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SCALE-HEIGHTS OF GALACTIC DISKS AND THEIR CORRELATION WITH THE COLOUR INDEX OF THE GALAXIES

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I. INTRODUCTION

The scale-height of galactic disk (SGD) is certainly an important parameter for understanding spiral galaxies. While the SGD of edge-on galaxies may been determined through the van der Kruit's method (1981) (with a locally isothermal model and based on their surface photometry), SGD of the non edge-on spiral galaxies (which are the most of spiral galaxies) may be determined by observing the spiral pattern (Peng 1988). Based on Peng's method with good quality images of galaxies through CCD image observasion (using the 1-m telescope at Yunnan Observatory), the scale-hights of seven face-on spiral galaxies have been obtained(Shang et al. 1992). Using the Atlas of Galaxies (Sandage & Bedke,1988) and based the Peng's method, the scalehights of 35 spiral galaxies also obtained and a statistical correlation between the colour indices and the scalehights of disk galaxies has been found in the present work.

II. PRINCIPLE OF DETERMINING SCALE-HEIGHT OF NON EDGE-ON GALAXIES

It is found that there is a forbidden region around the center for the spiral pattern of any spiral galaxy with a finite thickness, i.e. the spiral arms may appear only in the outer region with the radius (Peng et al. 1979): $r > r_0 = \frac{H}{2}\sqrt{(m^2 + \Lambda^2)}$, where r_0 is the radius of the forbidden (or prohibited)region radius of density wave (or spiral parttern)and, Λ, a parameter describing the winding tightness of the spiral arm: $\Lambda = m/\tan i, i$ is the pitch angle of the arm. H is the scale-height (or thickness) of the galactic disk. The physical reason of existence of the forbidden region of spiral pattern is: the responded gravitational potential disturbance due to the disturbant matter outside of the galactic plane (z=0) must interfere with the spiral pattern of the density wave in the galactic plane. The interference in the central region is stronger than one in the outer parts of the galaxy. In the inner region with $r < r_0$, the inteference is strong enough to destroy the density wave and thus no arms appear. Of course, the thicker the galactic disk is, the stronger the interference is. For some tightly wound spiral arms, $\Lambda >> m$ and $r_0 \simeq H\Lambda/2$. The radial wave length of the density wave is: $\lambda_r = 1/k_r$(k_r is the radial wave number),$k_r = (\partial/\partial r)(\Lambda \ln r - m\theta) = \Lambda/r$. Thus in the region $r < r_0$, we have $\lambda_r < H/2$ which is just the condition that the density wave cannot exist. The exitence of the forbidden region of the spiral arms is just the effect of the thickness on the spiral structure of disk like galaxies with a finite thickness. It should be emphased that r_0 depends on the SGD, H, besides on the winding parameter, Λ, and the number of arms of the galaxy. Conversely, using the effect of the thickness on the spiral pattern, we may get the information about the thickness or scale-height of the galactic disk through an observation of spiral pattern. For example, finding the winding parameter Λ by fitting the arms with a logarithmic spiral on the photograph of the galaxy (the fitting is slightly complicated due to the inclination of the galaxy in general (Peng 1988)) and measuring the forbidden radius r_0 which is the distance of the innermost point of the arms from the center of the galaxy, we may determine the SGD by the following formula. $H = 2r_0/\sqrt{m^2 + \Lambda^2}$.

III. TABLE OF SGD

Using the Atlas of Galaxies(Sandage & Bedke, 1988) and Following Peng (1988), the SGDs of 35 galaxies with clear and long arms are have estimated recently. The results are listed in the Table 1. Besides, the Table 1 also includes some known SGDs of galaxies, seven of the edge-on galaxies taken from van der Kruit(1981), three taken Peng(1988), and six taken Shang(1992). These categories are specified by the letters ' van, S and P' in the 'source' respectively. Also, other parameters of spiral galaxies are included in the Table 1, where /*gamma* is the inclination, B-V the colour index, H/(2R) the flatness of a galaxy, dH/H the relative error of the scale-height.

IV. STATISTICAL CORRELATION OF THE FLATNESS WITH THE COLOUR INDEX OF SPIRAL GALAXIES

For all spiral galaxies, SGD's of which have been estimated, we have made the statistics of correlation between the flatness, H/(2R), with the colour index, B-V, where R is the radius of the galactic disk. Both the colour indices (B-V) and radius R are all taken from the Third Cataloque of Bright Galaxies (RC3).It

Table 1. Parameters of spiral galaxies

Name	Type	γ (o)	B-V	H/R	dH/H (%)	Source
NGC 628	Sc	24	.56	.009	27.0	P
NGC 753	Sbc	39	.66	.011	14.8	
NGC 1566	Sbc	37	.60	.012	60.0	
NGC 2336	Sbc	57	.62	.013	25.4	
NGC 3031	Sab	58	.95	.037	12.1	
NGC 3147	Sbc	27	.82	.024	13.2	
NGC 3223	Sb	53	.82	.027	37.5	
NGC 3351	SBb	47	.80	.022	49.0	
NGC 3642	Sbc	34	.49	.019	7.0	
NGC 4303	Scd	34	.53	.035	34.3	
NGC 4321	Sbc	32	.70	.021	29.2	
NGC 4536	Sbc	65	.61	.012	59.2	
NGC 4725	Sab	45	.72	.027	42.5	
NGC 5194	Sbc	52	.60	.015	16.0	P
NGC 6384	Sbc	49	.72	.025	9.1	
NGC 6951	Sbc	34	.99	.044	39.1	
NGC 7171	SBb	54	.70	.018	39.2	
NGC 2608	SBb	53	.71	.055	11.1	S
NGC 2713	SBab	65	.97	.130	14,4	S
NGC 2776	Sc	27	.52	.013	24.3	S
NGC 3631	Sc	17	.58	.021	7.0	S
NGC 5985	Sb	58	.77	.025	7.5	S
NGC 7156	Scd	29	.60	.012	9.4	S
NGC 5236	Sc	27	.66	.019	13.0	P
NGC 5247	Sc	30	.54	.021	24.8	
NGC 895	Sc	41	.53	.012	32.5	
NGC 289	SBbc	44	.73	.037	18.3	
NGC 210	Sb	46	.71	.041	12.2	
NGC 5364	Sc	45	.64	.015	14.5	
NGC 1042	Sc	34	.54	.008	31.9	
NGC 1637	SBc	30	.64	.011	21.2	
NGC 3938	Sc	25	.52	.008	19.0	
NGC 5085	Sc	27	.87	.018	28.4	
NGC 1232	Sc	27	.63	.010	42.3	
NGC 2835	SBc	46	.49	.008	21.9	
NGC 3184	Sc	11	.58	.015	17.1	
NGC 5457	Sc	11	.45	.009	45.2	
NGC 5660	Sc	25	.47	.008	44.0	
NGC 1228	Sc	21	.68	.013	17.7	
NGC 2935	SBb	34	.80	.042	11.5	
NGC 2942	Sc	36	.57	.013	29.7	
NGC 5468	Sc	11	.49	.014	39.1	
NGC 5885	SBc	27	.52	.007	35.8	
NGC 6118	Sc	61	.76	.008	32.7	
NGC 891	Sb	79	.88	.047	....	van.
NGC 4013	Sb	79	.96	.077	....	van.
NGC 4217	Sb	73	.87	.120	....	van.
NGC 4244	Scd	83	.50	.042	....	van.
NGC 4565	Sb	82	.84	.031	....	van.
NGC 5023	Scd	83	.53	.059	....	van.
NGC 5907	Sc	84	.78	.043	....	van.

Table 2. The regression coefficients and correlation

N	a	b	r	$r\alpha$	F	$F\alpha$
51	1.32±.12	-2.55±.09	.658	.354	38.1	7.19
44	1.31±.12	-2.55±.09	.673	.380	35.6	7.29
47	1.46±.13	-2.66±.09	.723	.361	50.3	7.27

$\alpha = 1\%$

is reasonable to assume that both the flatness and the colour index are independent of the distance of the galaxy. The statistics are made for some cases: 1) for all 51 samples of galaxies including both van der Kruit's (seven) samples and 44 samples obtained by Peng's method; 2) for 44 samples of galaxies by the Peng's method only; 3) similar to the case 1) except the four Scd galaxies subtructed. The equation of regression is $\log(H/R) = a(B-V) + b$. The regression coefficients, a and b, and their errors are shown in the Table 2. r is the correlation coefficient and $r_\alpha(\alpha = 0.01)$ the lowest correlation coefficient. Besides, we have also checked the correlation by the F-test. $F_\alpha(\alpha = 0.01)$ is the critical value, and the condition $F > F_\alpha$ shows that the flatness does correlate with the colour index of spiral galaxies. The statistical results show that galaxies with bluer colour (i.e. they contain more massive or hotter stars) have thinner galactic disk in average. Or the thinner the disks are, the bluer the galaxies would be. It seems to infer that the spiral galaxies with thinner disk should contain more hotter massive stars. In other words, the (massive) star formation rate is higher in thiner disk like galaxies than in thicker galaxies. We may come to the conclution that the spiral arms develop more in the thin galaxies than in the thick ones.

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