Chapter 15
A Preliminary Budget for the Ionizing Photons in HII Regions of M51

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Abstract The purpose of this work is to quantify the ionizing photon budget in the HII regions, deriving the fraction of the Lyman continuum (Lyc) absorbed by dust or escaping from the regions. An underlying aim is to explore the degree of inhomogeneity of a typical HII region.

Using broad band and narrow band (Hα) images of M51 from ACS/HST we have examined the ionizing radiation budget in a set of luminous HII regions in a spiral arm between 5 and 12 kpc from the centre. In the BVI filters we identified sets of point sources within the HII region boundaries (as defined in the Hα image), whose absolute magnitudes and colours identify them as young massive star clusters. Plotting a B-V vs V-I colour–colour diagram we estimated the internal visual extinction for a given region. Also, a mean value for the differential extinction coefficient, $R_V$, of 3.3, similar to the Galactic value, was derived.

We used the I band filter to continuum-subtract the Hα image, and derived absolute fluxes using the distance to M51 of 8.4 Mpc [2].

The Lyman continuum (Lyc) luminosities of the ionizing clusters were derived from their stellar contents, taking an average type for the ionizing stars as O7V [9]. We computed the equivalent O7V number for each region, and the total Lyc luminosity Qo [10]. Thence, we derived the corresponding predicted Hα luminosities from the HII regions, assuming the “Case B” of [6], and a dust free HII region opaque to Lyc. These exceeded the measured values by a factor of order 7.

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The first result to bring out is the range of extinction values: $A_V$ between 0.42 and 3.56 with a mean value of 1.51, agreeing well with [1]. There is no correlation between reddening and galactocentric distance (Fig. 15.1a), nor between extinction and region diameter (Fig. 15.1b), indicating highly inhomogeneous regions.

A second result is the ratio of detected (extinction corrected) Hα to predicted Hα. This value is, strikingly only 0.12, i.e. 88% of the predicted Hα is not detected (Fig. 15.1c). Defining the effective Lyc extinction $A_{\text{Lyc,eff}} = 2.5 \times \log\left(\frac{H\alpha_{\text{pred}}}{H\alpha_{\text{obs}}}\right)$ as [4], and assuming no Lyc photon escape, we find values of $A_{\text{Lyc,eff}}$ between 0.6 and 4.8 (Fig. 15.1d). We can see that if the gas and dust distribution in HII regions were homogeneous, this range of values is inconsistent with that of $A_V$ (the values for $A_{\text{Lyc,eff}}$ should be 5–10 times greater). In addition, if we assume that about 50% of Lyc photons escape from an HII region ([5] or [8]), the discrepancy with a homogeneous model is even bigger. This is in good qualitative agreement with the now classical [7] clumpy model for the gas and dust in HII regions (see also [3]).

References