# MORPHOLOGY AND H II GALAXIES

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**Abstract**

Despite the fact that H II galaxies present a large variety of morphology (compact, double, multiple, with or without tidal interactions), they have very homogeneous overall properties ($H\beta$ luminosities, oxygen abundances, line widths, and velocity dispersions). We show that morphology has no systematic effects neither on the physical properties of the nebular component of H II galaxies ($T_e$ and O/H) nor on the H$\beta$ luminosity - velocity dispersion relation. So H II galaxies, even at very high redshift, remain a reliable distance indicator, unbiased by morphologies.

## 1 Introduction

H II galaxies are characterized by having small dimensions, spheroidal shapes, very young stellar populations, and giant H II regions which dominate their observable properties at optical wavelengths. Searle & Sargent [8] recognized that H II galaxies are ionized by massive clusters of O and B stars. Most H II galaxies are metal poor systems ([3] and references therein). It is very likely, therefore, that at least some, if not most H II galaxies are young systems in the process of forming their first generation of stars.

Many H II galaxies studies have already been carried out. Kobulnicky & Skillman [2], for instance, have discussed the physical properties of the gaseous component, and Telles et al.[10] discussed the morphology of H II galaxies and their environments.

The L(H$\beta$)[1] - velocity dispersion ($\sigma$) relation for H II galaxies provides a powerful distance indicator which can be applied to very high redshift objects and which, at least to first order, is free from the changes in stellar population which bedevil the traditional techniques [5]. This is because by selecting objects with very large emission line equivalent widths, one can form samples of galaxies with very narrow age distributions. Moreover, the extinction and the

[1] A value of $H_0 = 100$ km s$^{-1}$ Mpc$^{-1}$ has been assumed throughout the paper.

metallicity of these galaxies can be directly determined from the emission line spectra. So, the effect of systematic changes in metallicity with redshift, for instance, can be corrected in a relatively straightforward way.

H II galaxies can be used as distance indicators at least out to redshifts of z=3 ([4],[6]) provided we can understand the systematics of the method. Since the correlation between L(H$\beta$) and $\sigma$ is empirical, this requires a thorough understanding of the properties of the local sample. The effects of age, metallicity, and extinction, have been discussed in detail by Melnick et al.[5]. Interestingly, correcting for these effects improves only marginally the scatter of the correlation (and hence the goodness of the distance indicator). This suggests that other parameters may be at play. An obvious choice is morphology. Telles et al.[10] have studied the morphological properties of the galaxies in the sample of Melnick et al.[5], and found a wide range of forms within these otherwise compact class of objects. In particular, they have found that luminous H II galaxies tend to have multiple or distorted morphologies, while lower luminosity objects tend to be compact and regular. A significant number of galaxies have double morphology.

H II galaxies with companions tend to have low luminosity and velocity dispersion and have symmetric or regular morphology without any evidence of tidal effects whereas H II galaxies without companions have higher luminosity, higher velocity dispersion and tend to present distorted morphologies. This is in contradiction with the hypothesis that starbursts in H II galaxies are triggered solely by tidal encounters ([7] and references therein).

Clearly, since the L(H$\beta$) - $\sigma$ relation was established on the basis of observations through a fixed photometric aperture, morphology may increase the scatter of the correlation, and may also introduce significant systematic effects since multiple objects would in principle be expected to be overluminous for a given velocity dispersion. The aim of this contribution is to examine quantitatively the effect of morphology in the integrated properties of nearby H II galaxies.

## 2 Morphology and physical properties of H II galaxies

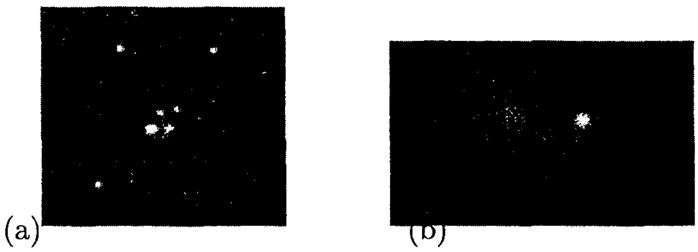


Figure 1: (a) V image of Tol 1334-326 showing clearly four knots separated by about 1kpc. North is up and East is right. The image is 9x9 kpc$^2$. (b) R image of UM 439 showing clearly two knots separated by about 0.5kpc. North is left and East is down. The image is 2x1 kpc$^2$.

Figure 1 presents images of two H II galaxies with multiple morphology: Tol1334-326, that has 3 emission line knots embedded in a diffuse component that also shows emission lines, and UM439, which shows "classical" double component consisiting of a low surface brightness fan and a compact strong emission line knot. This structure is reminiscent of magellanic irregulars and is relatively common for H II galaxies.

We have obtained spectra of these objects in order to study the physical conditions of the different emission components. We find that, within our errors, all components have similar electronic temperatures and oxygen abundances. If this trend is the norm for the class, then we do not expect different morphologies to introduce systematic effects in the L(H$\beta$) - $\sigma$ relation.

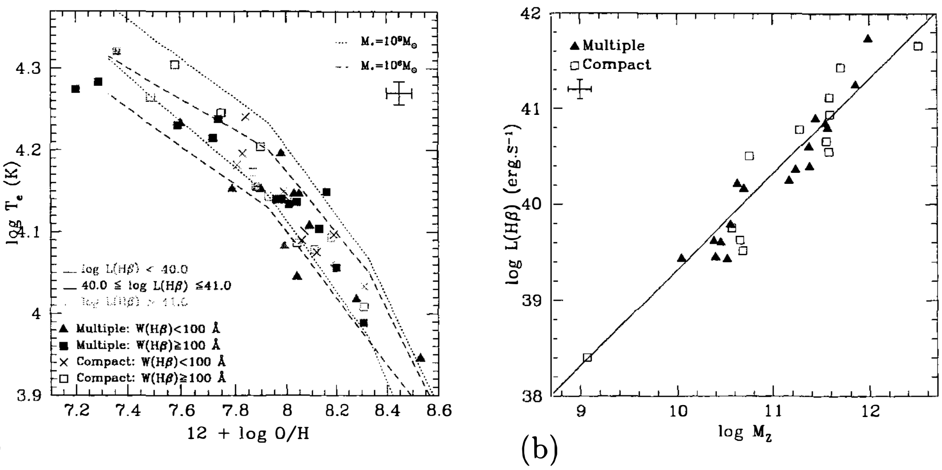


Figure 2: (a) Logarithmic plot of electronic temperature, $T_e$, versus oxygen abundance for H II galaxies. Starburst isochrones (1, and 3 Myr) are superimposed. (b) $H\beta$ luminosity is plotted versus $M_Z = \sigma^5/(\mathrm{O/H})$. The line shows the relation: log $L(H\beta) = 1.0\log$ $M_Z + 29.32$. In both plots, we give typical error bars.

Figure (2a) plots the electronic temperature $T_e$ versus abundance for a sample of 45 H II galaxies for which accurate data exist in the literature. To build this sample, we imposed $W(H\beta) > 30$ Å to be sure that these H II galaxies are young star forming regions in order to limit evolutionary effects. Also, we restricted our analysis to H II galaxies with lines narrower than 60 km s$^{-1}$. Indeed, single giant H II regions with lines broader than $\sigma = 60$ km s$^{-1}$ cannot exist since the sizes of the ionising clusters of giant H II regions cannot be so large that their dynamical time-scales are longer than the main-sequence lifetimes of the ionising stars.

We have subdivided the sample in groups according to the H$\beta$ luminosity, equivalent width and morphology. The dashed lines represent photoionisation models from Stasińska & Leitherer [9] obtained with Kurucz model atmospheres and NLTE atmospheres to compute the ionising spectra. The nebular gas was assumed to be spherically distributed around the ionising cluster of stars, with a constant electronic density $n_e = 10$ cm$^{-3}$ and a constant filling factor $\epsilon = 1$. We superimpose the models for $M_{up} = 100 M_\odot$ with $M_* = 10^9 M_\odot$ and $M_* = 10^6 M_\odot$, and for starburst ages of 1 Myr (upper line) and 3 Myr(lower line).

There are several aspects of this plot which are of relevance for our discussion:

- There is no systematic segregation according to morphological type.
- While in the broad sense the models reproduce the range of observed parameters, in detail there are contradictions. For instance, the low electronic temperatures of the lowest abundance galaxies indicate either very low masses ($M_* < 10^6$ $M_\odot$) or ages > 3 Myr, while the H$\beta$ luminosities and equivalent widths of these objects correspond to ages < 2 Myr and masses > $10^6$ $M_\odot$. There are other similar cases in the sample at lower abundances.

The interpretation of these observations is complicated by the fact that the observations have not been done in a uniform fashion. It is well known , for example, that the equivalent widths are very sensitive to aperture diameter. So our main conclusion from this diagram is that the physical properties of the nebular component of H II galaxies ($T_e$ and O/H) do not depend systematically on morphology.

For the different morphological types, Figure (2b) shows the $H\beta$ luminosity as a function of $M_Z = \sigma^5/(\mathrm{O/H})$. The line represents the least-squares fit obtained by Melnick et al.[5]: $\log L(H\beta) = 29.32^{\pm 0.08} + 1.0^{\pm 0.04} \log M_Z$

We can see from Fig. (2b) that there is no strong segregation due to multiple structures. Actually, one could have expected that multiple systems would have had higher $H\beta$ luminosities at given velocity dispersions (i.e., at given $M_Z$) since the observed luminosity is the *sum* of all the individual ones. The first impression is that multiple systems have generally lower luminosities than compact ones. Indeed, we find the median value of the luminosity is 40.7 for compact systems and 40.2 for multiple ones. However, a Student's t-test indicates that the significance of the different means in our two distributions is only 0.37: we cannot assert that there is a discrepancy between luminosities of multiple and compact H II galaxies.

## 3 Conclusion

In spite of their different morphologies, H II galaxies are a remarkably homogeneous class when viewed through their integrated emission line properties (abundance, luminosity, line-widths). By selecting very young objects using the emission line equivalent widths, H II galaxies define a narrow correlation between L(H$\beta$) and velocity dispersion, which can be used as a distance indicator. This correlation does not appear to be biased by different morphological types. This is fortunate because at high redshifts it will in general be very difficult to determine the morphological types or separate components of H II galaxies.

## References


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