THE THERMAL AND NON- THERMAL COMPONENTS OF SIXTEEN NEBULAR COMPLEXES

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Abstract. The nature of the fine structure of sixteen galactic nebular complexes is investigated by producing their radio spectra. The complexes are: W31, W33, W35, K39, W42, W40, W43, W48, W47, W49, K47, W51, W3, Carina, NGC 6334 and NGC 6357. Various physical parameters of the thermal components are derived by adopting a homogeneous, optically thin, spherical model. The variations of the physical parameters derived from the model as a function of the electron temperature and distance are investigated. A discussion about the thermal and non-thermal spectra is included. Some simple statistics on the physical parameters of the thermal sources (diameter, density, mass) are also presented by employing a sample of sixty-seven thermal components.

1. Introduction

In recent years high resolution radio observations (≤ 5' HPBW) have revealed the fine structure of various galactic complexes. The usual pattern of these complexes is an apparent mixture of various thermal (H II regions) and non-thermal (possibly supernova remnant, SNR) components. For some of these the association of H II regions with supernova remnants is believed to be real (W28) whereas for others it is simply an effect of perspective.

The detailed study of the nature of the fine components of these galactic complexes seems to be a necessary first step towards the physical explanation of these vast interstellar regions. This analysis deals with sixteen of these galactic regions namely: W31, W33, W35, K39, W42, W40, W43, W48, W47, W49, K47, W51, W3, Carina, NGC 6334 and NGC 6357. The nature of these complexes is studied by producing the integrated radio spectra over their various components from observations compiled from a large number of authors. The nature of the individual sources predicted by the present results is cross-checked with observations of radio recombination lines (H109α mainly) whenever such information is available.

The physical parameters of the components which show a thermal radio spectrum are also derived by employing a model of a spherical, homogeneous, optically thin H II region (Mezger et al., 1967a). Thus the turnover frequency νT, the spherical angular size θsph, emission measure at the centre Ec, root mean square electron density rms Ns, mass of ionized material M_{HI}/M_⊙, and the excitation parameter u of the various thermal components are estimated.

The variations of the various physical parameters versus the electron temperature T_e and the distance D of the complex (two parameters which have to be adopted in the

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use of the model) are also studied. Graphs are provided for an immediate correction of the derived physical parameters when different values of \( T_e \) and \( D \) have to be used (better estimation or for reasons of comparison with results of other authors). Statistics on the actual diameter, density and mass of the various components are also presented by including not only the thermal components of the sixteen galactic complexes but the components of previously studied well known H II regions (Goudis, 1975b, 1976a, b, c).

2. The Radio Spectra

The integrated radio spectra of the various components of each galactic complex are presented as a log-log plot of the integrated flux density, \( S_v \), in f.u. versus frequency, \( v \), in MHz. All the radio spectra of the components of each galactic complex are shown in one figure in which a known radio continuum contour map is generally included showing the structure of the complex and the correspondence of the various components with their respective radio spectrum. A \( \pm 20\% \) error in the estimation of the flux density has been adopted unless otherwise quoted in the original reference.

The radio spectra of the fine components of the sixteen galactic complexes are shown in Figures 1 to 16 respectively. The original references of the available observational points are quoted in the legends of the respective figures. For three of these complexes (Carina, NGC 6334, NGC 6357) short exposure photographs taken with the SRC 48-in. Schmidt telescope are also presented. The photographs, taken in the H\( \alpha \) + [N II] light either through the 15-in. square mosaic interference filter designed by J. Meaburn for this purpose, or through a broader dye filter, reveal visually the fine structure of the bright cores of these nebular complexes.

3. Derived Physical Parameters of the Thermal Components

The adoption of a spherical, homogeneous, optically thin and dust-free model for an H II region leads to the estimation of various physical parameters of the region (Pariskii, 1961; Mezger and Henderson, 1967; Mezger et al., 1967a; Terzian, 1974). In the present study the estimation of the physical parameters of the thermal sources is obtained by adopting the model introduced by Mezger et al. (1967a). On this basis the following parameters are estimated:

(a) The emission measure at the centre of the source, \( E_c \), which is given by the relation

\[
\frac{E_c}{\text{pc cm}^{-6}} = 18.82 T_e^{1.35} \nu_t^{2.1},
\]

where \( T_e \) is the electron temperature of the source (6000 K is adopted) and \( \nu_t \) is the turnover frequency of the radio spectrum. The estimation of the \( \nu_t \) has been obtained by using the well-studied Orion spectrum as a calibration source. For each source