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Comparison of the Physical Trace of Global Luminosity Emission at Multiwavelength and Star Formation Rates of Luminous Infrared Galaxies Using Extragalactic Distance Scale Techniques

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Abstract

This paper aims to study the rate of star formation (SFR) in luminous infrared galaxies at different wavelengths using distance measurement techniques (dl, dm) and to know which methods are the most accurate to determine the rate of star formation as we present through this research the results of the statistical analysis (descriptive statistics) for a sample of luminous infrared galaxies. The data used in this research were collected from the NASA Extragalactic Database (NED) and HYPERLEDA, then used to calculate the star formation rate and indicate the accuracy of the distance methods used (dl, dm). Two methods were tested on Hα, OII, FIR, radio continuum at 1.4 GHz, FUV, NUV, and total (FUV + FIR). The results showed that the dl measurement method has the most accuracy in calculating SFR as it depends on the redshift where the relationship between them is direct. while the other distance method (dm) depends on absolute blue magnitude (MB), it was somewhat less accurate, but the two methods are helpful for this type of calculation.

Keywords: Luminous infrared galaxies; star formation rate; luminosity distance, modulus distance.

مقارنة الأثر الفيزيائي لانبعاث الضيائية الشامل عند ألاطوال االموجية المتعددة ومعدلات تكوين النجوم لمجرات الأشعة تحت الحمراء المضيئة باستخدام تقنيات مقياس المسافة المجرات الخارجية

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الخلاصة:

تهدف هذه الورقة البحثية الى دراسة معدل تشكل النجوم (SFR) في مجرات الأشعة تحت الحمراء المضيئة بأطوال موجية مختلفة وباستخدام تقنيات قياس المسافة (مسافة اللمعان ، معامل المسافة) ومعرفة الطرق الأكثر دقة في قياس معدل تكوين النجوم ومقارنتها ، كما سنعرض من خلال هذا البحث نتائج التحليل الإحصائي (الإحصاء الوصفي) لعينة من المجرات تحت الحمراء المضيئة. تم جمع البيانات المستخدمة في هذا البحث من قاعدة بيانات ناسا خارج المجرة (NED) و HYPERLEDA، ثم استخدمت البيانات لحساب معدل تكوين النجوم وبيان دقة طرق المسافة المستخدمة (dl، dm). وتم اختبار الطريقتين على Hα و OII و

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FIRوسلسلة الراديو عند 1.4 جيجا هرتز و FUV و NUV والإجمالي (FUV +FIR) . وأظهرت النتائج أن طريقة قياس dl هي الأكثر دقة في حساب (SFR) لأنها تعتمد على الانزياح الأحمر وتكون العلاقة بينهما مباشرة ، أما الطريقة الأخرى للمسافة (dm) فهي تعتمد على المقدار الأزرق المطلق (MB) وكانت أقل دقة إلى حد ما ، لكن الطريقتين مفيدة في هذا النوع من الحسابات.

1. Introduction

The rate of star formation is one of the significant parameters in the process of studying and understanding the evolutionary stages of galaxies, as many different wavelengths indicate the rate of star formation, such as a deep-red visible spectral line of the hydrogen atom, $H\alpha$, OII emission line luminosities, ultraviolet UV in the Far-UV (FUV), and near UV (NUV) bands, far infrared luminosity (FIR), and radio luminosity at 1.4 GHz [1]. The star formation process involves dust and gas coming together in space and forming nebulae. As these nebulae condense under gravity, leading to the formation of a star, scientists describe these nebulae as generating stars [2,3]. The infrared luminosity of galaxies that arise from thermal dust emissions has been used as an indication of the rate of star formation (SFR), as it is necessary to understand how stars form in the universe, especially since the current universe is filled with stars in addition to, very large amounts of radiation energies [4,5]. Therefore, the nature of the birth and formation of a star is necessary for understanding how the current universe formed [4].

Many factors affect the rate of star formation, including the temperature of the gas, magnetic influences, ionizing photons from nearby stars, and gravity, as stars are formed by the gravitational contraction of large dust and gas clouds of interstellar material [6,7].

Many techniques are used to measure the extragalactic distance, including the two methods used in this research, luminosity distance (dl) and modulus distance (dm). The luminosity distance technique allows us to measure the distance of objects through their brightness, as it depends directly on the redshift, which is one of the remarkable concepts in cosmology [8]. In terms of modulus distance, it can be defined as the difference between apparent and absolute magnitude (m-M), where the difference between the two magnitudes is used to calculate the distance between stars and objects [9].

Several previous studies have shown star formation rates for luminous infrared galaxies. Lisa J. K et al. (2004) studied the emission line of OII as an indicator of the star formation rate and compared it with the Hα emission line. They found a systematic difference between the SFR Hα and SFR OII using the Kennicutt calibrations. The difference results from using the observed uncorrected OII/Hα ratio to convert the OII luminosity into an SFR indicator [10]. J. Iglesias-Paramo et al. (2006) reviewed star formation in the nearby universe from ultraviolet and infrared points of view. They compared ultraviolet emissions with far infrared radiation to conclude that there are minor differences in the ability to SFR between the NUV and total FIR, where NUVselected galaxies show large values for birth rate (b) for lower masses, dust attenuation, and SFR, while other selected galaxies FIR only 20% of them showed high birth rates(b) [4]. Wiphu Rujopakarn et al. (2010) investigated the evolution of star formation in galaxies, where they surveyed star-forming galaxies in the redshift range 0.6 to 3.8 at 24µm rest farm luminosity. They found many active galactic nuclei (AGN) are formed from star formation activity [11]. Miguel P. S. (2011) concluded that infrared galaxies are a significant and effective contributor to star formation at high redshifts, based on his thesis on star formation and nuclear activity in infrared galaxies [12]. A. Domınguez et al . (2013), Through their research, the Hα line was studied for 128 galaxies. The percentage of star formation was studied in the redshift range (z) between 0.75-1.5, where they measured the percentage of interstellar dust extinction as evidence of the brightness of Hα. The galaxies with a high redshift have a higher brightness at Hα [13].Veronique Buat. (2015), through his research on measuring the rate of star formation, showed the need to study and understand SFR in galaxies because of its importance in knowing the evolution of galaxies and how they are formed. It was found that data of different wavelengths are too important and necessary for recovering visible and hidden star formation [14]. Barnes A.T. et al. (2017) analyzed the star formation process in the galaxy's center. They concluded that the selected region has less potential for star formation than the disk because it suffers from high pressures, density of gas, and a high ionization field for cosmic rays compared to other parts of the galaxy, and they reached this conclusion by using Spitzer and Herschel infrared observations [15]. Miguel P.T. et al. (2021) studied the rate of star formation and the activity of the galactic nucleus in the luminous infrared galaxies (LIRGs), where they explained through their research a glimpse of the influence of infrared radiation in the study of the interstellar medium, star formation, and the active galactic nucleus they demonstrated the importance of infrared rays in observing and studying star formation rates. In addition, they expected these rays would bring about a breakthrough in the star formation study obscured by dust [16]. A.Teklu et al. (2023) have found through cosmic simulations that the star formation rate decreases during galaxies' evolution due to the depletion of cold gas or gas responsible for star formation in galaxies [17].

2. Data collection

The NASA /IPAC Extragalactic Database (NED), which is considered one of the essential astronomical databases on the internet used to collect and link data for external bodies, as it contains information for about 206 million astronomical bodies and contains a measure of the redshift of more than 5 million bodies [18,19]. This site provides many of these parameters such as the redshift of galaxies (z)and the Flux density of (F60J, F100J, F1.4 GHz, (FUV), (NUV), and FOII). The Hypract Lyon Meudon Extragalactic Database (HyperLeda), is a database of galaxies established in 1983 that was utilized to obtain apparent and absolute magnitude (m_{btc}, M_B) [20]. The names of the galaxies in Table (1) were taken from our previous study [21].

From Table1, column 1 presents the number of objects, column 2 presents the name of the galaxy, column 3 is devoted to the morphological classification, column 4 is specified for the redshift, column 5 gives the apparent B-magnitude, column 6,7 presents the infrared fluxes in different bands at 60 and 100 Jansky, column 8 presents the flux of radio at 1.4 GHz, column 9 refers to the magnitude in red band, column 10,11 refers to ultraviolet fluxes at far and near bands, column 12 presents the flux at OII, and column 13 refers to the absolute blue magnitude.

Table1: Parameters of the studied galaxies samples, from NED&HYPERLEDA.

No.	Name of galaxy	Morphological type	z	m_{btc} (mag)	F60 Jy	F100 Jy	F1.4 Jy	R band	F_{FUV} $erg.s^{-1}$	F_{NUV} $erg.s^{-1}$	F_{OII} $erg.s^{-1}$	MB
1-	NGC 23	Sa	0.01523	12.51	9.03	15.66	7.43E-25	12.035	1.06E-26	2.34E-26	3.52E-13	-21.45
2-	NGC5257	SABb	0.02267	13.04	8.1	13.63	4.98E-25	13.42	2.84E-26	3.65E-26	4.44E-13	-21.96
3-	NGC5258	SBb	0.01523	13.5	3.94	7.27	4.3E-21	13.399	1.16E-26	1.89E-26	1.35E-13	-21.5
4-	NGC 877	SABc	0.01306	11.82	8.82	25.56	1.1E-24	/	5.11E-26	1.02E-27	2.7E-16	-21.93
5-	PGC049264	SABb	0.03304	15.99	6.27	10.71	4.4E-25	14.053	/	/	/	-19.86
6-	NGC 958	SBc	0.01915	11.86	5.85	15.08	7.19E-25	12.219	1.5E-26	2.46E-26	3.2E-13	-22.6
7-	NGC 3683	SBc	0.0057	12.24	13.87	29.3	1.27E-24	12.189	8.79E-27	/	/	-20.26
8-	UGC 1845	Sab	0.03304	14.32	9.919	15.51	6.23E-25	/	/	/	/	-19.44
9-	UGC 02982	SABa	0.01514	13.31	8.391	16.82	9.24E-25	/	6.3E-27	3.38E-28	9.7E-16	-20.94
10-	UGC 3351	Sab	0.01486	13.99	14.45	29.26	1.48E-24	/	/	/	/	-20.01

3. Calculations, Statistical Analyses, and Results

In this research, the star formation rate for different wavelengths of luminous infrared galaxies, using different distance measurement methods (luminous distance, modulus distance) was calculated by the equations in the following sections. Table 2 displays the average values for the various parameters of luminous infrared galaxies, obtained through the “statistics-wine program”. The number of valid galaxies, standard error of the arithmetic averages, minimum and maximum values, and standard deviation are listed in Table 2.

It is also possible to see from Table 2 that there are differences in the average values and standard deviation of the star formation rate for luminous infrared galaxies at different wavelengths for the distance measurement methods used.

Table 2: The descriptive statistics results of the data.

Variable	**Descriptive Statistics**						
	Valid N	**Mean**	**Median**	**Minimum**	**Maximum**	**Std.Dev.**	**Standard Error**
Log SFR $_{\text{H alpha dl}}$	97	83.73110	83.89140	80.20207	84.84872	0.685951	0.069648
Log SFR $_{\text{H alpha dm}}$	98	83.70883	83.93378	80.11938	85.69538	0.753008	0.076065
Log SFR $_{\text{OII dl}}$	70	72.65523	73.35082	69.38162	74.74326	1.523272	0.182066
Log SFR $_{\text{OII dm}}$	70	79.65106	80.38081	76.34302	81.75162	1.515630	0.181152
Log SFR$_{\text{1.4 dl}}$	122	56.73188	56.82109	53.09929	60.72651	1.232160	0.092638
Log SFR $_{\text{1.4 dm}}$	123	56.72866	56.81547	53.71002	61.11059	1.534010	0.094982
Log SFR $_{\text{FIR dl}}$	133	86.67751	86.92554	84.06152	88.21545	0.791449	0.068627
Log SFR $_{\text{FIR dm}}$	134	86.67130	86.82886	83.70095	88.36184	0.858278	0.074144
Log SFR $_{\text{FUV dl}}$	82	50.33996	50.39406	48.59926	51.95951	0.698988	0.077190
Log SFR $_{\text{FUV dm}}$	83	50.35782	50.48184	48.59043	51.77273	0.697643	0.076576
Log SFR $_{\text{NUV dl}}$	84	50.65166	50.77550	49.12674	52.31232	0.676961	0.073863
Log SFR $_{\text{NUV dm}}$	85	50.66624	50.82553	48.76644	51.83986	0.665334	0.072166
Log SFR $_{\text{total(FIR+FUV) dl}}$	82	86.18293	86.34671	83.66358	87.81751	0.807637	0.096146
Log SFR $_{\text{total(FIR+FUV) dm}}$	83	86.17668	86.34908	83.30301	87.88556	0.924362	0.101462

3.1 The star formation rate of the radio continuum at 1.4 GHz (SFR$_{1.4\ \mathrm{GHz}}$)

For the radio continuum, the star formation rate is calculated from the following equation [22]:

$$\mathrm{SFR}_{1.4\ \mathrm{GHz}} = \frac{\mathrm{L}_{1.4\ \mathrm{GHz}}}{4 * 10^{28}\ \mathrm{erg.s^{-1}.Hz^{-1}}} \tag{1}$$

Where L$_{1.4}$ is the radio luminosity in $erg.s^{-1}.\ Hz^{-1}$ units, and its computed radio flux densities at 1.4 GHz [23].

3.2 The star formation rate of far infrared (SFR $_{\mathrm{FIR}}$)

The following equation estimated the star formation rate in the far infrared wavelength [24,25]:

$$\mathrm{SFR_{FIR}}\ (\mathrm{M_{\odot}\,yr^{-1}}) = \frac{\mathrm{L_{FIR}(erg.s^{-1})}}{2.2 * 10^{43}\mathrm{(erg.S^{-1})}} \tag{2}$$

Where L$_{\mathrm{FIR}}$ is the far infrared luminosity at the wavelength(60-100) µm, in the $(erg.s^{-1})$ unit [26].

3.3 The star formation rate of OII emission (SFR$_{\mathrm{OII}}$)

The relation between OII luminosity L$_{\mathrm{OII}}$ and SFR can be calculated by the following equation [27,28]:

$$\mathrm{SFR_{OII}}\,(\mathrm{M_{\odot}\ yr^{-1}}) = \frac{\mathrm{L_{OII}}}{2.97 * 10^{33}} \tag{3}$$

Where $\mathrm{L_{OII}}$ is the optical luminosity of OII at (λ=372.6nm) in a unit (erg/s) [29].

3.4 The star formation rate of the UV emission ($\mathrm{SFR_{FUV}}$, $\mathrm{SFR_{NUV}}$)

The rate of star formation at far ultraviolet length can be calculated by the following equation [30, 31]:

$$\mathrm{SFR_{FUV}}\,(\mathrm{M_{\odot}yr^{-1}}) = \frac{\mathrm{L_{FUV}(ergs^{-1})}}{3.83 * 10^{33}} * 10^{-9.51} \tag{4}$$

Where $\mathrm{L_{FUV}}$ is the luminosity of far ultraviolet in $\mathrm{erg}s^{-1}$ unit [32].

The rate of star formation at near-ultraviolet length can be calculated by the following equation [30, 33]:

$$\mathrm{SFR_{NUV}}(\mathrm{M_{\odot}yr^{-1}}) = \frac{\mathrm{L_{NUV}(ergs^{-1})}}{3.83 * 10^{33}} * 10^{-9.33} \tag{5}$$

Where $\mathrm{L_{NUV}}$ is the luminosity of near-ultraviolet at $\mathrm{erg}s^{-1}$ unit [34,35].

3.5 The star formation rate of Hα (SFR Hα)

The rate of star formation at Hα calculated by this equation [36, 37]:

$$\mathrm{SFR_{H\alpha}}(\mathrm{M_{\odot}yr^{-1}}) = \frac{\mathrm{L_{H\alpha}}}{1.27 * 10^{41}\ (\mathrm{ergs^{-1}})} \tag{6}$$

Where $\mathrm{L_{H\alpha}}$ is the luminosity of the brightest hydrogen line in the Palmer series, as it has a wavelength of approximately 656.28 nm [38, 39]. As a result of the abundance of hydrogen in the universe, it is considered the most available element. Filters that allow hydrogen permeability have been used to monitor stars and other celestial bodies which are calculated in ($\mathrm{erg}s^{-1}$) unit.

3.6 The star formation total (FIR, FUV)

The SFR total (FIR+FUV) can be calculated by this formula [30, 34]:

$$\mathrm{SFR_{total}}\,(\mathrm{M_{\odot}yr^{-1}}) = \mathrm{SFR_{FUV}} + (1.06) * \mathrm{SFR_{FIR}} \tag{7}$$

The above equations 1 to 7 in this work were calculated in two cases: modulus distance (dm) and luminosity distance (dl), as described in our previous paper [21].

The goal of this study focuses on how to estimate the physical trace of global luminosity emission at multiple wavelengths and the star formation rate in bright infrared galaxies using extragalactic distance scale techniques. Due to this large number of data points, as shown in Table 1, It was required to use the statistics program to analyze the data of 134 galaxies to gain knowledge of the strength of the relationships between the different variables. At first, the partial correlation coefficient was calculated to know the strength of the relationships, as it measures the direction and strength of the linear relationship between two variables by excluding another variable. It was noticed that the results of the partial correlation coefficient were almost equal and convergent for both methods of measuring the extragalactic distance (dl, dm), which means the previous techniques are perfect and positive in measuring distances to outer galaxies, so replace relying on the partial correlation coefficient and resorted to descriptive statistics to find out which methods are considered more accurate, as shown in Table 2. The histogram is used to display data smoothly and easily, and the arithmetic mean and standard deviation are relied upon to determine accuracy, as when the arithmetic mean for both methods is equal, the dispersion is reliable. The lower the dispersion, the more accurate the data [40-43]. The rate of star formation for luminous infrared galaxies was studied using two methods of measuring the external distance, which is the modulus distance (dm), which depends on the difference between the apparent and absolute magnitude, and the luminosity distance (dl), which depends on the redshift (z) [44-45]. The above equations were applied for each method, and then the results were analyzed as follows:

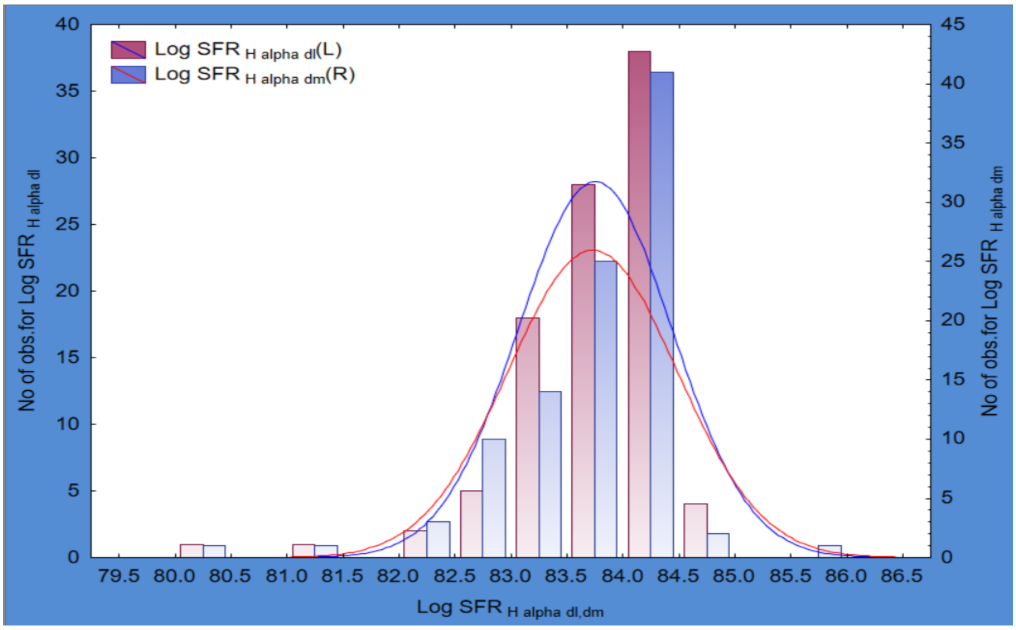

Figure 1: Histogram shows the accuracy of the Log SFR $_{H\ \alpha}$ in both cases of extragalactic distance (dl &dm).

Figure 1 shows the rate of star formation on the hydrogen spectral line, where this line was considered a basic star which was used as an important indicator of the rate of star formation. The Hα emissions originate from the creation of ionized gas by massive O-type stars and early B-type stars, indicating the ongoing process of star formation lasting several million years. Both distance measurement techniques were examined for accuracy, yielding the results in Table 2 showing that Hα emissions arise from the reformation or formation of larger-mass ionized gas in OII and early B-type stars. These emissions follow the star formation process and continue throughout their lifetime for several million years. The accuracy of the two distance measurement methods was tested, and the following results were obtained, as demonstrated in Table 2. Both distance measurement techniques were examined for accuracy, yielding the results displayed in Table 2 On the left of Figure 1, using the luminosity distance (dl) measurement method, the arithmetic mean was equal to ± 83.73, and the standard deviation was equal to ± 0.68. On the right of Figure 1, we noted the measurement method modulus distance (dm), where the arithmetic mean was equal to ±83.70, while the standard deviation was equal to ±0.75. Therefore, despite the similarity of the statistical results, according to the observation of the standard deviation in both methods, dl is considered more accurate in the measurement because its standard deviation is relatively less than dm. This result means that the data is tightly clustered around the mean because the Hα line is widely used as an indicator of the rate of star formation in the universe with a high redshift. Based on the truth that the luminosity distance directly depends on the redshift, this method was considered more accurate than others.

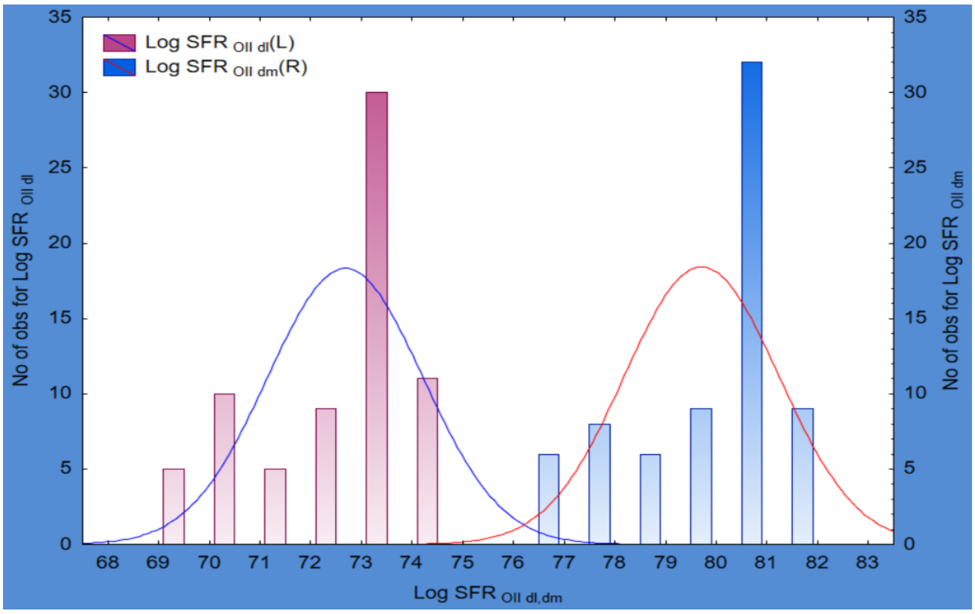

Figure 2: Histogram shows the accuracy of the Log SFR $_{OII}$ in two cases of extragalactic distance (dl&dm).

The rate of star formation for ionized oxygen is seen in Figure 2. In terms of blue color, this line had the strongest blue color emission. However, overall, the OII lines provide a considerable estimation of the star formation rate in a sample group of luminous infrared galaxies and for both cases of (dl, dm) distance measurement techniques. Based on the results of descriptive statistics, the distance technique on the left of Figure 2 (dl) had an arithmetic mean equal to ± 72.65, and its standard deviation was ±1.52. On the right of Figure 2, the second method of distance (dm) was demonstrated, where its arithmetic mean was ±79.65, and its standard deviation coefficient was ±1.51. Therefore, in this case, the modulus distance is more accurate than (dl) because the OII emission line correlates very well with the absolute magnitudes of the B band. Therefore, the modulus distance technique relies on the difference between the magnitudes, which leads to this technique being more accurate than the (dl).

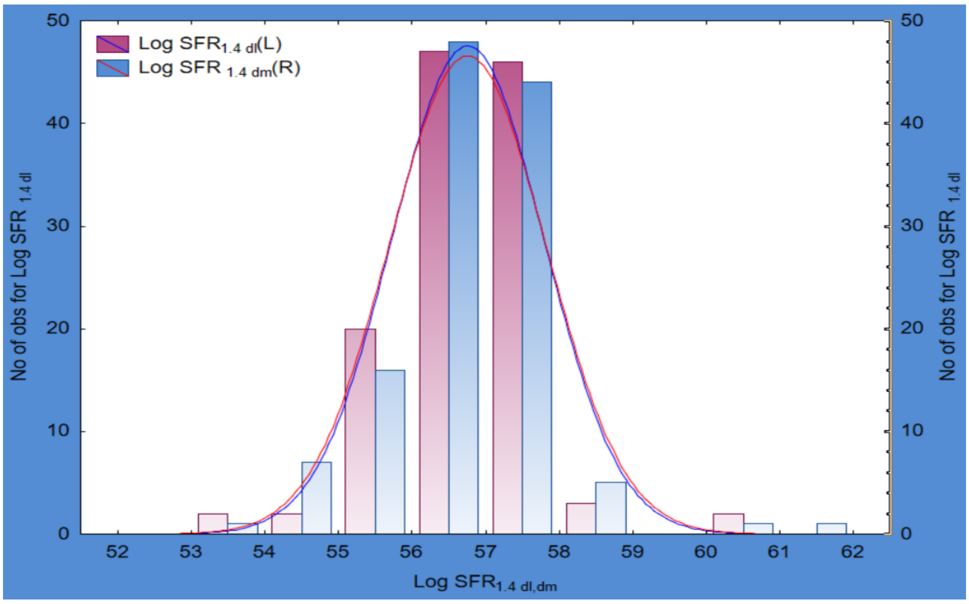

Figure 3: Histogram displays the accuracy of Log SFR $_{1.4}$ in both cases of extragalactic distance (dl&dm).

Figure 3 shows the calculation of the star formation rate in the radio continuum at 1.4 GHz for both methods (dl and dm), where this radiation is perfect because it does not suffer from absorption in addition to having a wide range of luminosity. Radio emissions in galaxies can be used to estimate the rate of star formation without interference from dust, particularly at lower frequencies like 1.4 GHz, which are not influenced by thermal emissions. After observing the statistical results, it was found that the luminosity distance method (dl) is more accurate than modulus distance (dm), as the (dl) method has an arithmetic mean equal to ± 56.7 and a standard deviation coefficient of ±1.2. The other method (dm) had an arithmetic mean equal to ±56.7 and a standard deviation of ±1.5. It indicates the possibility of using radio observations as a tool to track star formation processes up to a redshift of z = 10.

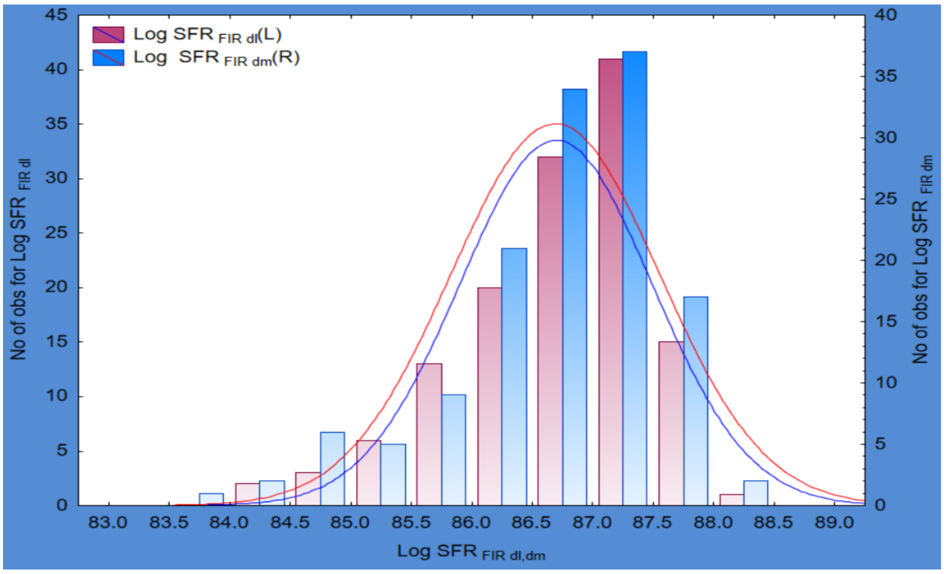

Figure 4: Histogram shows the accuracy of Log SFR $_{\mathrm{FIR}}$ in both cases of extragalactic distance (dl&dm).

Figure 4 illustrates the rate of star formation in the far infrared for both distance methods dl and dm. The emission of far infrared radiation is one of the most important ways to find out how fast stars are formed in galaxies since the brightness of these rays can be used directly to measure temperature. On the left of Figure 4, notice the (dl) method according to the statistical results, the arithmetic mean for it was equal to ±86.6, and the standard deviation was equal to ±0.79. On the right of Figure 4 where the (dm) method is clarified, one can find that the arithmetic mean was equal to ±86.6. At the same time, the standard deviation was equal to ±0.85. So, based on the standard deviation, the first method (dl) is the most accurate in measuring the rate of star formation in the FIR wavelength, as well as these waves are more accurate for calculating star formation rates because they have longer wavelengths than visible light which can pass through dense areas filled with dust and gas with less scattering and absorption.

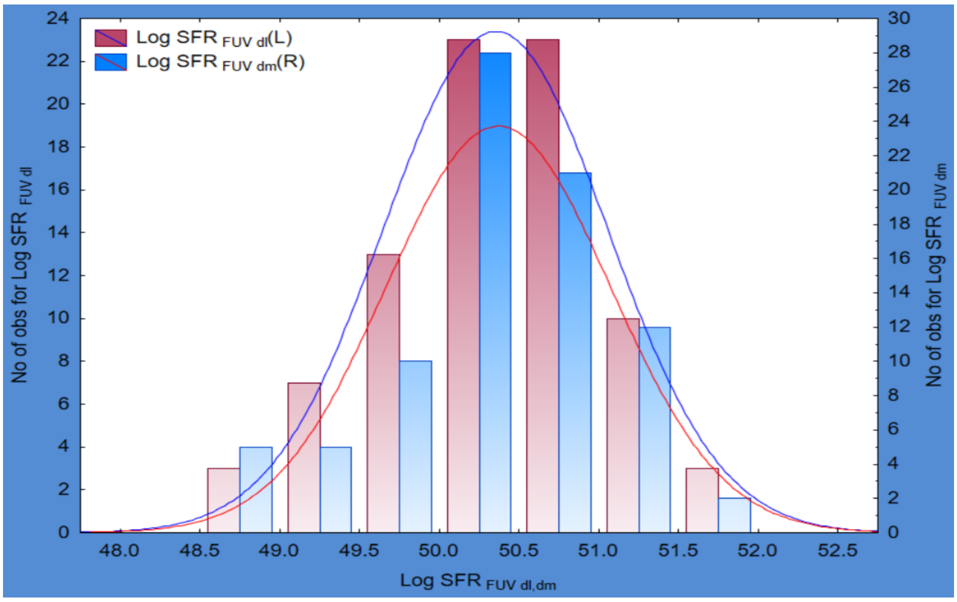

Figure 5: Histogram displays the data of Log SFR $_{\rm FUV}$ in both cases of extragalactic distance (dl, dm).

Figure 5 illustrates the level of star creation resulting from far-ultraviolet radiation, which is commonly known as the type of light that illuminates the initial and concluding stages of a star's life. According to the statistical results, the dl distance technique has an arithmetic mean equal to ±50.3 with a standard deviation of ± 0.698, and the other technique (dm) has an arithmetic mean equal to ±50.3 with a standard deviation of ±0.697. Due to the closeness of the results to a large extent between using methods, both dl and dm techniques help calculate the star formation rate in the case of far-ultraviolet radiation (FUV).

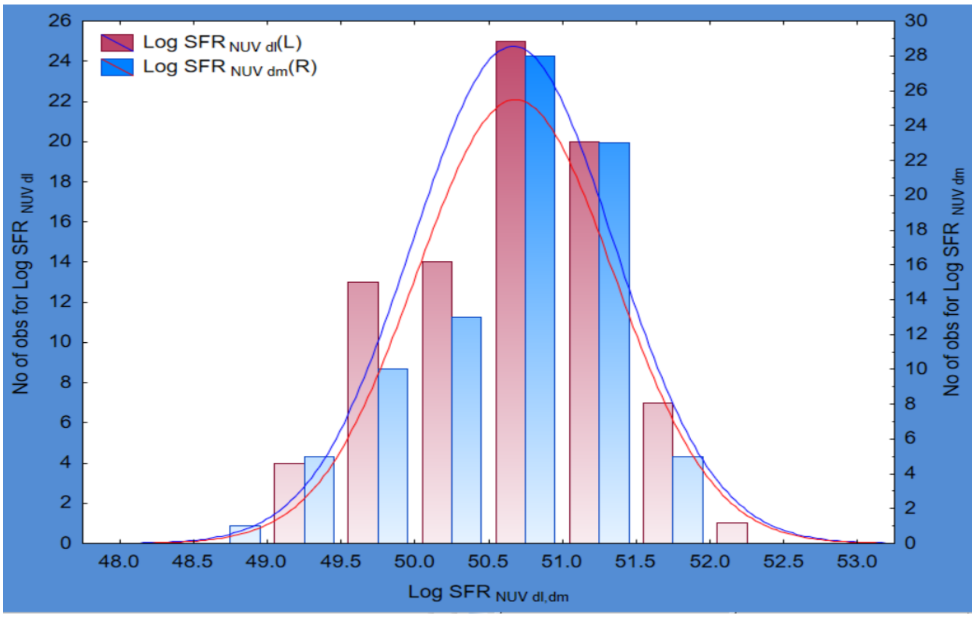

Figure 6: Histogram clarifies the Log SFR $_{\rm NUV}$ in both cases of extragalactic distance (dl, dm).

The methods' accuracy for measuring the rate of star formation at near-ultraviolet radiation (NUV) using distance measurement methods (dl, dm) was exhibited in Figure 6. The left side of the Figure showed the measurement method (dl), which had an arithmetic mean value of ±50.6 and a standard deviation of ±0.67. The right side of the Figure was for the (dm) technique, with its arithmetic mean value of ±50.6, and the standard deviation was ±0.66. Thus, we conclude that the two methods are valid for measuring the star formation rate, and one can note this result only at far and near ultraviolet radiation. Statistical analysis has shown different results for near and far ultraviolet rays, and this may be due to the difference in wavelengths, in addition to the fact that they can provide information about the properties of young stars and know their temperature and dynamics, and this is not available for other wavelengths.

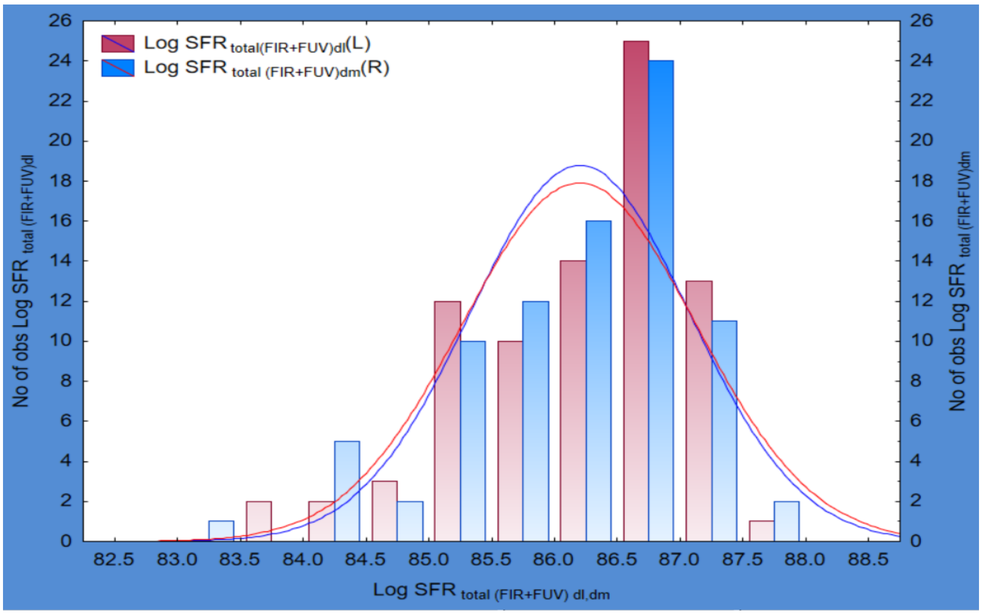

Figure 7: Histogram illustrates the Log SFR $_{\text{total(FIR+FUV)}}$ in both cases of extragalactic distance (dl, dm)

The total rate of star formation (FIR+FUV) is shown in Figure 7 using distance measurement methods (dl, dm). According to the results of descriptive statistics, the distance measurement method (dl) had an arithmetic mean equal to ±86.1 with a standard deviation of ±0.8, whereas the (dm) method had an arithmetic mean of ±86.1 and a standard deviation is ±0.92. Depending on the standard deviation value, the distance measurement method (dl) is the most accurate from others. Testing this relationship is one of the necessary tests because it combines far-ultraviolet radiation and far-infrared radiation. This relationship has proven that combining them is required to obtain accurate results for star formation rates. It clarifies that infrared radiation alone is not sufficient to get results with high accuracy, especially in galaxies with low star formation rates.

4. Conclusion

From the result of our work, we conclude that: the method of measuring the luminosity distance, which depends on the redshift, is considered the most accurate in calculating the rate of star formation at a different wavelength, as the relationship between the redshift and the star formation rate is a direct relation, compared to the other modulus distance that depends on (M_B). The two methods were tested on Hα, OII, FIR, radio continuum at 1.4 GHz, FUV, NUV, and total (FUV + FIR) based on the arithmetic mean and standard deviation, and all of them gave the same results except for near and far ultraviolet radiation both of them gave the same accuracy of results, and that may be due to their fall within a different wavelength from others, in addition to their ability to provide information about the properties of young stars, the temperature of the stars with their dynamics, and this is not available for other wavelengths.

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