Lyman-alpha emission reveals an unusual fast rotating dwarf galaxy

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The Lyman-alpha emission line is a strong indicator of star formation. Observations of this line are central to construct samples of the most distant star forming galaxies, which in turn are useful for studies in cosmology and galaxy evolution. The intepretation of Ly-α observations has to go together with computational models for the radiative transfer of Lyman-alpha photons. Recent theoretical work suggests that galaxy rotation has a measurable impact on the shape of the Lyman-alpha line. Here we report that lyman-alpha observations of a blue dwarf compact galaxy (TOL 1214-277) in the local universe, which had previously evaded theoretical interpretation, are naturally explained by rotational effects. We constrain the rotational velocity, viewing angle and total neutral hydrogen mass from the Lyman-alpha observations. These values are in broad agreement with other observational constraints, although they point towards a rather atypical physical nature for the source. Our results present a new observational method to estimate the rotational velocity of dwarf galaxies. Considering the expected similarities between the local and the most distant dwarf galaxies, we anticipate that the Lyman-alpha line could be used to constraint the rotational state of the neutral gas in the highest redshift galaxies to be detected with next generation infrared spectroscopic facilities such as the James Webb Space Telescope.

1. General paragraph about the Lyman alpha line.

2. General paragraph about modelling the Lyman alpha line. Outflows.

3. Rotation and the expected features. It has been 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 TOL1214-277, a unique feature that other theoretical models find impossible to reproduce.

4. The charachteristics of the dwarf galaxy of interest.

TOL1214-277was first observed by ... it is a compact dwarf galaxy and does not have old stars.

The Lyα emission line was first observed in the TOL1214-277 galaxy by [5]. It has two main important features which make this a very uncommun LAE. First it shown a symmetric profile which is , Second the Lyα line is not shifted with respect to the Hβ line. Blue compact Dwarf Galaxy

5. The results of the fit.

Figure 1. shows the observational data for TOL1214-277with 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 and a viewing angle $\theta < 30$ degrees.

Observed line + fit.

Assuming spherical symmetry and a homogeneous gas distribution we estimate the total neutral hydrogen mass to be on the order of $M \approx m_H \tau^3 \sigma^{-3} n^{-2}$, where m_H is the mass a Hydrogen's atom, τ the optical depth, σ is the cross section at the line's center and n is the number density of neutral Hydrogen atoms. For this system we estimate that for average values of $n = 1 \times 10^3$ the total hydrogen mass is $M \times 10^{14}$M$_{\odot}$. However, blind HI surveys have put an upper limit in the neutral hydrogen mass of ???

7. Implications for outflow+rotation in existing samples.

References

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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 [5]
[a] Units of right ascension are hours, minutes and seconds.
[b] Units of declination are degrees, arcminutes and arcseconds.

The receeding velocity is 7785 ± 50km s^{-1}, which translates into a distance of 106.6 Mpc (Hubble constant 73 Mpc km^{-1} s^{1}) The metallicity is $\sim Z_{\odot}/24$ [2] 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} Å^{-1} [5] and a Equivalent Width of 70Å, with the emission comming from a region with approximate diameter ?? [1]. 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$_{\odot}$ [4].

Interpretation by [3].

For an homogeneous sphere the HI optical depth can be written as $\tau = \sigma_0 n s$, where σ_0 is the optical depth at the line's center, n is the number density and s is the sistem's size. This can be rewritten in terms of the gas' temperature T and column density $N_H$as $\tau = 3.31 \times 10^{-14}(10^4\mathrm{K}/T)^{1/2}(N_H/\mathrm{atoms\ cm}^{-2})$.

This allows us to approximate the total hydrogen mass as

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

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

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