	0.60 ± 0.04	1.80 ± 0.02

made use of mass specific momentum determination from rotation curves. (In reality the rotation mass may differ from the full one). Below all galaxy masses are measured in $M_\odot$, radii in kpc, velocities in km/s, specific momentum in kpc km/s.

The elliptical galaxies masses were derived from the usual relation (see Sargent *et al.*, 1978) according to the value of the central velocity dispersion and effective radius R (Davis *et al.*, (1983). The ratio of axes was taken as 2. To derive the spheroid mass component for SO galaxies, the method suggested by Dressler and Sandage (1983) was used. The kinematic characteristics of the galaxies of different types are also cited there. The sample of E and SO galaxies is not uniform. Using the galaxies catalogues, RSA & RC3, we chose for further investigation 27 E galaxies and 27 SO galaxies from these samples. The masses of spiral galaxies were taken equal to $M(R_{25})$ according to works by V. Rubin and coauthors (1982–1986). The specific angular momentum was calculated according to the rotation velocity and radius by common formulae e.g. those used by Fall (1983).

2 THE STATISTICAL DEPENDENCES

The specific momenta j versus masses M for galaxies of different types are shown in the diagram (Figure 1). For S galaxies the straight lines $\log j = \log j_0 + k \log M$ are drawn by the least-square method. The elliptical galaxies fill the bottom part of the diagram with $j > 100$. The trapezium-like form of points distribution in the diagram is the result of selection because of small rotation velocities. So the slope of dependence of the maximum values of $\log j_m$ on $\log M$ was found and then with such a slope a middle straight line for all E galaxies was drawn. The values of $\log j_0$ and k are given in Table 1.

Also statistical dependencies of galaxy radius ($R = R_0 M^{k_r}$) and mean density ($\rho = \rho_0 M^{k_\rho}$) on mass within each morphological type (Table 1) were calculated, as well as the dependences of the velocity V and of the mass-luminosity ratio (M/L) on mass, which together with some description of the statistical calculations we suppose to present in a more detail report.

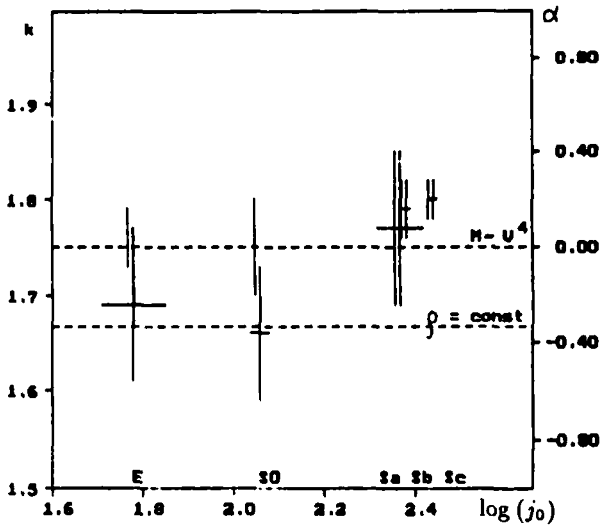

Figure 2 The values of the exponent k in the dependence $S \sim M^k$ as a function of the effective momentum connected with the morphological type (the crosses show the mean-square error of the estimations of the quantities). The vertical line segments (displaced in order not to overlap crosses) show the k values calculated from the statistical dependence of radius on mass (for the same samples). To the right there is an axis of the index α from the dependence of M/L on mass, satisfying conditions of FJ & TF laws.

3 DISCUSSION

The coefficients k, k_r, k_p, which are defined by the found statistical relations are self-dependent. Evidently for each morphological type the relation $k_p = 1 - 3k_r$ will take place, and with account for the rotation balance $k = (3 + k_r)$. As Table 1 and Figure 2 show, the dependences drawn for spirals are self-consistent. The sample of elliptical galaxies is inhomogeneous by real oblateness. This also probably causes their large dispersion in Figure 1. The dependence found, $j_m(M)$, apparently corresponds to the galaxies with maximum oblateness. This is confirmed by the data of the catalogues RSA & RC3 according to which E5 & E6 types are mainly concentrated close to the straight line $j_m(M)$, whereas E0–E2 ones are placed in the right bottom corner of the diagram. The sample of galaxies SO is also essentially inhomogeneous.

The coefficients (powers) k slightly differ for E & SO galaxies, on the one hand and for the spirals, on the other hand. For S galaxies the k values somewhat exceed 7/4, which corresponds to the FJ dependence and to the positive exponent α in the ratio $M/L \sim M^\alpha$, this former coinciding in order of magnitude with that cited in the literature. For E & SO galaxies, the k value is closer to 5/3, though with greater dispersion. Agreement with the FJ dependence may be reached at the expense of a small difference of the FJ exponent from 4 or at the cost of moderate but negative value of α. The similarity of k for SO & E can most likely be accounted for by the

SO data referring to a bulge but not to a disk. Because the differences between the exponents are small, we may speak about a possibility of introducing the common characteristics for Hubble's sequence – the effective momentum, as it is shown in Figure 2. In future we hope to refine these preliminary results at the cost of more detailed differentiation by types and extending our data base.

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