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Low Redshift Star-Forming Galaxies: What Can They Teach Us About Primeval Galaxies?

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ABSTRACT

The analysis of the UV plus optical spectra of three star-forming galaxies, Mrk 496, Mrk 357, TOL1924-416, obtained by matching the size of the optical aperture with that of IUE, has given unexpected results. These can be summarized as: 1) the dereddened Lyα/Hβ ratios are consistent with the prediction of case B recombination for nebular emission, within the uncertainties; 2) the decrease of the Lyα/Hβ ratio with increasing metallicities is not confirmed in our three objects, although the sample is too small to consider this result definitive. The first result is surprising, mainly because at least the two Markarian galaxies have a large enough HI content to markedly increase the optical depth for the Lyα photons and to trigger their absorption by dust. This finding can probably be explained as an effect of the inhomogeneous distribution of gas and dust within the galaxies. On the basis of these results, we conclude that the detection of the Lyα emission line in searching for primeval galaxies (PGs) can be still considered a valid technique.

The UV+optical spectra (1200Å$\leq \lambda \leq$ 7700Å) of the three metal-poor blue galaxies, Mrk 496, Mrk 357, TOL1924-416, have been assembled by using archival IUE spectra together with new optical observations obtained in an aperture whose size matches that of the IUE aperture. The choice of the aperture has been driven by the necessity of accounting for possible inhomogeneous distributions of the dust present in the galaxies[2]. These three objects, selected because of their Lyα emission, are the first galaxies observed in a IUE-matching optical aperture of a sample of 30 galaxies contained in the *Atlas of Ultraviolet spectra of Star-Forming Galaxies*[5] with high enough redshift to allow observations of the Lyα wavelength region.

The optical spectra has been used to derive: a) the metallicity of the galaxy from the oxygen lines and b) the dust extinction parameter E(B-V) from the observed Hα/Hβ ratio (see Table, where the intrinsic contribution, and the contribution from our Galaxy to the extinction are shown separately).

The estimated E(B-V) has then been used to deredden the Lyα/Hβ line ratio. This ratio is critically dependent not only on the extinction parameter, but also on the adopted extinction law. Since our three galaxies span a range of metallicity, we have used three different extinction laws to deredden the Lyα/Hβ ratios, that is, the Galactic, the LMC and the SMC extinction curves[9,6,7], assuming a crude matching between the average metal content of Mrk 496, Mrk 357, TOL1924-416 and the metal content of the Galaxy, the LMC and the SMC.

The Table shows the dereddened Lyα/Hβ line ratios for the three galaxies. It is evident that such ratios are, within the uncertainties, in the expected range for case B recombination ($[Ly\alpha/H\beta]_{theor} = 23 - 34$), and the agreement is even better if the underlying stellar absorption for the $Ly\alpha$ line is taken into account. In contrast with our result, Hartmann, Huchra & Geller[3] report values for the $Ly\alpha/H\beta$ ratios of the two Markarian galaxies which are 20-30 times below the expectation, due to the underestimation of the E(B-V) value. Our result is also in disagreement with the theoretical expectations for the dust absorption of multiply scattered $Ly\alpha$ photons in an homogeneous gas+dust medium[8]. In fact, the HI column density in front of the two Markarian galaxies is $> 10^{21}$ cm^{-2}, enough to scatter substantially the $Ly\alpha$ photons and to increase the probability of their absorption by dust. The lack of this effect can probably be explained as the result of the uneven distribution of gas and dust inside the galaxy.

From the $Ly\alpha/H\beta$ values reported in the Table, it is also clear that there is no evident anticorrelation between the $Ly\alpha/H\beta$ and the metallicity of the galaxy. The discrepancy between our results and the previous works[4] can be due to the different aperture sizes used in the optical observations. We assume that our estimation of the dust extinction and, consequently, of the $Ly\alpha/H\beta$ line ratios, are more accurate, since we use matching apertures for the UV and optical observations. Neverthless, we are waiting for observations of additional galaxies in the optical before considering this finding as a definitive result.

If the large values of the $Ly\alpha/H\beta$ ratios found here are confirmed, and found to be representative of starburtsting galaxies in general, then the search for $Ly\alpha$ emission from PGs at higher redshifts will continue to be a viable strategy, since the dust in PGs is expected to be of much lower content than in our present examples and there are no hints that it should be homogeneously distributed.

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Galaxy Name	$[O/H]$ solar units	E(B-V)[1] Gal.	E(B-V) intrin.	$Ly\alpha/H\beta$ underedd.	$Ly\alpha/H\beta$ Gal. ext.	$Ly\alpha/H\beta$ LMC ext.	$Ly\alpha/H\beta$ SMC ext.
Mrk 496	−0.05	0.00	0.52 ± 0.15	0.60	$12.4^{+17.3}_{-7.2}$	...	...
Mrk 357	−0.5	0.04	0.26 ± 0.15	1.45	$8.3^{+11.6}_{-4.8}$	$20.8^{+32.2}_{-15.7}$	...
TOL1924-416	−0.7	0.07	0.05 ± 0.10	2.40	$4.8^{+3.8}_{-1.2}$	$5.7^{+8.9}_{-2.1}$	$7.0^{+19.8}_{-3.5}$