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**Star-forming Compact Dwarf Galaxies (CDGs) resemble the expected pristine conditions of the first galaxies. Until these early galaxy generations are observationally detected, CDGs are the best systems to test our ideas on primordial galaxy formation and evolution. Here we report on one of such CDGs, Tololo 1214-277, which presents features in its Lyman-$\alpha$ emission thad had evaded theoretical interpretation so far. We show that these special features, a symmetric triple peaked emission line, are naturally explained by gas rotation. We find that the Lyman-$\alpha$ emission region in Tololo 1214-277 should have a rotational velocity of $V_r = 300$ km s$^{-1}$ and a neutral Hydrogen column density of $\log N_{HI}/\text{atoms cm}^{-2} = 20.5$. Using archival observational information we find that the diameter for that region should be in the range of $110$ pc $< D < 340$ pc and its total dynamical mass should be between $2.1 \times 10^9\mathrm{M}_\odot < M_D < 6.6 \times 10^9\mathrm{M}_\odot$. This dynamical mass is at least $16 \pm 9$ times larger than the neutral mass hydrogen. We argue that a possibility to explain the excess in dynamical mass is the presence of a super-massive black hole.**

The first generation of galaxies point to our cosmic corigins. Their initial conditions and characteristiscs are the first page on the evolution of galaxies such as the milky way that evolve to the present time. In the standard big bang cosmology the only elemets that were created in the nucleosynthesis where Hydrogen, Helium and Lithium. Heavier elemets must hve been created in the internal processes of stellar evolution. Therefore the first generation of galaxies shoudl be metal free and rich in hydrogen. We haven detected these galaxies yet. The best obsrevational proxy we have for them are dwarf star forming galaxies with a low metallicity content. Compact dwarf galaxies (CDGs) are the best observational example.

How can we develop a strategy to look for the first galaxies How can we recognize a first galaxy when we see one? Almost fifty years ago [7] realized that young galaxies could be detected through a strong Lyman-$\alpha$ line emission. This theoretical prediction was only confirmed XX year later. Currently, Lyman Alpha Emitting galaxies are commonly measure in surveys. The presence of this line provides confirmation of the distance of a galaxy and also provides clues about the stellar population powering the emission.

Lyman alpha emission, as suggested in the first paragraph, is not exclusive of high redshift galaxies. Any galaxy with low metallicity and dust content and ongoing star formation should present this line. This has motivated the creation of local Universe surveys to perform a detailed study of the Lyman-alpha emission [6]. A nearby simple permits the study of other indicators that might be more difficult to obtain for distant galaxies such as morphology, dust attenuation, neutral hydrogen contents and ionization state.

The Lyman-$\alpha$ line is resonant. A yman-$\alpha$ photon will follow a difussion-like process before escaping the galaxy or being absorbed by dust. This makes it hard to interpret Lyman-alpha line observations as the reulting profile is sensitive to the dynamical, chemical and thermal conditions in the interstellar medium. State-of-the-art models use montecarlo radiative transfer simulations to interpret lya line profiles. Only in very few symmetric cases analytical solutions are available.

Recent models computational models [2] have shown that rotation also imprints an effect on the Lyman-alpha morphology. The most important consequence of rotation is that spherical symmetry is broken. The line morphology now depends on the viewing angle respect to the rotation axis. For a line of sight perpendicular to the rotation axis the intensity and the line center and the line width increase with rotational velocity. When the rotational velocity is close to the half-line width of the static line, the line becomes single peaked as it is observed in Tololo 1214-277, a unique feature that other theoretical models find impossible to reproduce.

The Ly$\alpha$ emission line was first observed in the Tololo 1214-277galaxy by [10]. It has two main important features which make this a very uncommun LAE. First it has symmetric profile without any systemic displacement from the expected line-center. Second it shows a triple peak, while the most common observational feature corresponds either to a single or asymetric double peak. This profile has escaped a clear theoretical understading based on models that consider galaxies as spherical gas distributions with an outflow. We have attempted an interpretation of the lya spectrum in Tololo 1214-277 wihas a central feature the bulk gas rotation without any outflow. This model provides a complete explanation of Tololo 1214-277's puzzling feature.

Dots in Figure 1. represebt the observational data for Tololo 1214-277with the overplot from our best fit model from the full radiative transfer simulation. The parameters for the best fit are $v_{max} = 300$km s$^{-1}$, $\tau = 1 \times 10^7$, $T = 1.5 \times 10^4$K. The optical depth and temperature can be translated into a column density of $N_{HI}$. Our model is also able to constrain the angle between the rotation axis and the observational line-of-sight to $\theta = 65°\pm$. To constrain the model uncertainties we perform a Markov Chain Monte Carlo calculation using an approximate analytical solution for the lya spectrum in the bulk rotation case.

Radio surveys have put an upper limit to the neutral hydrogen mass in Tololo 1214-277of $M < 2.65 \times 10^8$ M$_\odot$. Together with our velocity and column density results, under the assumption of spherical symmetry, we can constrain the total dynamical mass of the HI region to be in the range $2.1 \times 10^9$M$_\odot$ $< M_D < 6.6 \times 10^9$M$_\odot$ and the diameter of HI region should have a diameter of $0.11 < D/\mathrm{kpc} < 0.34$. This makes the dynamical mass at least 7 to 25 times larger than the H$I$ mass.

We consider three possibilities to contribute to this high dynamical mass:

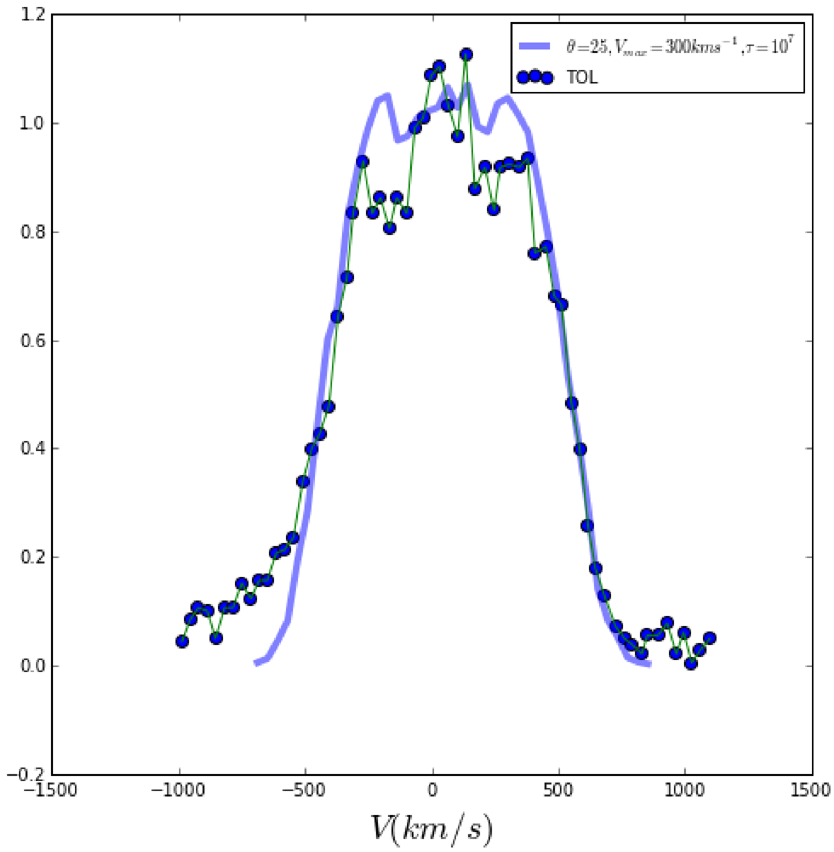


Figure 1: Nice fit

stars, dark matter and a supermassive black hole. The stellar mass can be constrained by measurements of the stellar continuum, this can only represent $xx\mathrm{M}_\odot$ of the total contribution . Considering a standard variations for the dark matter halo, it can only constributio to $xx$ $\mathrm{M}_\odot$ in the region of interest. A super massive black hole remains an open possibility. Recent observations of ultra-compact dwarf galaxies [9] have confirmed the presence of super-massive black holes containing 15% of the total objects mass, suggesting that there is a large population of undetected black holes.

A future observational test of this possibility in Tololo 1214-277 would require integral field unit measurements spatially resolving its spatial extent. Tololo 1214-277 spans a region of $\approx 4$ arcminutes. An instrument such as the Multi Unit Spectroscopic Explorer with its nominal 0.2 arcseconds spatial sampling over a 1.0 arcminute field in wide-field mode could provide a detailed mapping of different ionization lines and infer a kinematic map.

Why are not more examples of triple peaked emission in observed Lyman-alpha emitting gaalaxies? The ubiuquity of galaxy outflows overimposed to the rotation transforms the line into the common double or single peaked observations. Therefore, the absence of HI outflows in Tololo 1214-277 is another special feature that permitted a symmetric triple peaked lya line to emerge.

The implications of our finding for the study of lyman-alpha emitters, including the first generation of galaxies are manifold. First of all, it provides support to including rotation as a feature to interpret observed spectra. Secondly, it provides a motivation to explore under what conditions rotation dominated dynamics are expected in comparison with outflow dominated dynamics. Finally, if the hypothesis of a supermassive black hole in Tololo 1214-277 proves to be consistend with future observational kinematic maps, it would provide a new information to test and probe theories on the coevolution of galaxies and black holes.

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|---|---|
| $\alpha(2000)^a$ | 12h17min17.1s |
| $\delta(2000)^b$ | -28d02m32s |
| $l$, $b$ (deg) | 294, 34 |
| $m_V$ | 17.5 |
| $v$(km s$^{-1}$) | 7795 |

Table 1: Observational characteristics of TOL1214-277 [10]

# Tololo 1214-277 characteristics

Tololo 1214-277receeding velocity is $7785 \pm 50$km s$^{-1}$, which translates into a distance of 106.6 Mpc (Hubble constant 73 Mpc km$^{-1}$ s$^{1}$) Its metallicity is $\sim Z_{\odot}/24$ [4] as derived from optical spectroscopy.

The observed flux for the Lyman alpha line is $\sim 8.1\times 10^{-14}$ erg cm$^{-2}$ s$^{-1}$ [10] and a Equivalent Width of 70Åand its H$\beta$ flux is $1.62 \times 10^{-14}$ erg cm$^{-2}$ s$^{-1}$ cm$-2$ [4] which gives a Ly$\alpha$/H$\beta$ flux ratio of 4.9$\pm$0.1. Comparing this ratio with the theoretical expectation from case B recombination of 23.3 [3] one can estimate an escape fraction of 20% for Ly$\alpha$ radiation.

The optical emission comes from a region with approximate diameter ?? [1].

# MCMC constraints

# Physical Interpretation

Interpretation by [5].

There is an upper limit for the integrated flux of $< 0.10$ Jy km s$^{-1}$, which translates into a upper limit for the HI mass of $M < 2.65 \times 10^8$ M$_{\odot}$ [8]. From the optical depth of $10^7$ and the non-detection in the HI line, we have an upper limit for the size where the Lya emission comes of $D < 0.34$kpc.

For an homogeneous sphere the HI optical depth from its can be written as $\tau = \sigma_0 n D/2$, where $\sigma_0 = 5.898 \times 10^{-14}$cm$^{-2}$ is the Lyman$\alpha$ optical depth at the line's center, $n$ is the number density and $D$ is the sphere's diameter. From this we can impose additional constrains on $D$ from the tipical values of the Hydrogen number density and our constrain on $\tau = 10^7$. Using a range of $1 < n/\text{atoms/cm}^{-3} < 10^{-3}$. This gives us a range of $0.11 < D/\text{kpc} < 100$. Together from the total HI mass we have thus that the HI region should have a diameter of $0.11 < D/\text{kpc} < 0.34$.

This can be rewritten in terms of the gas' temperature $T$ and column density $N_H$as $\tau = 3.31 \times 10^{-14}(10^4\text{K}/T)^{1/2}(N_H/\text{atoms cm}^{-2})$.

This allows us to approximate the total hydrogen mass as

$$M_H = m_H N_H D^2 = 226 \times \tau \left(\frac{T}{10^4\text{K}}\right)^{1/2} \left(\frac{D}{\text{kpc}}\right)^2 M_{\odot} \tag{1}$$

On the other hand, we have an estimate for the dynamical mass from the galaxy size $D$ and its rotational velocity $V$:

$$M_T = \frac{V^2 D}{G} = 2.16 \times 10^5 \left(\frac{V}{\mathrm{km\ s^{-1}}}\right)^2 \left(\frac{D}{\mathrm{kpc}}\right) M_\odot \tag{2}$$

From this limit and the rotational velocity of 300 km/s and the limit in the size $D$ we have limits of for the dynamical mass of $2.1 \times 10^9 \mathrm{M}_\odot < M_D < 6.6 \times 10^9 \mathrm{M}_\odot$. which is at least 7 to 25 times larger than the H$I$ mass.

## Joint Effect of Rotation and Outflow

The almost complete absence of outflows is a central requirement for reproducing the lyman alpha line in Tololo 1214-277. In this section we present some results on the exploration of the presence of outflows join with the bulk rotation. We defer a detailed exploration of this effects for another publication.

Figure XX shows the results of four different models. a) pure rotation ($V_{\mathrm{rot}} = 100$ km s$^{-1}$), b) pure outflow ($V_{\mathrm{out}} = 100$ km s$^{-1}$), c) mixed outflow with rotation ($V_{\mathrm{rot}} = 100$ km s$^{-1}$)($V_{\mathrm{rot}} = 25$ km s$^{-1}$).