

MASSES AND ROTATIONAL MOMENTA OF 84 MARKARIAN AND 13 NORMAL GALAXIES

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The present study is the first of the series dedicated on the determination of masses, mass-to-luminosity ratios, total and relative rotational momenta of Markarian, Arakelian and Seyfert galaxies. In this communication 84 non-Seyfert Markarian galaxies are considered and for control of the sample, 13 normal galaxies are included, i. e. not belonging to any of the above-mentioned types. In all cases we apply a unified method for the determination of masses, luminosities and rotational momenta of galaxies. The galactic mass is determined under the assumption of spherical distribution of matter, i. e. $m(R) = \gamma^{-1} \cdot V^2 \cdot R$ where V is the rotational velocity and γ is the gravity constant. In cases of flat rotational curves the mass increases linearly with the radius. As Karatchentsev has shown [1], the mass enclosed in isophote $25m/\text{arcsec}^2$ in a first approximation is the total mass of the galaxy, i. e. $m_{25} = \gamma^{-1} \cdot V_m^2 \cdot (A_{25})^2$ where V_m is the maximum rotational velocity of the galaxy, A_{25} is its linear diameter up to the afore-said isophote and m_{25} is the galactic mass expressed in units of $10^{10}/m_0$. When V_m is unknown, we can use Fisher and Tully's [2] dependence $1.2 V_m = 0.5 W_{20}/\sin(i)$ for the line $\lambda 21$ cm at a level of 20% of the maximum intensity W_{20} provided that the slope of the galaxy with reference to the line of sight is i . The relation $W_{20} = 1.38(W_{50})$ was obtained by Karatchentsev [3].

The reduction of the diameters and magnitudes was carried out according to Karatchentsev et al. [3].

The rotational momenta of the galaxies were determined under the assumption of dynamic equilibrium of a rotating homogeneous sphere (Zasov and Ozernoi [4]) by taking into account the corrections for the flatness of rotating spheroid according to [1].

The masses, mass-to-luminosity ratios, total internal and relative rotational momenta of 84 Markarian and 13 normal galaxies were determined after the method described here. The data are listed in Tables 1 and 2 whose columns contain the following: 1 — object, 2 — other denomination, 3 — morphological type, 4 — profile width of the line $\lambda 21$ according to Huchtmeier et al. [5], 5 — radial velocity of the galaxy according to Palumbo et al. [8], 6 — linear diameter in kpc, 7 — galactic mass in $10^{10} m_0$, 8 — absolute magnitude, 9 — mass-to-luminosity ratio f in $(m/L)_0$, 10 — total internal moment K_G in $1.15 \times 10^{74} [\text{g} \cdot \text{cm}^2/\text{s}]$ — rotational moment of the galaxy, and 11 — relative internal moment k_G in $3.85 \times 10^{29} [\text{cm}^3/\text{s}]$ — relative rotational moment of the galaxy.

Below we present the mean values of the mass-to-luminosity ratios and their dispersions for the various morphological types of galaxies:

Table 1 Masses and angular for 84 Mafkarian momenta Galaxies

Mr k	NGC/I C	T	W_{20} [km]	V_o [km/s]	A_{25} [kpc]	M_{25} [1010]	M_{Ho}	f_{25}/t_o	LgK	Lgk
1	2	3	4	5	6	7	8	9	10	11
5		Im	130	1007	2.66	0.33	-15.52	14.10	-2.95	-1.29
7	U3998	Sc	232	3260	13.91	4.61	-19.86	3.63	-0.90	-0.38
8	12184	Sa	400	5655	17.02	17.67	-20.25	9.76	-0.08	-0.15
13	12209	Sb	420	1562	6.67	5.09	-17.69	0.59	-1.04	-0.57
33	U5720	Sm	150	1579	6.86	3.20	-18.71	7.27	-1.27	-0.59
35	3353	Sm	141	1034	6.02	0.52	-18.16	1.95	-2.49	-1.01
36		Sb	99	601	0.75	0.05	-13.98	8.88	-4.57	-2.04
49	U7354	Sc	104	1448	2.81	0.17	-17.16	1.60	-3.40	-1.44
52	4385	So	99	2003	14.77	0.44	-20.36	0.22	-2.70	-1.16
59	4861	Sm	125	847	14.79	0.54	-18.40	2.08	-2.26	-0.81
71	2366	Sm	98	259	7.63	0.19	-16.94	2.20	-3.12	-1.18
86	2537	Sm	126	450	2.97	0.42	-17.54	2.78	-2.78	-1.21
89		So	190	1611	3.50	0.36	-16.91	4.29	-3.13	-1.51
131	3073		218	1250	5.82	3.64	-17.77	19.57	-2.22	-1.65
156	U5998	Sm	189	1369	4.78	0.41	-17.31	3.39	-2.69	-1.11
157	U6029	Im	222	1427	5.54	1.53	-17.76	8.36	-1.80	-0.80
158	3471	Sa	524	2204	16.25	11.56	-19.87	8.96	-0.37	-0.24
169	1691	Sb	152	1371	4.26	0.33	-17.49	2.31	-2.92	-1.26
170	U6448	Sm	87	1131	8.78	0.18	-16.72	2.56	-3.07	-1.16
178	U6541	Sm	110	301	1.52	0.05	-14.58	5.11	-4.35	-1.82
185	3811	Sc	284	3079	29.87	10.10	-20.55	4.19	-0.22	-0.04
186	3870	So	190	728	2.54	0.47	-16.98	5.23	-3.04	-1.52
195		Sa	177	1375	8.06	0.72	-17.60	4.53	-2.33	-1.00
201	4194	Sm	145	2609	23.28	1.94	-20.18	1.14	-1.33	-0.xx
207	4384	Sa	115	2505	13.61	0.97	-19.52	1.04	-2.02	-0.xx
209		So	67	333	1.12	0.05	-13.37	15.48	-4.72	-2.19
277		Im	182	1972	5.43	0.42	-17.00	4.60	-2.64	-1.08
281	5383	Sb	327	2338	31.75	13.08	-20.48	5.81	-0.09	-0.02
296		Im	192	4832	205.3	15.47	-20.00	10.67	0.50	0.49
297	6052	Sc	416	4827	14.98	9.99	-20.35	5.02	-0.38	-0.19
300	11189	Sa	115	12041	28.97	1.25	-21.15	0.30	-1.69	-0.60
303	7244	Sm	287	7747	22.24	5.39	-20.76	1.65	-0.67	-0.22
307	7316	Sm	188	5841	24.93	5.43	-21.25	1.18	-0.64	-0.19
313	7465	So	179	2198	10.23	1.00	-19.52	1.07	-2.24	-1.06
314	7468		225	2256	10.07	1.91	-18.93	3.56	-2.52	-0.67
318	7580	Sm	300	4879	15.14	6.29	-19.96	4.53	-0.66	-0.27
323	7624	Sc	414	4598	17.84	12.11	-20.75	4.18	-0.22	-0.11
325	7673	Sc	224	3596	23.72	20.64	-21.15	4.95	0.19	0.07
326	7677	Sc	371	3849	25.39	12.22	-20.29	6.50	-0.13	-0.04
328		Sb	141	1551	1.80	0.21	-16.48	3.72	-3.39	-1.54
332	7798	Sb	92	2772	15.06	1.90	-20.50	0.83	-1.51	-0.60
363	U694	Sb	257	3076	13.13	2.20	-18.21	7.88	-1.44	-0.60
370	1036	Sm	145	870	6.89	0.61	-17.42	4.55	-2.34	-0.95
384	2512	Sb	455	4626	29.80	25.12	-20.53	10.69	0.32	0.11
385		Sb	165	8023	34.86	2.02	-20.92	0.64	-1.29	-0.41
398		Sb	345	3990	7.74	2.56	-19.17	3.77	-1.46	-0.68
400	U5023	Sb	200	2354	7.31	2.62	-18.49	7.26	-1.45	-0.69
404	2964	Sc	346	1174	15.94	5.44	-19.51	5.91	-0.76	-0.31
409	3011	So	198	1423	4.97	1.89	-17.58	12.19	-1.98	-1.07
411	12524	Sm	202	1461	4.19	0.72	-17.06	7.48	-2.35	-1.02
416	U5833	So	138	1182	7.34	0.31	-16.64	4.74	-3.08	-1.38
418	3442	Sa	196	1739	4.86	1.00	-18.83	2.04	-2.23	-1.04
426		Sc	163	1500	3.61	0.28	-16.98	3.13	-3.01	-1.28
430	3921	Sa	337	6028	52.39	21.29	-21.70	3.06	0.28	0.14
446	4719	Sb	154	7135	47.06	9.99	-21.20	2.29	-0.18	0.01
449	5014	Sa	206	1079	7.12	0.70	-17.83	3.59	-2.37	-1.03

1	2	3	4	5	6	7	8	9	10	11
450	U8320	Sm	110	888	3.79	0.20	-15.93	5.87	-3.20	-1.32
454		S0	428	7002	35.86	16.63	-20.46	7.56	-0.14	-0.17
	11076	Sm	331	6208	28.90	9.63	-21.14	2.33	-0.24	-0.44
	7518	Sc	88	3745	52.31	0.83	-20.28	0.44	-1.73	-0.46
534	7679	So	250	5363	35.37	7.73	-21.82	1.00	-0.64	-0.35
538	7714	Sb	264	2974	20.77	6.07	-20.56	2.52	-0.68	-0.28
545	23	Sa	364	4792	40.90	23.42	-22.08	3.38	0.29	0.11
575	U1260	Sa	445	5423	18.94	19.34	-20.95	5.59	0.00	-0.10
600		Sb	114	1025	1.99	0.07	-16.13	1.71	-4.06	-1.76
603	1222	Sb	199	2574	13.18	5.07	-19.80	4.22	-0.90	-0.42
685		Sc	167	4560	13.18	1.08	-19.21	1.55	-1.86	-0.70
829	U9560	Sa	160	1288	4.00	0.23	-17.18	2.13	-3.23	-1.40
934	7803	Sa	205	5595	21.71	3.61	-21.24	0.80	-1.06	-0.43
960		Sm	220	6478	18.60	3.38	-21.29	0.71	-1.02	-0.37
1081	1507	Sm	205	816	11.40	1.07	-18.11	4.21	-1.87	-0.72
1087	U3179	S0	270	8392	36.82	16.09	-21.53	2.72	-0.16	-0.18
1089	1741	Sm	280	3922	25.26	5.64	-20.76	1.94	-0.62	-0.18
1094	U102a	Sc	164	2739	6.70	0.49	-19.64	0.48	-2.52	-1.02
1124	7298	Sc	202	5155	30.20	11.97	-19.99	8.31	-0.11	0.00
114		E	110	5400	12.15	0.50	-19.37	0.62	-3.36	-1.92
117	783	Sc	74	5217	34.41	1.16	-21.97	0.13	-1.60	-0.48
1236	3023	Sc	151	1620	20.11	1.23	-19.30	1.62	-1.68	-0.59
1341	1904	Sc	271	1183	11.02	2.71	-18.68	6.30	-1.30	-0.54
1346	5167	Sc	197	1009	7.05	0.60	-17.54	3197	-2.38	-0.97
1355		Sc	331	7140	41.00	9.73	-20.39	4.68	-0.18	-0.02
1379	5534	Sb	106	2590	13.87	0.47	-20.05	0.31	-2.44	-0.92
1443	3600	Sa	221	7221	117.7	12.31	-23.11	0.48	0.10	0.21
1446	4123	Sc	240	1153	22.37	7.23	-18.86	14.32	-0.50	—

Table 2 Masses and angular momenta for 13 normal galaxies

NGC	T	W20 km	V_0 km/s	A_{25} kpc	M_{25} [10^{10}]	${}^M c H_0$	f_{25}/f_0	LgK	Lgk
224	Sb	708	-61	42.08	48.56	-21.23	10.77	0.83	0.32
2782	Sa	335	2564	41.47	22.25	-20.96	6.34	0.26	0.10
2805	Sc	118	1868	54.36	4.24	-20.81	1.39	-0.66	-0.10
2989	Sc	267	3909	21.38	6.21	-19.58	6.32	-0.61	-0.21
3310	Sb	320	1088	16.04	21.59	-20.16	12.93	0.09	-0.06
3738	Sm	121	258	3.50	0.40	-16.56	6.59	-2.77	-1.19
3912	Sb	225	1691	11.81	1.76	-19.01	3.02	-1.61	-0.67
4694	So	91	1121	15.22	0.32	-19.41	0.38	-2.90	-1.22
4700	Sc	167	1281	15.01	0.89	-17.75	4.89	-1.95	-0.72
5253	Sa	157	216	3.34	0.21	-14.99	1469	-3.31	-1.46
6764	Sb	300	2701	24.10	6.97	-20.52	2.99	-0.56	-0.22
7052	E	460	4918	47.70	29.69	-21.29	6.28	-0.40	-0.73
7552	Sb	207	1607	22.13	3.86	-19.31	5.03	-0.96	-0.37
		Type	S O	S a	Sb	Sc	Sm		
		η	1	1	16	19	19		
		$\langle f \rangle$	5.4	3.4	5.7	4.26	3.32		
		σ	1.5	0.8	1.7	0.76	0.46		

The mean value obtained for the mass-to-luminosity ratio $\langle f \rangle$ for SO galaxies is lower

than the analagous one from data of T o n r y and D a v i s [⁷J f=8.3±0.5. The results are close to those obtained by M i n e v a [⁸] for triple galaxies.

The mean values for the rotational momenta of the studied types of objects presented below are in good accordance with the results obtained by other authors —see Mineva [⁹]:

Type	SO	Sa	Sb	Sc	Sm
η	10	13	16	19	19
(K_G)	0.17	0.57	0.26	0.48	0.09
σ	0.09	0.20	0.13	0.17	0.03
	0.21	0.57	0.37	0.51	0.28
σ	0.08	0.15	0.10	0.08	0.06

The variation of the determined parameters with the morphological type will be discussed after summing up the data also for the rest of the galactic types studied by us. At this stage the statistics is insufficient for final conclusions.

REFERENCES

- ¹ Karatchentsev, I. D. Sov. A. J., 62, 1985,3. ² F i s h e r, J. R., R. B. Tully. Ap. J. Suppl., 47, 1981, 139. ³ K a r a t c h e n t s e v, I. D., V. Karatchentseva, A. Sterbanovskii. Astroph. Invest. (SAO), 19, 1985, 3. ⁴ Zasov, A. B., L. M. Ozernoi. Astr. Tsirc, 405, 1967, 1. ⁵ Huchtmeier, W. K., O. G. Richter, H. D. Bohnenstengel, M. Hauschlldt. A General Catalog of HI Observations of External Galaxies, 1983, ESO Prepr. No. 250. ⁶ P a l u m b o, G. G. C., G. Tan z e l l a-N i t t i, G. Vetolani. Catalogue of Radial Velocities of Galaxies, New York, London, Paris, Cordon and Breach, 1983. ⁷ Tonry, J. L., M. Davis. Ap. J., 246, 1981, 666. ⁸ Mineva, V. A. Astrofizika, 26, 1987, 335. ⁹ Id. Sov. A. Lett., 13, 1987, 367.

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