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Galactic Carbon Recombination Lines near 327 MHz

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Abstract. A survey of radio recombination lines (RRLs) in the Galactic plane ($l = 332° - 0° - 89°$) near 327 MHz made using the Ooty Radio Telescope (ORT) has detected carbon RRLs from all the positions in the longitude range $0° < l < 20°$ and from a few positions at other longitudes. The carbon lines detected in the survey are, most likely, emission counterparts of the absorption lines observed at frequencies below 150 MHz. Observations towards $l = 13°.9$, $b = 0°.0$ indicate that the broader (~ 38 km s^{-1}) carbon line detected in the lower resolution observation consists of multiple narrow components (~ 10 km s^{-1}) with different central velocities. The implications of the presence of such narrow components for the modeling of line emission is discussed.

1. Introduction

Recombination lines of carbon originate either in regions adjacent to H II regions (classical C II regions) or in neutral components (H I or molecular) of the interstellar medium (diffuse C II regions). The diffuse C II regions are identified through observations of carbon RRLs in absorption at frequencies below ~ 150 MHz and in emission above ~ 200 MHz (Payne et al 1989).

We have made extensive new observations of the diffuse CII regions in carbon recombination lines at frequencies near 327 MHz. Our objectives were to determine the distribution of the carbon line emitting region in the Galactic plane and to constrain its angular extent. The data was obtained while surveying the Galactic plane for hydrogen lines.

2. Observations and Results

Observations were made using the ORT in the longitude range $l = 332° - 0° - 89°$ at two different angular resolutions – $2° \times 2°$ and $2° \times 6'$. In the low resolution survey, carbon RRLs were detected at almost all the positions in the longitude range $l = 0°$to $20°$and at several positions between $l = 20°$to $88°$. The lv diagram and the radial distribution of carbon lines show some concentration of line emission in the spiral arms.

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The *lv* diagram constructed from the present data shows good similarity with that obtained from the carbon lines observed in absorption at frequencies near 34.5 MHz (Kantharia 1998) and near 76 MHz (Erickson et al. 1995). This similarity indicates that the lines observed near 327 MHz are likely to be the emission counterparts of the carbon absorption features observed at lower frequencies.

3. Angular Extent of the Carbon Line Emitting Region

Observation towards the position G13.9+0.0 with a beam of $2^\circ \times 2^\circ$ has detected a narrow ($\Delta V = 7$ km s^{-1} , $V_{LSR} = 17$ km s^{-1}) and a broad ($\Delta V = 38$ km s^{-1} , $V_{LSR} = 35$ km s^{-1}) carbon line. To study the angular extent of the line emitting region in this direction, 20 positions within the $2^\circ \times 2^\circ$region were observed with the $2^\circ \times 6'$ beam. The narrow line is present in almost all the 20 spectra. If the line emitting region is at the "near" kinematic distance, then the size of the region is $\sim$ 70 pc. Examination of the individual spectra shows that the broader feature (ΔV= 38 km s^{-1}) detected at low angular resolution is a result of blending of several narrow components (ΔV $\sim$10 km s^{-1}) at different central velocities.

4. Width of the Carbon line

The width of RRLs from high quantum levels is expected to be affected by pressure and radiation broadening as observed towards Cas A (Payne et al 1989). However, in the inner Galaxy, Kantharia (1998) found that the width of the carbon lines at 34.5, 75 and 327 MHz were very similar, implying that pressure or radiation broadening could be insignificant. We mentioned above that, towards G13.9+0.0, the large line width at 327 MHz is due to blending of a number of narrow components. Even if each of these components becomes wider at 34.5 MHz due to pressure or radiation broadening, the net observed width could be comparable to the width at 327 MHz because of the spread in the central velocities. Thus, in this situation, similarity of widths at 34.5 MHz and 327 MHz does not rule out pressure and radiation broadening at low frequencies. For example, the physical properties of the line emitting region towards G13.9+0.0 can very well be similar to that derived for the Perseus arm clouds towards Cas A ($T_e \sim 70$ K, $n_e \sim 0.2$ cm^{-3} ; Payne et al. 1989) where such broadening effects are clearly observed. For these parameters, each of the individual components towards G13.9+0.0 will be pressure and/or radiation broadened at frequencies < 150 MHz. The net combination of the systemic velocity of the different components and the broadening effects at lower frequencies will result in line widths which are similar at both high and low frequencies.

References

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