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PHOTOIONIZATION OF THE DIFFUSE INTERSTELLAR GAS IN SPIRALS BY LYMAN PHOTONS ESCAPING FROM H II REGIONS

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The existence of an extended component of diffuse ionized gas (DIG) is a well-known property of spiral galaxies. The integrated Hα luminosity of the DIG is very high (accounting for $\sim$ 50% of the total Hα emission in a galaxy), which makes it important to understand the origin of this diffuse component.

From photometric and high spatial resolution Hα images of six selected spirals we made a detailed study of their DIG (Zurita, Rozas & Beckman 2000). We found a clear spatial correlation between the H II region emission and that from the DIG as previously noted by other authors (e.g. Ferguson et al. 1996). This result, together with the fact that the most luminous H II regions in these galaxies can supply the global energy requirements to keep the DIG ionized (Zurita et al. 2000) and the evidence for enhanced density bounding at high luminosity in the H II regions, strongly supports the theory that these regions are the principal source of ionization of the DIG. However, this implies that Lyman continuum (Lyc) photons must traverse hydrogen path lengths of over 1 kpc. In the case of the Galaxy, several models suggest that this is possible (Miller & Cox 1993; Dove & Shull 1994). However, until now, no model has been developed in external galaxies and what is more, no studies to date have proposed specific and quantified sources of ionization of the DIG.

In view of the intrinsic complexity of the problem we have adopted a schematic approach. From the known distribution of the H II regions in the disc of the galaxy NGC 157 (for which an H I map was available, Ryder et al. 1998) we have made simplified models of the distribution of ionizing photons across the disc of this galaxy. We have used several assumptions about the escape fraction and the effective absorption coefficient corresponding to a neutral hydrogen column density. The escape fraction of Lyc photons has been assumed to be: (a) constant for all the cataloged H II regions, or (b) zero for H II regions with $\log L_{\mathrm{H}\alpha} < 38.6$ (in erg s^{-1}) and a fraction given by Figure 1 at higher luminosities (Beckman et al. 2000); or (c) constant at low luminosities and increasing at high luminosities (Fig. 1).

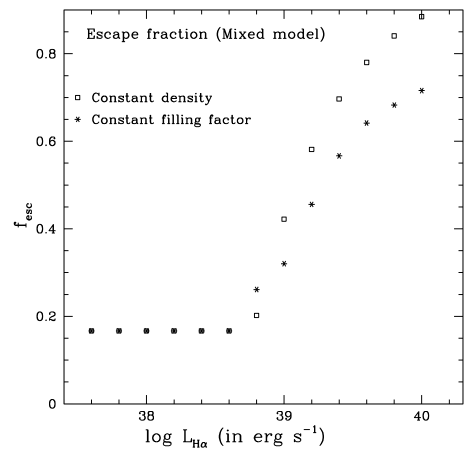

Fig. 1. Fraction of the total Lyc flux emitted within an H II region which escapes. In this model (c), for Hα luminosity less than $L_{\mathrm{Str}} = 10^{38.6}$ erg s^{-1}, a constant fraction of the Lyc photons escapes while for $L_{\mathrm{H}\alpha} > L_{\mathrm{Str}}$ the escape fraction is given by the parametric formulation for density bounded regions from Beckman et al. (2000).

The resulting maps and the computed predicted Hα emission from these models show good general spatial agreement with the observed diffuse Hα emission (Zurita et al. 2001). The best agreement occurs for models based on assumptions (a) and (c). This spatial agreement, together with the fact that H II regions can give the power required to keep the DIG ionized, confirm them as the most probable principal source of the ionization of the DIG in spirals.

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