Distance, Rotational Velocities, Red Shift, Mass, Length and Angular Momentum of 111 Spiral Galaxies in the Southern Hemisphere

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Abstract

To date, methods of direct measurement of the distance to galaxies have been limited in their range[1]. This paper makes direct measurements of distant galaxies by comparing spiral arm structures to the expected locus of gravitational influence along the geodesic in a centripetally accelerating reference frame. Such measurements provide a method of independent validation of the extragalactic distance ladder without presupposition of the uniformly expanding universe theory. The methodology of this paper avoids the use of Hubble's constant in the measurement of the distance to galaxies beyond the range of contemporary direct measurement methods. The measurements are validated by meaningful trends between distance and other variables such as mass, rotational velocity, size and angular momentum to validate the measurements made. A Hubble diagram calculated using this method is presented from data obtained from 111 spiral galaxies in the southern hemisphere to about 200 MPc distance. The galactic red shift from these galaxies appears independent to distance. Galactic structure, size, masses and angular momentum are seen to have a distinct relationship to the spin velocity, or tangential velocity, associated with each galaxy.

Previously a way to determine the distance to galaxy NGC 3198 was determined from its spiral morphology and rotational velocity[5]. It was also seen that the stars of the galaxy orbit the galaxy with the same orbital velocity independently of the distance from the centre of the galaxy. This is only possible if the member stars of spiral galaxies detect gravitationally and visually that galactic matter, notably stars and interstellar dust and gas, have a linear orientation with constant linear density. However, spiral galaxies also have a spiral morphology which is the result of the finite velocity of light and gravitational interactions over very large distances coupled with a relatively high rotational velocity. This is an excellent example of delayed gravitational interaction. Each star orbiting within the galaxy detects all of the other stars in a stationary linear orientation. Observers not orbiting the galaxy, and in a comparatively inertial reference frame, see the orientation of stars as a spiral. Since the orbital velocity of the stars is constant throughout the galaxy and since gravitational interactions travel at the speed of light, the absolute size of the galaxy can be calculated and a direct measure of its distance can be made.

The spiral shape of the galaxy is determined by:

$$r = \frac{2\pi\theta}{(v/c)} \tag{1}$$

where r is in light years and θ is in radians. From this we can determine the distance to the galaxy by:

$$\begin{aligned} \Delta r &= \tfrac{2\pi^2}{(v/c)} \\ d &= \tfrac{\Delta r \times 360 \times 60}{4\pi\alpha} \end{aligned} \tag{2}$$

where Δr is the distance between spiral arms along the major axis of the galaxy in light years, α is the angular separation between spiral arms along the major axis of the galaxy in minutes of arc, v is the rotational velocity of stars in the galaxy, c is the speed of light and d is the distance to the galaxy in light years.

The rotational velocities of galaxies studied were originally taken from a survey of 1,355 galaxies in the southern hemisphere by Mathewson. We have included a typical page of Mathewson's rotation profiles, Figure 1, to show that the member stars of spiral galaxies orbit the galactic centre with a common rotational velocity. It can be seen that each of the velocity profiles show lines of constant rotational velocity extending to the ends of the graphs, one showing the receding arm and the other showing the advancing arm. There is an adjoining line between these two extensions crossing the central location of each galaxy. The shape is somewhat like a pulled apart "Z". We interpret this as a horizontal line representing one side of the galaxy where all the member stars have the same velocity, say, of recession, then the opposite side of the galaxy containing stars approaching us, as in this example, mixes with the measurements as a slit, or beam of a radio telescope, begins to cross the central region. This causes the line portraying the measurements in the central region to be diagonal. As the slit, or beam, finishes crossing the central region and only detects stars on the other side of the galaxy, the line returns to a horizontal orientation portraying the velocity of, say, approaching stars.

We have taken the analysis and results of Persic[2] for rotation velocities and angular size of each galaxy presented here. The data has been corrected for angle of inclination for each galaxy and transformed into a heliocentric reference frame.

We have then measured the distances to 111 galaxies in the southern hemisphere using the above described method. Since the distance to each galaxy is known, we can then measure its total length, mass and angular momentum. This data is presented in the following table of galactic data. Various graphs are displayed as well.

We note from figure 2 that there appears to be no relationship between galactic red shift and distance. The analysis shows a statistical $\mathbf{R}^2$, or coefficient of determination, of -1.0558, (less than one), upon an attempted linear fit. There is, therefore, no acceptable linear fit and the data appears completely random. However, it is obvious that all of the galaxies displayed are indeed red shifted. It appears unlikely, therefore, that this red shift is the result of a Doppler effect.

We call the rotational velocity of the stars within the galaxy the spin velocity or spin of the entire galaxy.

We can also see that:

1. more massive galaxies spin faster

2. more slowly spinning galaxies tend to be more spread out and therefore larger than faster spinning ones

3. the angular momentum of galaxies are heavily dependent on their mass squared

4. spiral galaxies have similar masses to within an order of magnitude

Error

The distance to the galaxies are determined from measurements of angular distance between galactic arms along the major axis of the galaxy and their spin velocity. Mathewson reports an error within 10 Kps in spin velocity and upon examining the data, we feel that this is acceptable. The angular distance between galactic arms is determined from noting the pixel locations at either end of each galaxy on well defined digital photographs from the Hubble space telescope. We submit an error estimate of 2 pixels for each measurement.

Table of Galactic Data

Name	Rotation Velocity Kps	Dist. MPc	Red Shift Kps	Length 10^3 LY	Mass 10^{11}solar masses	Angular Momentum 10^{46} J-s
1-G6	137	49	2245	101	1.35	3.68
1-G7	120	158	4994	203	2.08	4.98
101-G20	178	97	5845	135	3.05	10.78
101-G5	178	103	6638	124	2.80	9.92
102-G10	178	74	4698	131	2.96	10.50
102-G15	178	104	5018	136	3.08	10.89
102-G7	227	99	5014	143	5.24	23.67
103-G13	210	32	4664	67	2.10	8.77
105-G20	122	84	5672	105	1.11	2.70
105-G3	162	72	4860	104	1.95	6.27
106-G12	130	103	4155	161	1.94	5.02
107-G36	208	23	3096	61	1.87	7.75
108-G11	214	97	2979	158	5.17	22.00
108-G19	165	47	2956	67	1.29	4.24
113-G21	90	107	4822	103	0.59	1.06
114-G21	166	101	6378	125	2.46	8.11
116-G14	152	55	5417	75	1.24	3.74
117-G18	206	80	5795	85	2.58	10.58
117-G19	177	58	5386	81	1.82	6.40
120-G16	138	71	3674	132	1.80	4.93
121-G26	226	34	2220	68	2.48	11.14
121-G6	146	33	1228	98	1.50	4.34
123-G15	232	45	3215	93	3.55	16.38
123-G16	100	84	3194	141	1.00	1.99
123-G23	160	46	2910	74	1.36	4.32

Name	Rotation Velocity Kps	Dist. MPc	Red Shift Kps	Length 10^3 LY	Mass 10^{11}solar masses	Angular Momentum 10^{46} J-s
123-G9	151	63	3183	103	1.67	5.02
140-G24	206	76	3183	94	2.83	11.60
140-G25	100	76	2047	211	1.51	3.00
109-G32	112	85	3362	115	1.03	2.30
116-G12	145	42	1153	116	1.73	5.00
140-G28	111	100	4875	159	1.40	3.09
140-G34	103	70	3405	82	0.62	1.27
141-G20	238	51	4349	96	3.89	18.43
141-G34	271	50	4404	112	5.86	31.60
141-G37	282	50	4386	76	4.29	24.07
141-G9	219	40	3636	104	3.55	15.46
142-G30	181	70	4201	121	2.82	10.15
142-G35	223	44	2031	103	3.66	16.25
145-G22	198	71	4465	94	2.61	10.29
146-G6	108	110	4598	144	1.20	2.58
151-G30	180	91	5335	113	2.61	9.33
155-G6	105	24	1070	84	0.66	1.37
162-G15	93	205	2839	258	1.59	2.95
162-G17	60	128	2839	199	0.51	0.61
163-G11	198	45	2839	83	2.33	9.17
18-G13	219	58	2839	144	4.92	21.44
183-G5	90	117	2839	141	0.82	1.46
184-G51	230	69	2839	121	4.56	20.88
184-G54	160	44	2839	58	1.05	3.34
184-G63	170	57	2839	97	2.00	6.76

Name	Rotation Velocity Kps	Dist. MPc	Red Shift Kps	Length 10^3 LY	Mass 10^{11}solar masses	Angular Momentum 10^{46} J-s
184-G67	242	43	2839	101	4.20	20.21
185-G36	155	71	2839	87	1.49	4.61
185-G68	114	94	2839	115	1.06	2.41
185-G70	133	79	2839	98	1.23	3.26
186-G21	188	90	2839	128	3.22	12.04
186-G75	180	86	2839	101	2.33	8.35
186-G8	141	93	5709	129	1.83	5.13
187-G6	105	95	4652	152	1.19	2.49
187-G8	121	130	4404	170	1.77	4.27
196-G11	116	51	3637	82	0.79	1.82
197-G2	172	131	6306	144	3.04	10.41
197-G24	157	113	5877	182	3.20	9.99
200-G3	105	68	1034	353	2.78	5.80
202-G26	134	69	5111	78	1.00	2.66
204-G19	122	79	4516	95	1.01	2.45
208-G31	155	59	3068	95	1.63	5.03
215-G39	140	104	4335	127	1.78	4.95
216-G21	181	49	5086	62	1.44	5.18
220-G8	145	61	3013	105	1.58	4.56
231-G23	230	67	5024	103	3.88	17.77
233-G36	116	118	3291	188	1.80	4.16
233-G41	267	45	2951	96	4.89	25.99
233-G42	86	189	2561	240	1.27	2.16
234-G13	135	77	3186	83	1.08	2.90
235-G16	196	48	7147	56	1.54	6.02

Name	Rotation Velocity Kps	Dist. MPc	Red Shift Kps	Length 10^3 LY	Mass 10^{11}solar masses	Angular Momentum 10^{46} J-s
235-G20	150	105	4671	130	2.09	6.23
236-G37	180	57	5558	73	1.68	6.03
237-G49	87	158	2913	269	1.45	2.51
238-G24	209	72	7013	87	2.70	11.24
240-G11	235	31	2876	96	3.77	17.61
240-G13	143	70	3267	90	1.31	3.73
243-G8	174	85	7323	83	1.79	6.19
244-G31	242	48	6726	73	3.04	14.64
244-G43	160	79	6231	90	1.64	5.22
249-G16	186	27	1179	165	4.06	15.03
25-G16	125	113	6136	164	1.82	4.54
250-G17	261	25	4541	42	2.05	10.63
251-G10	230	53	4451	71	2.67	12.22
251-G6	142	107	4981	99	1.42	4.02
265-G16	174	84	5166	108	2.34	8.10
266-G8	113	118	3225	120	1.09	2.45
267-G29	200	66	5445	81	2.31	9.21
267-G38	225	81	5884	80	2.89	12.95
268-G11	231	31	8517	29	1.10	5.05
268-G33	215	49	5502	68	2.23	9.52
269-G63	146	100	3189	141	2.14	6.21
27-G24	200	106	4079	115	3.28	13.06
124-G15	129	78	2606	121	1.43	3.68
2-G12	137	101	4643	131	1.75	4.77
22-G3	107	131	2737	273	2.23	4.74

Name	Rotation Velocity Kps	Dist. MPc	Red Shift Kps	Length 10^3 LY	Mass 10^{11}solar masses	Angular Momentum 10^{46} J-s
231-G29	113	88	4940	109	0.99	2.23
249-G35	50	197	1035	250	0.45	0.44
26-G6	110	75	2743	151	1.30	2.85
269-G15	149	76	3376	182	2.89	8.55
269-G19	189	37	2173	119	3.04	11.41
269-G49	94	112	3238	150	0.94	1.76
269-G61	247	44	4917	94	4.08	20.04
284-G21	150	69	5773	79	1.27	3.79
285-G40	240	73	6735	88	3.63	17.31
286-G18	303	46	9150	88	5.79	34.89
287-G13	172	40	2703	93	1.97	6.74

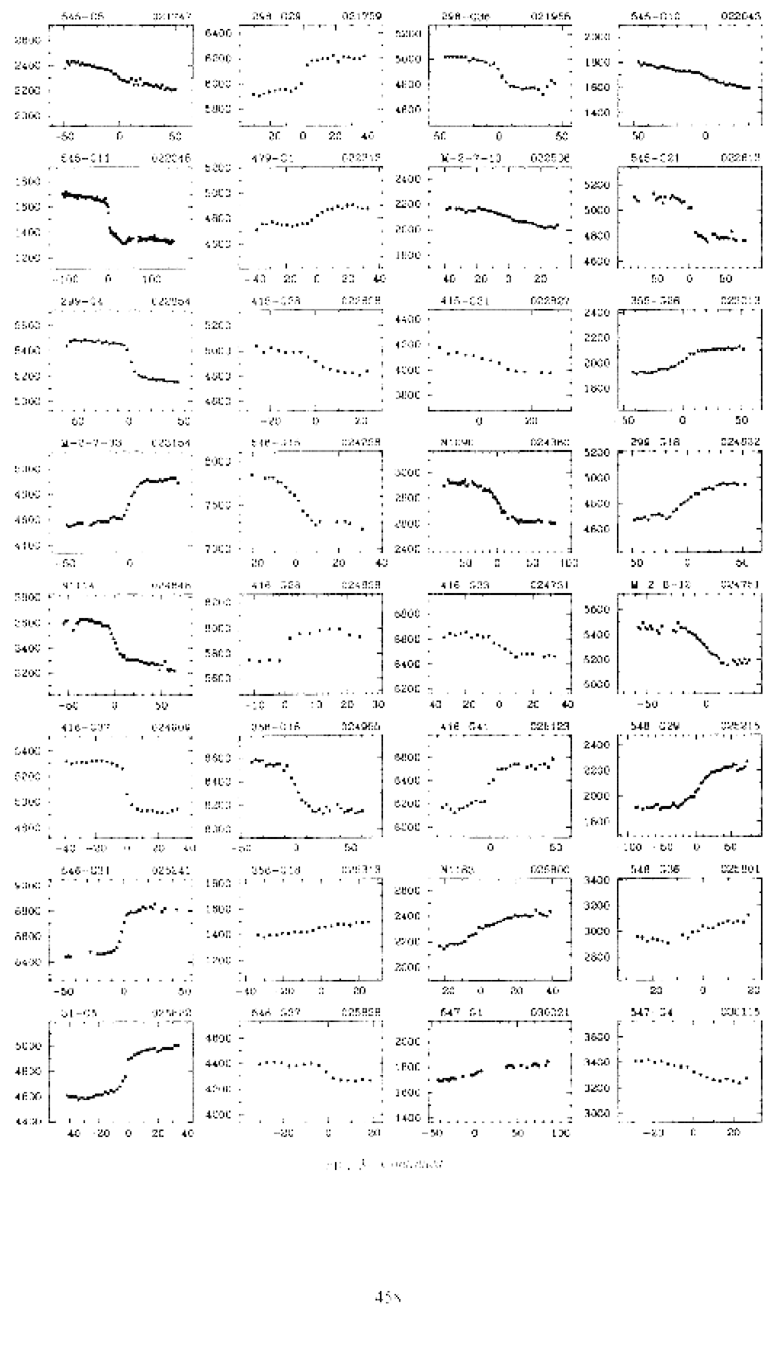

Figure 1: A typical page from the Mathewson Survey.

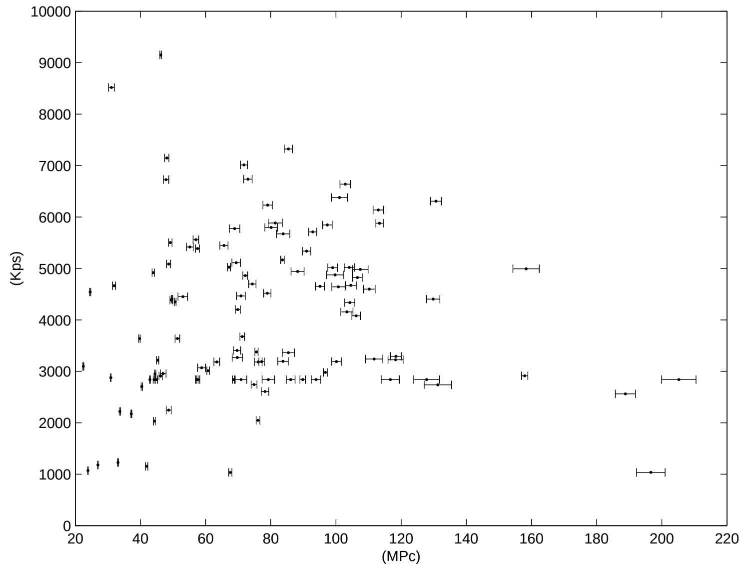

Figure 2: A Hubble diagram of 111 galaxies in the Southern Hemisphere with error bars for distance measurements. Red shift is in Kps and distance in MPc. There appears to be no linear relationship of red shift to distance.

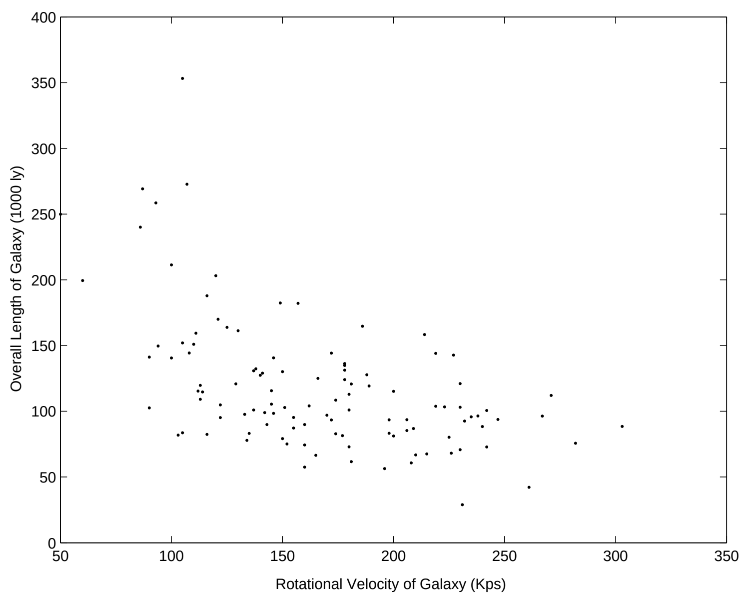

Figure 3: Rotational velocity of stars of galaxies vs. overall length of the galaxy in the reference frame of the member stars.

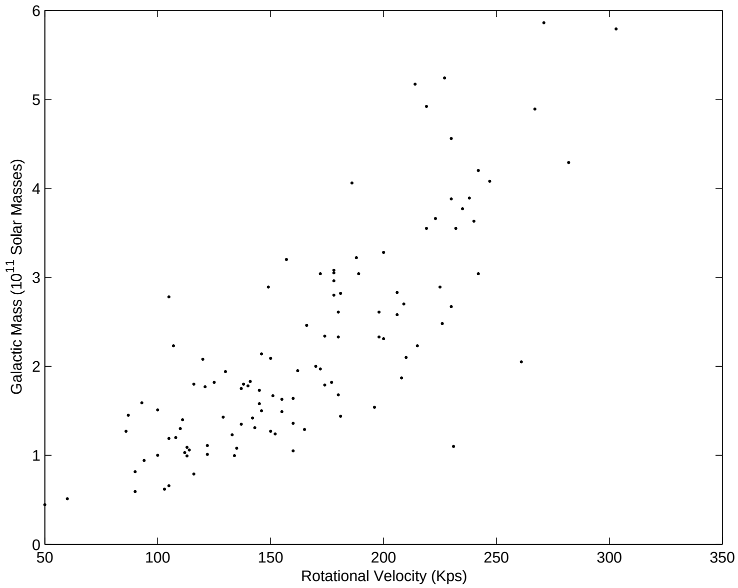

Figure 4: Mass of each galaxy vs. rotational velocity of stars within the galaxy.

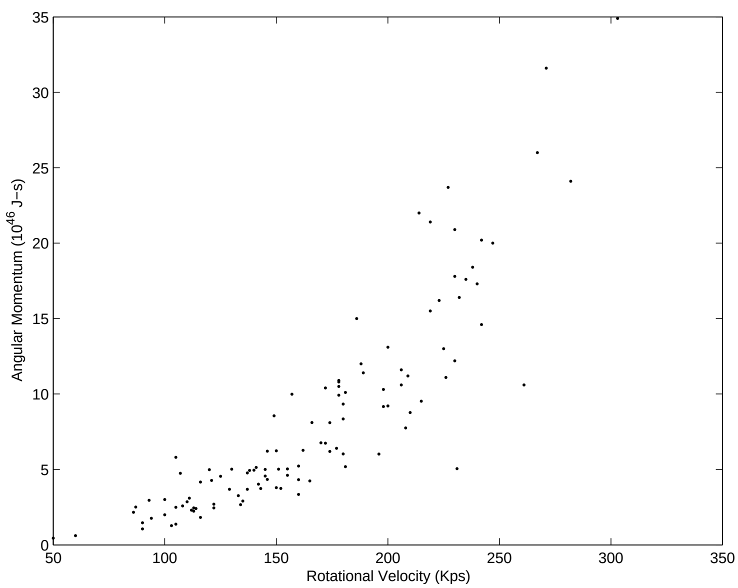

Figure 5: Angular momentum of each galaxy vs. rotational velocity of stars within the galaxy.

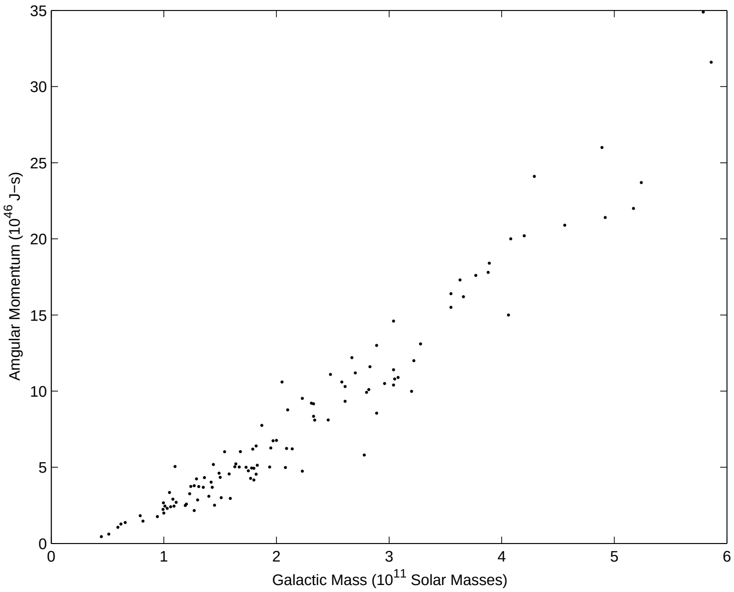

Figure 6: Angular momentum of the entire galaxy vs. mass of each galaxy.

References

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