DOI: 10.24996/ijs.2024.65.3.45

ISSN: 0067-2904

Kinematic Properties of the Gaseous Stellar Dynamics Using the Tully-Fisher Relation in the Different Types of Spiral Galaxies

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Received: 27/12/2022 Accepted: 9/4/2023 Published: 30/3/2024

Abstract

The goal of this paper is to show the kinematic characteristics of gaseous stellar dynamics using scaling coefficient relationships (such as Tully-Fisher) in different spiral galaxies. We selected a sample of types of spiral morphology (116 early, 150 intermediate, and 146 late) from previous literature work, and used statistical software (statistic-win-program) to find out the associations of multiple factors under investigation, such as the main kinematic properties of the gaseous-stellar (mass, luminosity, rotational speed, and baryons) in different types of spiral galaxies. We concluded that there is a robust positive connection between Log $V_{rot.max.)}$ and Log $M_{star(B-V)}$, as well as between Log $V_{rot.max.}$ and Log M_{bar} (B-V) in three types of spiral galaxies (early, intermediate, and late), with a sharply negative relationship found between $M_{Star}(B-V)$ and Log M_B in addition to the relationship between Log M_{bar} (B-V) and Log M_B, with the partial correlation coefficient ($R \approx -0.85$) in all the different types of spiral galaxies. Our results indicated that for early and intermediate kinds of spiral galaxies, the baryonic disk mass and the maximum rotational speed fit best with the formula M_{bar} (B-V) $\approx 60V^4_{rot.max.}$, but this relationship seems to be stronger in late-type spiral galaxies with M_{bar} (B-V) $\sim 60\ V^5_{rot.max}$. Whenever the observable stars and atomic hydrogen gas were taken into account, several scientific facts show that additional extremely massive baryon stores are virtually probably present in late spiral galaxies.

Keywords: Spiral – Galaxies: stellar mass, baryonic mass, luminosity, statistics analysis.

الخصائص الحركية للديناميكيات النجمية الغازية باستخدام علاقة تولي – فيشر في الانواع المختلفة من المجرات الحلزونية

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الخلاصه

ان الهدف من هذه البحث هو بيان الخصائص الحركية للديناميكية النجمية الغازية باستخدام علاقات معاملات القياس مثل (Tully–Fisher) في أنواع مختلفة من المجرات الحلزونية. اخترنا عينات لأنواع المجرات ذات الهيئة التشكيلية الحلزونية (116 قديمة التكوين ، و 150 متوسطّة التكوين ، و 146 حديثة التكوين) من الأعمال الأدبية السابقة، واستخدمنا برنامجًا إحصائيًا (statistic–win–program) لمعرفة ارتباطات العوامل

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المتعددة قيد البحث ، مثل الخصائص الحركية الرئيسية النجميه- الغازيه (الكتلة ،النورانية، سرعة الدوران والباريونات) في أنواع مختلفة من المجرات الحلزونية. استنتجنا أن هناك علاقة إيجابية قوية بين Log $V_{rot.max.}$ و $M_{Star}(B-V)$ Log وكذلك بين Log $V_{rot.max.}$ و Log M_{bar} (B−V) في ثلاثة أنواع من المجرات الحلزونية (القديمة والمتوسطة والحديثة) ، مع وجود علاقة سلبية حادة بين Log M_B و Log M_{bar} (B−V) بالإضافة إلى العلاقة بين Log M_B و $M_{Star}(B-V)$ ، مع معامل الارتباط الجزئي ($R \approx -0.85$) في جميع أنواع المجرات الحلزونية المختلفة.تشير نتائجنا إلى أن ألانواع القديمة والمتوسطة من المجرات الحلزونية، فإن كتلة القرص الباريوني وأقصى سرعة للدوران تتناسب بشكل أفضل مع الصيغة $M_{bar}(B-V) \approx 60V^4_{rot.max}$ ، ولكن يبدو أن هذه العلاقة تكون أقوى في النوع الحديث من المجرات الحلزونية M_{bar} (B−V) ~ 60 $V^5_{rot.max}$.عندما تؤخذ النجوم المرصودة وغاز الهيدروجين الذري في الاعتبار ، تظهر العديد من الحقائق العلمية أن مخازن الباريونات الضخمة للغاية قد تكون موجودة في المجرات الحلزونية الحديثة.

1-Introduction

Spiral galaxies share two characteristics with normal spiral galaxies “S” and barred spiral galaxies “SB”: a bulge and a circumferential disk with spiral arms [1]. Spiral galaxies usually contain abundant reserves of gas, dust, and a broad complex of older and younger stars [2]. In spiral galaxies, the regions with well-developed spiral arms have the highest HI, which is within the optical dimensions. [3]. Atomic hydrogen is widely distributed in galaxy disks and can be traced by the 21-cm line of cold gas hydrogen, making it the most abundant element in the interstellar medium (ISM). Because molecular gas is intimately connected to star formation, neutral atomic gas (HI) can be thought of as the galaxy's reservoir for future star formation in regions where it reaches high enough densities and metallicities to become shielded from interstellar ultraviolet (UV) radiation [4]. One of the most fundamental measurements of the galaxy population is the luminosity function (LF). It is crucial for characterizing the statistical characteristics of galaxies and how they alter over time. Understanding how the LF changes with cosmic era, galaxy type, and surroundings can reveal more about the physical processes that give galaxies their shape [5]. The "P-L" relationship between the Cepheid period-luminosity and secondary distance indicators like the Tully-Fisher relation determines the extragalactic distance measure (luminosity versus rotational velocity) for spirals, the supernova standard candle, surface illumination oscillations, the fundamental plane relationship and the Faber-Jackson relationship for ellipses, and the Dn- σ relationship [6-8]. It is essential to understand the proportional relationship between spirals and baryons. The first known scaling relationship of this kind is, of course, the baryon Tully-Fisher relationship (BTFR) between the baryon mass and the asymptotic angular velocity of disk galaxies [9]. The relationship between the total mass of stars and gas is called the baryon Tully-Fisher relationship (BTF) [8].

In previous research (S.S. Mcgaugh and W.J.G. De Blok, 1997) [10], it was shown that the gas mass fraction of spiral galaxies is closely related to luminosity and surface brightness. Most of the stars in these gas-rich galaxies must have come into being in the second half of the Hubble era. The visual Tully-Fisher relationship was clearly broken by S. S. Mcgaugh et al. in 2000 [11], and distant galaxies with $V_c \lesssim 90$ km/s now belong to the relationship characterized by brighter galaxies. However, these faint galaxies are very gaseous. Instead of a single linear relationship, we can add gas mass and chart the mass of the baryon disk $M_d = M^* + M_{gas}$. Furthermore, S. S. McGaugh [11] offered the Tully-Fisher relation between the stellar masses of galaxies with circular speeds ranging from about 30 and 300 km/s. at 90 km, which is within the connection established by brighter galaxies, there is a noticeable break in the optical Tully-Fisher link pattern galaxies. But the gas content of these faint galaxies is extremely rich, and the single linear relationship is restored when the gas mass is plotted instead of luminosity. As a result, it seems that the TF relation is primarily a relationship between the formation's rotational speed and total baryonic mass. Other researchers [12] showed that the mass-to-light ratio is dependent on the current star formation rate (SFR) by analyzing sample spiral galaxies, and they discovered that differentiation in the stellar content of galaxies is a major source of intrinsic scatters in the TF relation. This study also showed that the physical basis of the (TF) relation lies in a relationship between the luminous mass and rotation velocity, an association between luminosity and bright mass, that is often based on the history of star formation in galaxies. C. Trachternach et al 2009 [8] studied the baryon-Tully-Fisher (BTF) relationship at low spin rates and galaxy masses; it can be used to estimate distance. They discussed several estimates of the maximum rotational speed and the choice of the stellar mass-to-light ratio "$Y*$". This study showed that the contribution of stellar mass to the total baryon mass is generally smaller than that of luminous massive galaxies. This makes it possible to estimate, with surprising accuracy, the mass of rotating galaxies, as well as the form in which the baryonic mass exists and the mass of stars and gas. S. S. McGaugh (2018) [13], found that the mass-to-light ratio of the optimal BTF is in good agreement with the stellar population synthesis model. As expected, stellar fraction, mass-to-light ratio "$Y\star$", and color are all correlated. Undeveloped galaxies with low "$Y\star$" tend to be blue and have low "$Y\star$", while more evolved galaxies have higher stellar scores, redder colors, and higher mass-to-light ratios. These parameters are also related to disk mass and rotational speed; larger mass disks are more evolved.

This article is organized as follows: the second section declaratively exhibits the process followed in this project, the typical model utilized in mathematical analysis, and the method used to derive the study's parameters. The third section discusses the work that was agreed to be given, the calculations made, the samples' statistical analysis, and the outcomes of calculations made using statistical methods. The fourth portion will conclude the work by summarizing its findings.

2-Data collection used and estimated parameters of the sample.

2-1: Information gathering for the sample: In this paper, a sample of spiral-type galaxies (116 early, 150 intermediate, and 173 late) was selected from papers [14-16]. They were used to extract some parameters from the French website Lyon-Meudon Extra-Galactic Database (HyperLeda) and the NASA/IPAC Extra-Galactic Database (NED), such as the morphological type of galaxies, the apparent magnitude m_{Btc} in blue-band corrected by galactic extinction, the observed maximum rotation velocity of the gas (v_{maxg}), the neutral hydrogen HI flux in 21-cm line magnitude (m21), where the integral HI flux is expressed in the unit Jy km /s [17], in addition to the inclination of the line-of-sight (i), and (B-V) color index at the asymptotic B-band magnitude and asymptotic-band magnitudes in the UBV system. This data examined possible luminosity in the blue band, and also measured the mass of stellar and baryonic mass at the (B-V) color index of three types of spiral galaxies. A list of these parameters is shown in Table (1) for early, intermediate, and late spiral galaxies. In this work, we will mention the first ten data topics from each of these types of galaxies.

Table 1: Data used in our research for early, intermediate, and late spiral galaxies from the Lyon-Meudon Extragalactic Database website (HyperLeda), the NASA/IPAC Extragalactic Database (NED), and the work of papers [14- 16].

No.	Name of galaxy	Ref.	Morphology	v_{maxg} $(\frac{km}{s})$	m_{Btc}(mag)	i (deg)	(B-V)	m_{21}(mag)
Early spiral sample								
1.	NGC 23	14	SB(s)a	183.9	12.51	40.5	0.86	15.43
2.	NGC 34	14	(S0-a)	234.5	13.95	90	0.63	14.95
3.	UGC 556	14	(Sab)	171.3	14.56	60.9	0.86	15.46
4.	NGC 520	14	(Sa)	70.5	11.67	75.7	0.73	14.56
5.	NGC 660	14	SB(s)a	139.1	11.26	78.8	0.65	12.44
6.	NGC 693	14	(S0-a)	108.6	12.85	66.7	0.8	14.92
7.	UGC 1385	14	SB0/a	77.3	13.55	20.4	0.59	16.49
8.	NGC 835	14	SAB(r)ab	105	12.91	34.9	0.75	15.75
9.	NGC 839	14	(S0-a)	60.5	13.8	90	0.8	13.79
10.	NGC 972	14	(Sab)	134.6	11.3	65.8	0.83	14.19
Intermediate spiral sample								
1.	NGC 134	14	SAB(s)c	220.3	10.09	90	0.87	12.46
2.	ESO 079-G003	14	SBb	192	12.64	90	0.8	14.72
3.	NGC 150	14	SB(rs)b	151.4	11.42	64.5	0.56	13.78
4.	NGC 157	14	SAB(rs)bc	136	10.4	61.8	0.62	13.3
5.	NGC 278	14	SAB(rs)b	56.6	10.85	12.8	0.64	13.4
6.	NGC 289	14	SB(rs)bc	125.6	11.4	43	0.51	12.34
7.	NGC 317B	14	(SBbc)	116.6	12.85	65.5	0.22	16.13
8.	NGC 470	14	SA(rs)b	173.2	12.01	58.5	0.75	14.55
9.	NGC 613	14	SB(rs)bc	168.8	10.51	35.7	0.39	13.68
10.	ESO 297-G011	14	SB®b	65.4	13.33	31.5	0.72	15.98
Late spiral sample								
1.	NGC 247	14	SAB(s)d	82.2	8.61	76.4	0.46	10.58
2.	NGC 337	14	SB(s)d	106.7	11.18	50.6	0.53	13.46
3.	NGC 628	14	SA(s)c	21.8	9.35	19.8	0.39	11.56
4.	NGC 697	14	SAB(r)c	204	11.63	74.6	0.82	13.49
5.	NGC 701	14	SB(rs)c	107.2	12.17	62.5	0.66	14.27
6.	NGC 908	14	SA(s)c	177.4	10.14	64.7	0.51	13.55
7.	NGC 922	14	SB(s)cd	83.8	12.16	34.3	0.4	14.41
8.	NGC 925	14	SAB(s)d	90.2	9.77	58.7	0.47	11.76
9.	NGC 958	14	SB(rs)c	277.8	11.86	78	0.73	14.13
10.	NGC 1084	14	SA(s)c	148.7	10.76	49.9	0.58	13.31

Spiral galaxies can generally be classified into two types: normal spirals (letter S) and barred spirals (letter SB). Both types of spirals can be further separated by looking at the details of how they are put together. It is shown by adding a lowercase letter to the morphological type, as in the following example: Early (Sa, SBa), intermediate (Sb, SBb) and late (Sc, SBc) galaxies

[18 - 20]. We have used cosmological constants with the following values throughout this work $H_0 = 70$ km s^{-1} / Mpc, $\Omega_M = 0.3$, and $\Omega_\Lambda = 0.7$ [21, 22].

2-2: Characterization Parameters

1- To get a calculated distance of these galaxies D, we needed to calculate the absolute magnitudes of the galaxies (M_B). So, M_B represents the blue absolute magnitude of the galaxies at 0.44 µm blue-band, in the unit (mag) calculated from the Tully-Fisher relation. The Tully-Fisher relation as M_B vs $V_{rot.max}$ for a sample of Sa, Sb, and Sc is given by [23, 24].

$$\mathrm{M_B} = -9.95 * \log_{10} (\mathrm{V_{rot.max}}) + 3.15 \quad \text{, for type Sa, SBa} \quad (1)$$
$$M_B = -10.2 * log_{10} (V_{rot.max}) + 2.7 \quad \text{, for type Sb, SBb} \quad (2)$$
$$M_B = -11.0 * log_{10} (V_{rot.max}) + 3.31 \quad \text{, for type Sc, SBc} \quad (3)$$

While $\mathbf{V_{rot.max}}$ is the maximum velocity of rotation, this number represents the actual maximum speed of rotation corrected for inclination and is stated in km/s that is calculated by this relation [8].

$$V_{rot.max} = \frac{v_{maxg}}{Sin(i)} \quad (4)$$

Therefore, D is the galaxy's distance scale in units (Mpc) calculated using the cosmological distance modulus method of the galaxy of the following form [25]:

$$D = 10^{\frac{(m_{btc} - M_B - 25)}{5}} \quad (5)$$

2- L_B is luminosity visible in blue (LB) in solar units which has been computed at wavelength 4400A°, using the relations [26, 27]

$$L_B(L_\odot) = 10^{(12.192 - (0.4 * m_{Btc}))} \times D^2 \quad (6)$$

3- $\mathbf{M_{HI}}$ is the total of all the mass that is composed of neutral hydrogen gas (HI) in the solar mass unit ($M_\odot$) measured using the standard method using the 21 cm magnitude (m_{21}). Additionally, because the HI line appears visually faint on galactic estimates, its strength is mass proportionate [28, 29 , 30].

$$M_{HI=} 2.36 \times 10^5 \times D^2 \times \int S_{HI,V} dv \quad (7)$$

The raw fluxes $S_{HI} = \int S_{HI,V} dv$ is the HI line density able to integrate in to the Jy Km/s using m21 apparent magnitudes defined as [31]:

$$S_{HI} = 10^{-0.4 * (m_{21} - 17.4)} \quad (8)$$

4- $\mathbf{M_{gas}}$ is the total amount of gas in solar mass unit ($M_\odot$), in which the interstellar medium (ISM) contains a variety of components depending on the local conditions, viz. neutral HI, ionized H (HII), molecular H2, and helium He [32]. Therefore, M_{gas} is shown by the formula [33].

$$M_{gas} = 1.4 * M_{HI} \quad (9)$$

To account for contributions from metals and helium, we utilized the atomic gas content M_{gas} equal to 1.4 M_{HI}.

5- $M_{Star}(B-V)$ The mass-to-light ratio Υ^* can now be approximated by stellar population estimates with reasonable accuracy, even for the combined star populations of morphology-types spiral galaxies. When estimating the star population, the B-V color is prioritized. By estimating the stellar mass-to-light ratio Υ^* from the measured color (the index colors B-V in Table 1 that are bracketed), the same model [13] is adopted here, but the stellar population is dependent on the measured index color. *M_{star} (B-V)* is the most accurate estimate of the mass contained in stars when normalized to dynamical constraints of total apparent corrected (B-V) color index calculated through [10, 13].

$$M_{Star}(B-V) = L_B * \Upsilon^*_{B-band} = L_B * [1.936 * 10^{0.4*(B-V)} - 1.943](\text{in } M_\odot) \quad (10)$$

With the best stellar system disk fitting to the spiral galaxies, $\boldsymbol{\Upsilon^*_{B-band}}$ is the star population mass-to-light ratio in the blue band.

6- *M_{bar}(B-V).* Many of the angular momentum and mass in spiral disk galaxies are not found in the stars themselves, but rather in the disk gas. The masses of galactic HI regions may appear in galaxies where HI disk size is significantly greater than stellar disk size [34]. Hence, it is essential to calculate baryonic mass, which includes both gas and stars. *M_{bar}(B-V)* is the baryonic mass at the (B-V) color index, which represents the sum of the stellar mass and the gas mass [35].

$$M_{bar}(B-V)\ (in\ unit\ M_\odot) = M_{gas} + M_{Star}(B-V) \quad (11)$$

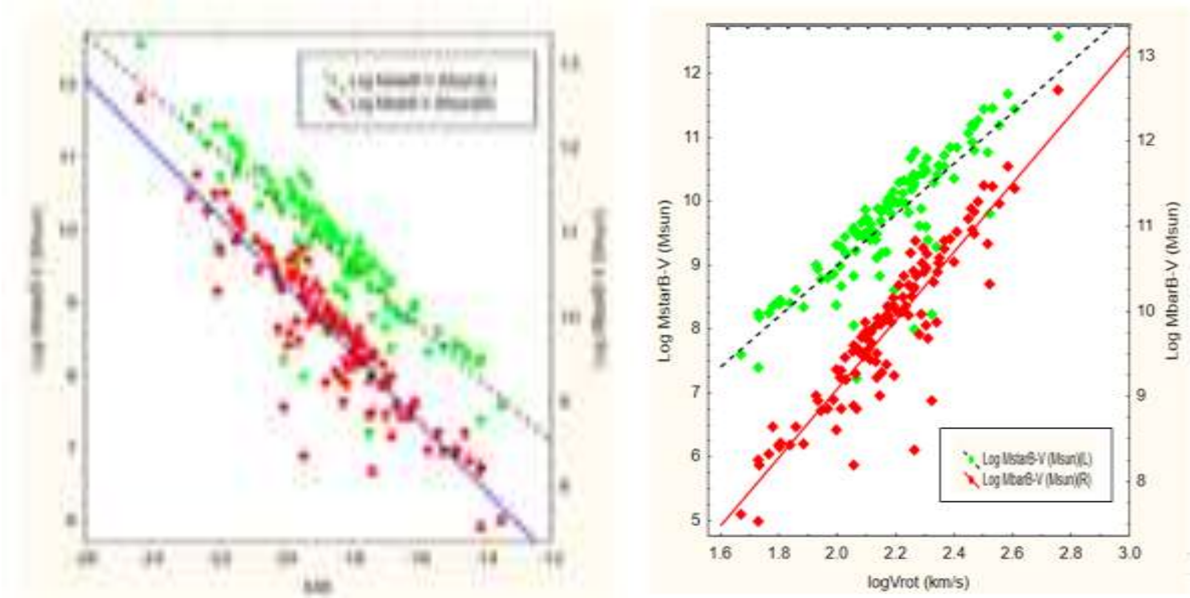
3- Results of statistical calculations and their discussion.

We present the results of the statistical analysis in this paper using WIN statistics software to check for a link and determine if there is a correlation of luminosity between multiple bands. To reach accurate results regarding the extent of correlation between the calculated physical properties, it uses the best line regression, as well as to determine whether there is any regression strength between the characteristics of the two parameters. The linear partial correlation coefficient (R) values fall between [+1, -1]. If the regression value is ±1, then the two components are completely related. However, when the measure of regression correlation (R) is between 0 and 1), the best value is close to 1, which means that the fitting model explains the variability of the responding points, as well as their mean [36, 37]. Utilizing statistical regression techniques, the spirals of galaxies are used for analysis:

For the early spirals extragalactic (N_{early} =116), it shows a strong relation between Log V_{rotmax} and log M_{Star}(B-V), as well as, between Log V_{rotmax} and log M_{bar}(B-V), with a very strong positive correlation coefficient ($R_{MStar(B-V)}$, $R_{Mbar(B-V)}$ = 0.75, 0.84 respectively). Furthermore, these correlations have an extremely high probability of ($P \leq 10^{-7}$), and we noticed that the slope is nearly linear for these relationships ($\log MStar(B-V) \propto \log Vrotmax^{0.83\mp0.07}$, $\log Mbar(B-V) \propto \log Vrotmax^{0.87\mp0.05}$), as shown in Figure 1-a. The analysis also found a strong relationship between $LogM_B$ and log M_{Star}(B-V), as well as between $LogM_B$ and $logM_{bar}$(B-V). The existence of a negative correlation was recorded between log M_{Star}(B-V) and log M_{Star}(B-V), with a partial coefficient of ($R_{MStar(B-V)}$, $R_{Mbar(B-V)}$ = - 0.75, - 0.84, respectively). Futhermore, these correlations have a very good probability of ($P \leq 10^{-7}$), and according to the findings of statistical analysis, the slope is approximately linear with a standard error (±) of this value

($\log M_{Star}(B-V) \propto \log MB^{-0.83\mp0.07}$, $\log M_{bar}(B-V) \propto \log MB^{-0.87\mp0.05}$). All of these relations have the mean values of the logarithmic scale of masses of all the stallers and baryonic (9.71 ∓ 0.09, 9.8 ∓ 0.085) with a minimum mass of star $M_{Star(B-V)min}$ =1.63× 10^7 $M_\odot$, and maximum mass of star $M_{Star(B-V)max}$ =3.8× 10^{12} $M_\odot$, however; the minimum baryonic mass is $M_{bar(B-V)min}$=3.31× 10^7 $M_\odot$ and maximum baryonic mass is $M_{bar(B-V)max} \approx$ 4× 10^{12} $M_\odot$ for this type of spiral galaxies (see Figure1-b). Additionally, results indicated that there is a relation between Log L_B and log M_{gas}, as well as, between Log L_B and log M_{gas}, with a positive and a

good correlation coefficient (R_{Mgas} =0.68). Moreover, this correlation has a very strong probability of ($P \leq 10^{-7}$) the results exhibited that the slope is almost linear (logMgas $\propto$ $logLB^{0.69\mp0.07}$). The average values with a standard error of the logarithmic scale of mass of atomic gas are (8.64 ∓ 0.097) with a minimum gas mass value
of about $M_{gas(min)}$ =2.691×10^{5} $M_{\odot}$ and a maximum mass of gas $M_{gas(max)}$ =8.317×10^{10} $M_{\odot}$, as demonstrated in Figure 2.



(a) (b)

Figure 1: (a) The relation between the staller mass of galaxies M_{Star}(B-V) (on the left), baryonic mass M_{bar}(B-V) (on the right), and Log $V_{rot.max}$. The straight red line and the dashed black line, respectively, indicate the fits to all the values for M_{bar}(B-V) vs $V_{rot.max}$ and M_{Star}(B-V) vs $V_{rot.max}$ correspondingly. **Fig. (b)** The relationship between staller masses of galaxies M_{Star}(B-V) and M_B (on the left), baryonic mass M_{bar}(B-V) and M_B (on the right). The dashed black straight line represents the fitting of all the data for M_{Star}(B-V) and the fitting of all data is depicted by the straight blue line for M_{bar}(B-V) versus M_B , respectively**.**

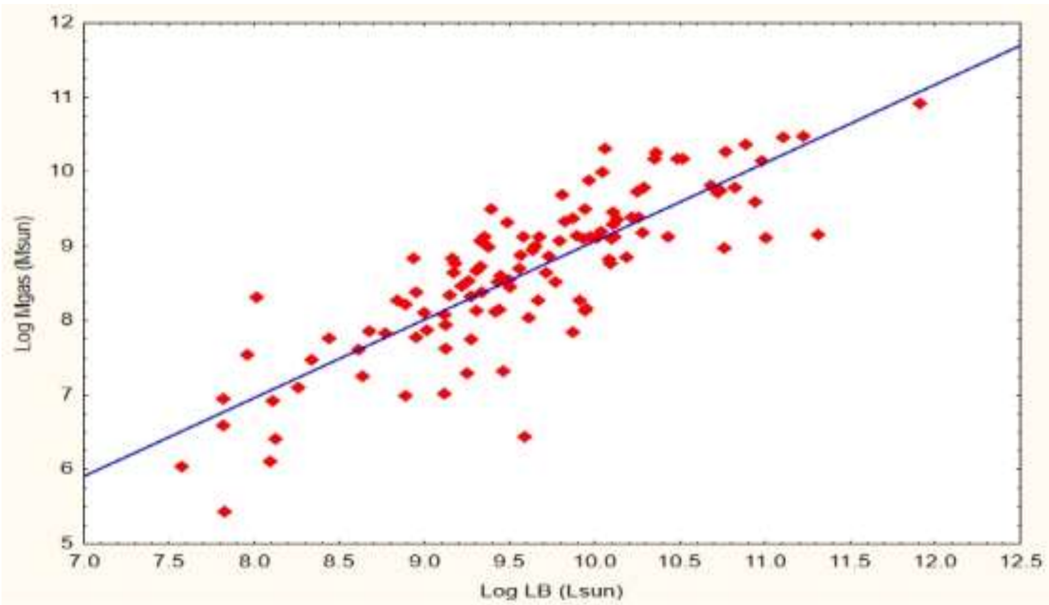
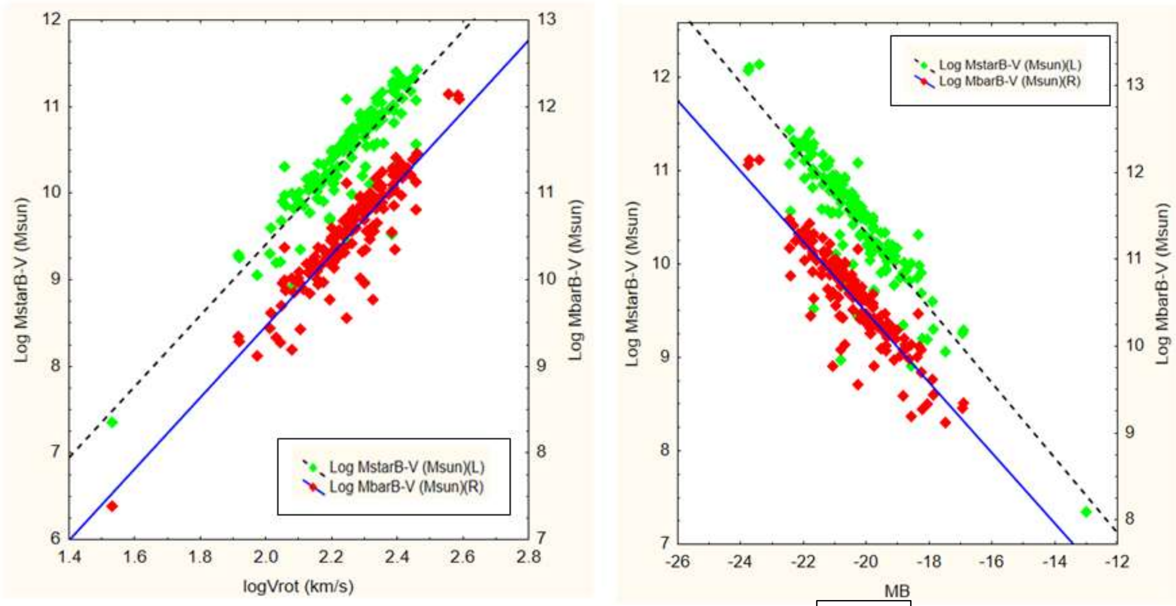


Figure 2: The relation between log Mgas and Log L_B for early spiral galaxies.

For intermediate-type spirals extragalactic ($N_{intermediate}=150$), our work reveals that there is a robust relation between $LogV_{rotmax}$ and log M_{Star}(B-V), as well as the relationship between $LogV_{rotmax}$ and log M_{bar}(B-V), with a very strong correlation coefficient ($R_{MStar(B-V)}$, $R_{Mbar(B-V)}$, = 0.81, 0.86, respectively). Similarly, these correlations have a very high probability of ($P \leq 10^{-7}$), and analysis of our results shows that the slope of the correlations is linear ($\mathrm{logMStar(B-V)} \propto \mathrm{logVrotmax}^{0.86\mp0.05}$, $\mathrm{logM_{bar}(B-V)} \propto \mathrm{logVrotmax}^{0.86\mp0.04}$), (see Figure 3-(a)). In our study, there is a discernible inverse relationship between $LogM_B$ and log M_{Star}(B-V), log M_{bar}(B-V), with a partial coefficient of $R_{MStar(B-V)}$, $R_{Mbar(B-V)}$= - 0.81, - 0.86 respectively. Likewise, this correlation has a high significance in the probability level ($P\leq 10^{-7}$), where the slope is nearly linear in relationships ($\mathrm{logMStar(B-V)} \propto \mathrm{logMB}^{-0.86\mp0.05}$, $\mathrm{logMbar(B-V)} \propto \mathrm{logMB}^{-0.86\mp0.04}$), as shown in Figure 3-(b). In all relationships, we find that the mean values of the logarithmic scale for stellar and baryonic masses are equal to (10.44 ∓ 0.053 ,10.51 ∓ 0.051), with $M_{Star(B-V)min}$ =2.23×10^{7} $M_\odot$, $M_{Star(B-V)max}$ =1.348×10^{12} $M_\odot$, $M_{bar(B-V)min}$=2.398×10^{7} $M_\odot$ and $M_{bar(B-V)max}$=1.38×10^{12} $M_\odot$. In these galaxies, the relation between Log L_B and log Mgas, as well as, between Log L_B and log M_{gas}, is found to have a positive and a strong correlation coefficient (R_{Mgas} = 0.80). Furthermore, this correlation has a high probability of ($P \leq 10^{-7}$). Figure 4 displays a roughly linear slope ($\mathrm{logMgas} \propto \mathrm{logLB}^{0.84\mp0.05}$). The mean values of the logarithmic scale of masses of gas (9.49 ∓ 0.052) with the minimum and maximum values for gas mass approximately $M_{gas(min)}$ =1.621×10^{6} $M_\odot$ and $M_{gas(max)}$=9.33×10^{10} $M_\odot$.



(a) (b)

Figure 3: (a) Represents two commons of the relationship between M_{star}(B-V) and M_{bar}(B-V) vs Vrot.max. **Fig.3-(b)** Illustrates two commons of the relationship between M_{star}(B-V) and Mb_{ar}(B-V) vs M_B. The dashed black line indicates fitting for all M_{star}(B-V) results, whereas the straight blue lines exhibit fitting for all M_{bar}(B-V) database results versus $V_{rot.max}$ and M_B.

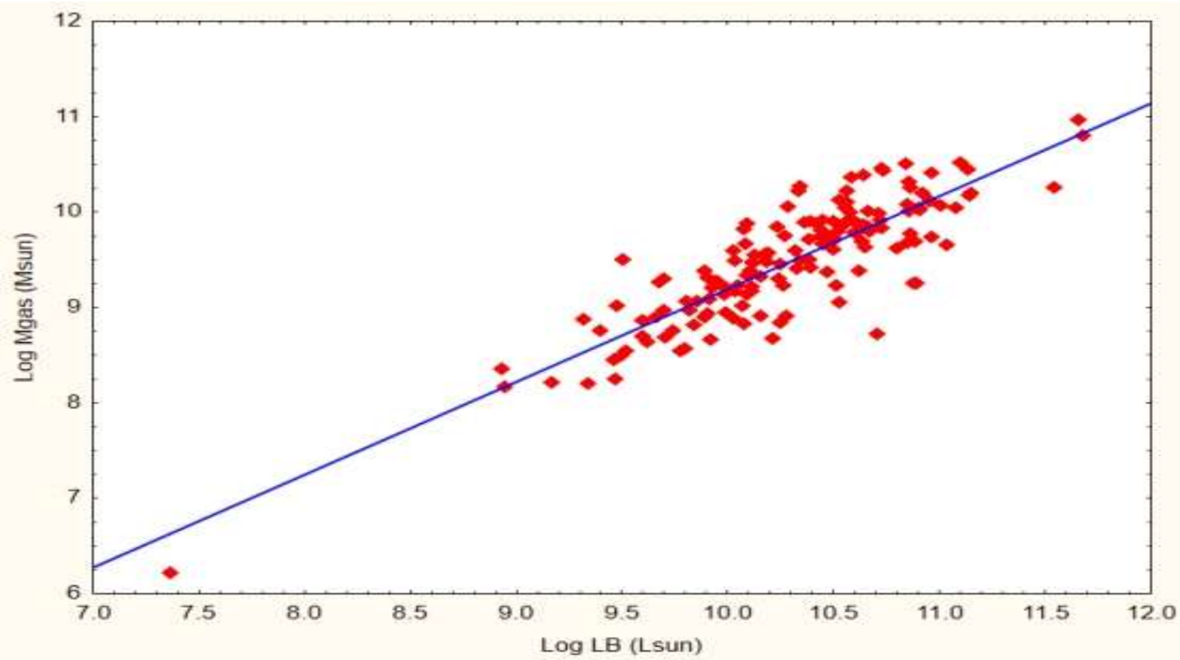


Figure 4- The relationship between log Mgas and Log L_B for intermediate spiral galaxies.

In the late spirals' extragalactic (N_{late} =146), these galaxies exhibited a very strong linear relation between Log V_{rotmax} and log M_{Star}(B-V), as well as, between Log V_{rotmax} and log Mbar(B-V), with a positive and very good correlation coefficient ($R_{MStar(B-V)}$, $R_{Mbar(B-V)}$, = 0.88, 0.94, respectively) and a very strong likelihood of ($P \leq 10^{-7}$), with the slope being linearly ($\log M_{Star}(B-V) \propto \log Vrotmax^{0.91\mp0.04}$,$\log M_{bar}(B-V) \propto \log Vrotmax^{0.96\mp0.03}$).
We can refer to Figures 5-(a), 5-(b) to estimate the correlation with the morphological type of the parameters of these galaxies. The strongest correlations are between Log M_B and log $M_{Star(B-V)}$, as well as, between Log M_B and log $M_{bar(B-V)}$, with a partial negative correlation coefficient of ($R_{MStar(B-V)}$, $R_{Mbar(B-V)}$ = -0.88, -0.94 respectively). The fitting relationships Log M_B and log $M_{bar(B-V)}$ and Log M_B and log $M_{star(B-V)}$ have a linear regression association with a linear slope ($\log M_{Star}(B-V) \propto \log MB^{-0.91\mp0.04}$,$\log M_{bar}(B-V) \propto \log MB^{-0.96\mp0.03}$), and have a very good probability of ($P \leq 10^{-7}$). Note that the average values with standard error of the logarithmic scale of masses for stellar and baryonic ($10.37 \mp 0.076, 10.48 \mp 0.073$) as well as minimum, maximum values ranging from $M_{Star}(B-V)_{min}$ =1.122× 10^8 $M_\odot$ and $M_{Star(B-V)max}$ =4.466× 10^{12} $M_\odot$, $M_{bar}(B-V)_{min}$=1.34× 10^8 $M_\odot$ and $M_{bar(B-V)max}$=5.88× 10^{12} $M_\odot$.

Figure 6 shows the Log L_B and log M_{gas} relation for the 146 late-type spiral galaxies. Indeed, there is a positive and very robust correlation coefficient (R_{Mgas} =0.93). Furthermore, this correlation has an extremely high likelihood of ($P \leq 10^{-7}$), with a very linear slope relationship ($\log Mgas \propto \log LB^{0.91\mp0.03}$). The mean values of the logarithmic scale of masses of gas are (9.65 ∓ 0.072) with $M_{gas(min)}$ =1.862 × 10^7 $M_\odot$ and $M_{gas(max)}$ =1.318 × 10^{12} $M_\odot$.

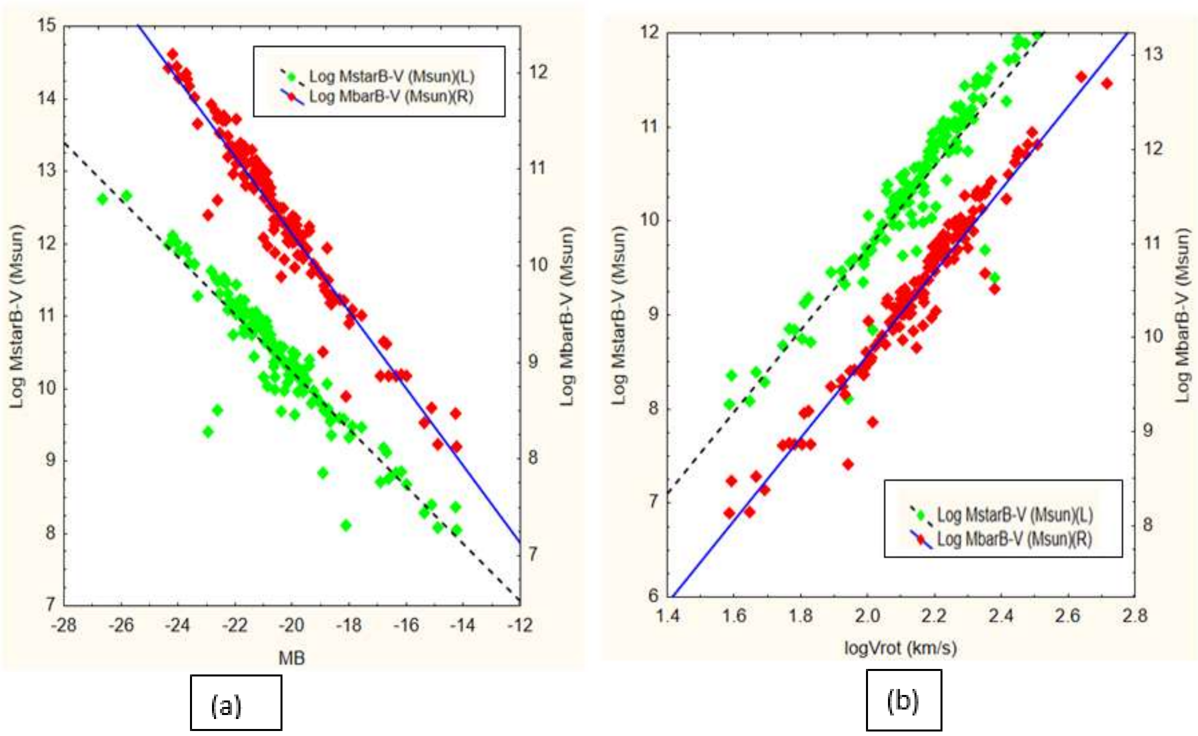


Figure 5-(a) Shows two prevalent patterns in the relationship between M_{Star}(B-V) and M_{bar}(B-V) versus $Vrot_{max}$. **Fig.5-(b)** Shows two prevalent patterns in the association betweenM_{Star}(B-V) and M_{bar}(B-V) versus M_B . The dashed black line represents fitting for all results for M_{Star}(B-V) and the straight blue lines describe fitting for all database Mbar(B-V) vs. Vrotmax and M_B .

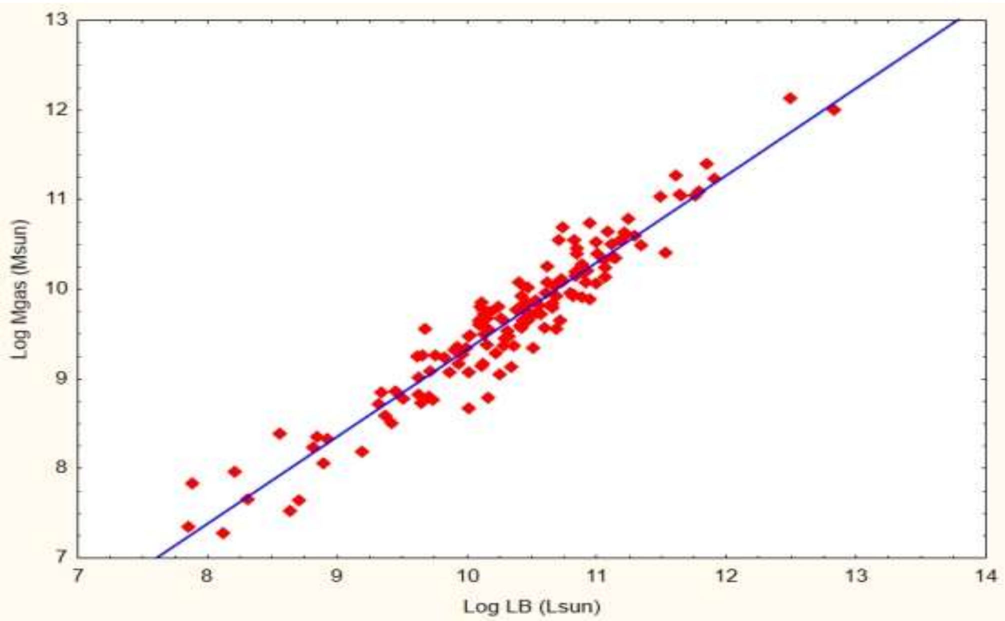


Figure 6: The relationship between log Mgas and Log L_B for late spiral galaxies.

The disk system of spiral galaxies revolves around their centers. Both the stars and the gases in the disk system follow the rotation. From the galaxy's center outward, the rotational velocity increases rapidly before leveling off for the majority of the remaining disk at a nearly steady amount. While some disks continue to increase slightly with radius, others "flip over" and begin to fall slightly. The information in the orbits about the total mass encircled by the orbit can be used to explain this rotation. Scaling connections between the luminous characteristics of spiral galaxies (luminance or disk illumination) and their kinematic characteristics (rotational speed or circular velocity) are noticed. As a result, spiral galaxies and their star inhabitants must develop and evolve in a way that places them on these scaling linkages. These findings strongly imply that the rotational speed and total baryonic disk mass are the fundamental factors in the Tully-Fisher formula. There are several significant applications of the baryonic Tully-Fisher relationship (BTF). The fact that it functions as stars in spiral galaxies makes it appropriate for compound stellar population systems. The shape of this relationship is $M_{bar}(B-V) = aV_{rot.max.}^{b}$, where the slope of (b) and (a) is the normalized number. Figures 1, 3, and 6 show the compiled results in details. The slope (b) rapidly increases as the star population's estimated mass-to-light ratio rises, depending on the morphological types of spiral galaxies from early (Sa-SBa), intermediate (Sb-SBb) to late(Sc-SBc, Sd-SBd, Sm-SBm). The fit for the typical scatter gives $M_{bar}(B-V) \approx\ 60V_{rot.max.}^{4}$ for early and intermediate types of spirals, while for $M_{bar}(B-V) \approx\ 60V_{rot.max.}^{5}$ for late spirals. Our outcomes in this part are consistent with the results of the analysis in the papers [8, 13] and differ slightly from the results of the author's Bell and de Jong, and Gurovich et al [38, 39], especially in early and intermediate-formation spiral galaxies (*a ≈ 4*). Bell and de Jong in 2001 discovered a slightly shallower slope (*a ≈3.5*). Low-mass galaxies followed a sharper slope, according to a breakdown in the relation found by Gurovich et al. in 2004. There is a correlation between disk spiral galaxies' color in the index colour (B-V), stellar trace, and mass-to-light ratio, as well as with M_{bar} *(B-V)*, with more massive morphological types of spiral galaxies typically being more developed. The degree of disk spiral maximality is fundamentally dependent on the illumination of the stellar surface. Various scientific arguments suggest additional incredibly massive baryon stores are almost certainly present in disk spiral galaxies when the observable stars and neutral hydrogen gas are considered.

4-Conclusion

Using scaling parameter relationships in various kinds of spiral galaxies, we have looked into the kinematic characteristics of the gaseous stellar dynamics. These results indicate the following:

A- In the early and intermediate types of extragalactic spirals, we noticed that empirical affinities between (Log V_{rotmax} - log $M_{Star\,(B-V)}$, Log V_{rotmax} - Log $M_{bar\,(B-V)}$, and LogL_B - log M_{gas}) have a strong regression relationship and it appears that the slope is almost linear (*slope ~ 1)*. Our results also demonstrate a negative association between (Log M_B -Log $M_{Star\,(B-V)}$, Log M_B- Log $M_{bar\,(B-V)}$) with a partial coefficient, in addition, these correlations have a very high probability.

B- In the late type of spirals, we specified that there is a very significant connection between (Log $\mathrm{Vrot_{max}}$ and Log $\mathrm{M_{Star}(B-V)}$, Log $\mathrm{Vrot_{max}}$ and Log $\mathrm{M_{bar}(B-V)}$, Log L_B and Log Mgas, Log MB and Log $\mathrm{M_{Star}(B-V)}$, Log MB and Log $\mathrm{M_{bar}(B-V)}$), and the slope seems to be very steep (*slope =1*). Our findings also reveal a negative association between (Log M_B - Log $M_{Star\,(B-V)}$, Log M_B- Log $M_{bar\,(B-V)}$), with a partial coefficient, thus, these links also have an extremely high likelihood.

C- Our findings show that the best fit of the baryonic mass with the maximum rotational speed for disk galaxies is $M_{bar}(B-V) \approx\ 60V_{rot.max.}^{4}$ for the early and intermediate types of spirals, whereas this relation appears to be steeper in the late-type spirals $M_{bar}(B-V) \approx\ 60V_{rot.max.}^{5}$. We are able to conclude that the rotational speed and baryonic disk mass are related fundamentally through the baryonic Tully-Fisher link (BTF). Moreover, it suggests that there is another significant source of baryons that contribute to the total: the stars and gas that have been observed in disk spiral galaxies contribute to nearly all of the baryonic disk mass, $M_{bar}(B\text{-}V)= M_{star}(B\text{-}V)+M_{gas}$ within them.

D- Our results demonstrate a significant relationship between the amounts of observable baryonic matter and dark matter in certain spiral galaxies.The analysis indicates that the slope steadily increases in the types of spirals, especially late types, and dynamic gaseous stellar masses are expected to increase. This late type of spiral galaxies indicates that they have a very large stellar and gaseous content and are high sources of stellar formation and optical brightness.

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