# EVOLUTIONARY MODELS OF THE DISSOCIATION ZONES SURROUNDING HII REGIONS

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Atomic hydrogen regions have been observed in λ21-cm emission around a number of galactic HII regions in various stages of evolution (Roger & Pedlar, 1981; Dewdney & Roger, 1982; Roger & Irwin, 1982). These HI zones are almost certainly formed by the dissociation of $H_2$ with Lyman-Werner band photons in the UV from the exciting stars. We describe some results of the computer modelling of the advancement of dissociation fronts with time as functions of various parameters, principally stellar type and ambient gas density. The modelling has shown that for most conditions a substantial HI zone is formed fairly rapidly around a new star. When the dissociation front moves out to a distance where absorbing molecules are predominantly in the ground vibrational state, further advancement of the front is much slower.

Hydrogen molecules are dissociated by excitation to the first electronic level and to a number of vibrational levels followed by prompt relaxation to the ground electronic state with ~11% gaining sufficient vibrational energy to dissociate (Stecher and Williams, 1967). The remaining molecules cascade through vibro-rotational levels eventually to the vibrational ground state. If the UV photon flux is sufficient to electronically re-excite the molecules before the cascade ceases (so called "multiple excitation"), many more Lyman-Werner band transitions are available and dissociation proceeds rapidly.

Our model calculates, at suitably fine intervals of time and radius, the various rates for ionization-recombination, dissociation-reformation, and heating-cooling. At each increment, the UV spectral densities are corrected for absorption and scattering by dust and adjusted for the optical depths of each Lyman-Werner line. The populations of vibrationally excited $H_2$ can then be determined from a previously calculated table (see Dewdney, Roger and Robert, this volume), and the local dissociation rate computed. Temperatures are derived by equating the heating rates for four processes with the radiation from thirteen temperature-dependent cooling transitions.

For most combinations of stellar type and ambient gas density, the model predicts that the dissociation front will initially move rapidly outwards because of multiple excitation near the ionization boundary. Figure 1 illustrates this rapid advancement for a

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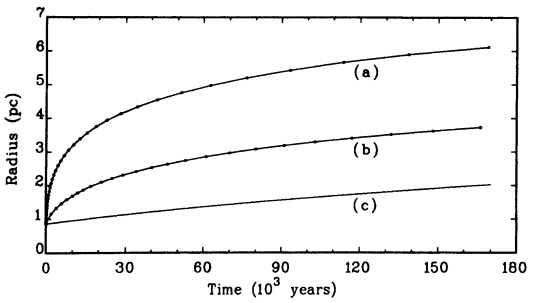


Figure 1. For a BOV star in gas of density 100 $cm^{-3}$, the variation with time of (a) the dissociation boundary (b) the boundary calculated when multiple excitation is neglected, and (c) the expanding ionization front.

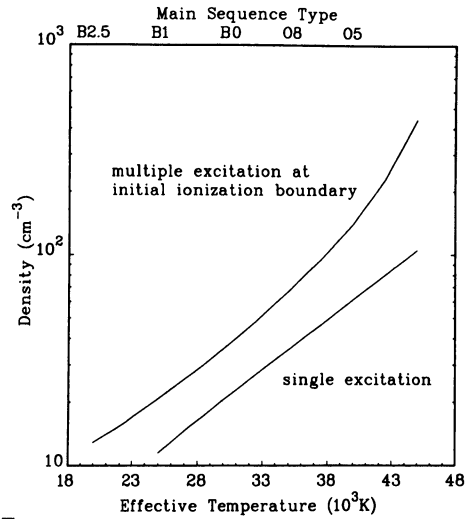


Figure 2. The upper and lower lines indicate combinations of stellar type and gas density for which the proportions of vibrationally excited molecules at the initial ionization boundary will be 20% and 10% respectively. Multiple excitations will greatly enhance the dissociation rate for combinations above the lines.

BOV star in gas of particle density 100 $cm^{-3}$. For comparison, we also show the expanding ionization boundary and the dissociation radius calculated by (wrongly) neglecting the excited vibrational levels.

The relative populations of vibrationally excited molecules are sufficiently high to influence the initial rate of advancement of the front provided the UV radiation density ($\lambda$100 nm) at the ionization boundary is greater than $\sim 10^{-13}$ ergs $cm^{-3}$ $s^{-1}$ or about 250 times the general interstellar (1 Habing unit) value. Combinations of stellar type (or effective temperature) and ambient gas density for which this multiple excitation plays an important role are illustrated in Figure 2.

Temperatures on both sides of the dissociation boundary are of the order of a few hundred Kelvin, determined primarily by photoelectric heating from dust grains and cooling in the 157 $\mu$m line of $C^+$. In the narrow zone where multiple excitation is effective dissociation heating predominates and may produce temperatures close to 2000 K.

The model explains why relatively young HII regions such as that surrounding LkH$\alpha$101 (Dewdney and Roger, 1982) have substantial HI zones around them.

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