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Quantifying the Ionising Flux escaping from the Ultra-luminous H II Regions in Four Spiral Galaxies

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Abstract: There are two principal problems in explaining, in terms of the emission from OB stars, the ionisation of gas which emits diffuse Hα in spiral galaxies. One is the long pathlength which the ionising photons need to traverse to reach their objectives, the other is whether sufficient photons can escape from within the H II regions which surround the hot stars. Here we treat the second point, assuming that the H II regions above a certain threshold luminosity are density bounded. We calculate the escaping Lyman continuum (Lyc) fluxes from the density bounded regions in four galaxies, and show that in each of them this is easily sufficient to produce the measured diffuse Hα emission.

Keywords: galaxies: ISM — galaxies: spiral — ISM: H II regions

1 Observations

All the galaxies were observed through the TAURUS camera on the $4 \cdot 2$ m William Herschel Telescope, La Palma. Calibrated photometric sub-arcsec images in appropriately red-shifted Hα were obtained by subtracting a nearby continuum image from that through the Hα filter. Absolute fluxes were determined via distances derived using $H_0 = 75$ km s^{-1} Mpc^{-1}.

2 Data Analysis

We derived the Hα luminosity function (LF) of the H II regions in each galaxy (for details see Rozas, Beckman & Knapen 1996) and measured, separately, the diffuse Hα flux for the whole disc, integrating this out to a radius close to R_{25}. We corrected this for unresolved H II regions by extrapolating the statistically incomplete LF below its completeness limit at $\sim 10^{37 \cdot 5}$ erg s^{-1} down to 10^{35} erg s^{-1}, using the only complete LF available, that of M31 by Walterbos and Braun (1992). To compute the Lyc flux escaping from the H II regions and available to ionise the diffuse gas we extrapolated the LF, using the slope measured below $L = 10^{38 \cdot 6}$ erg s^{-1}, to higher values, and subtracted off the observed LF. The procedure is illustrated in Figure 1. A brief explanation of the underlying theory is given in Beckman, Rozas & Knapen (1988, present issue p. 83). A comparison of the available Lyc, and that required to produce the observed diffuse Hα is shown in Table 1. We can see that there is more than sufficient ionising flux available in all four galaxies.

Table 1. Comparison between observed diffuse Hα and available ionising flux predicted from the density bounded H II regions

Galaxies	Diffuse luminosity (erg s^{-1})	Available luminosity (erg s^{-1})
NGC157	$1 \cdot 12 \times 10^{41}$	$3 \cdot 76 \times 10^{41}$
NGC676	$6 \cdot 67 \times 10^{40}$	$1 \cdot 92 \times 10^{41}$
NGC6951	$6 \cdot 75 \times 10^{40}$	$2 \cdot 78 \times 10^{41}$
NGC3631	$7 \cdot 87 \times 10^{40}$	$1 \cdot 13 \times 10^{41}$

3 Conclusions

These results give support to the hypothesis that the diffuse Hα in disc galaxies is produced by Ly continuum escaping from H II regions. This general idea agrees with work by Ferguson et al. (1996) who estimated the diffuse emission at some 40% of the total Hα produced by the galaxy, and showed a global geometrical association of diffuse emission and emission from the H II regions in the two galaxies they studied. Here we go further and identify the sources as the density bounded regions, showing that they emit enough Lyc to ionise the diffuse medium, and that a significant fraction of the ionising photons produced by a disk galaxy in fact escapes into the intergalactic medium. (*Project support:* Grant PB94–1107; DGICYT).

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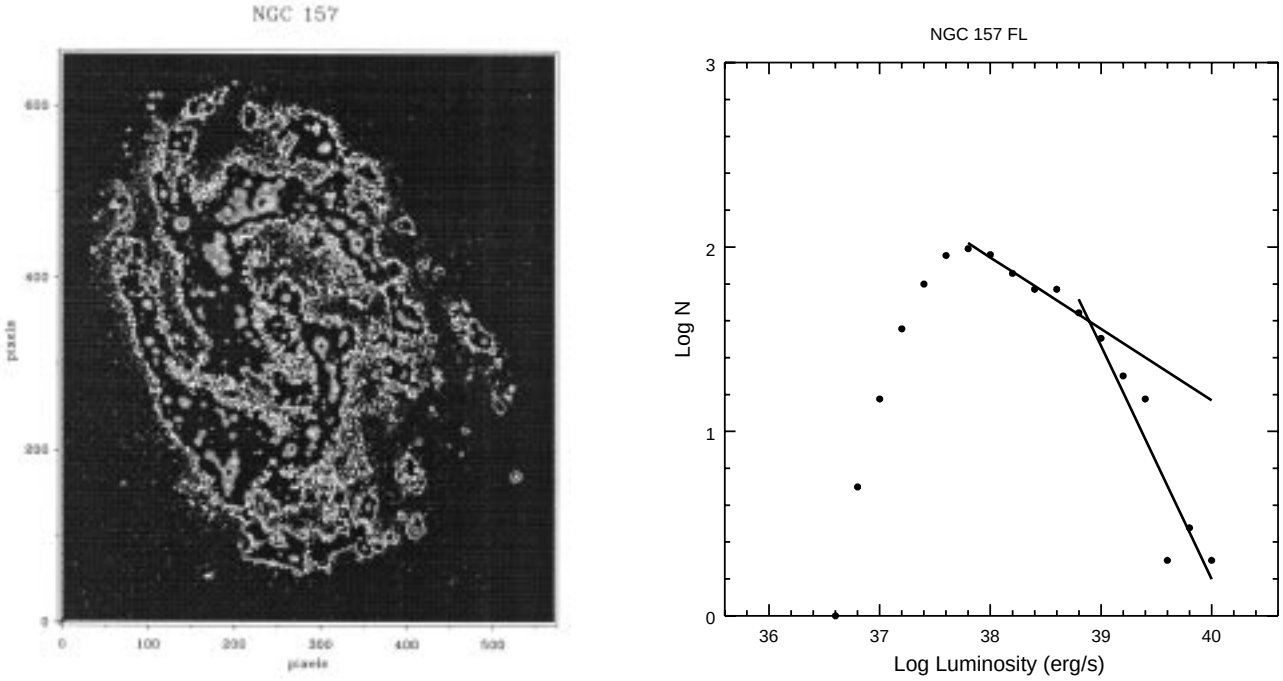

Figure 1—*Left:* Geometrical match between the observed diffuse Hα and the sites of the luminous regions (density bounded). *Right:* Procedure for estimating the Lyman continuum flux escaping from the H II regions in four disk galaxies, and available to ionise the diffuse medium. The difference between the extrapolated LF (upper line) and the observed LF from the density bounded high luminosity regions gives the available ionising component.

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