

Cool Diffuse Ionized Gas Revealed by Sensitive Radio Recombination Line Observations

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The physical nature of the warm ionized medium (WIM) remains poorly understood despite its prevalence in the Galactic disk. Radio recombination lines (RRLs) are an extinction-free probe of the Galactic WIM. The Green Bank Telescope Diffuse Ionized Gas Survey (GDIGS) mapped RRL emission in a section of the Galactic plane and revealed a significant amount of high emission measure WIM plasma. Due to the faintness of RRL emission, however, most of the GDIGS emission is confined to the vicinity of star forming regions. We report the discovery of faint RRL emission associated with the WIM along two sightlines through the Galactic midplane: at Galactic longitudes of 20° (G20) and 45° (G45). These positions were chosen to avoid contamination from discrete star forming regions. We detect broad, faint RRL emission that is consistent with the canonically pervasive, low density, $\sim 10,000$ K WIM plasma, but we also detect one narrow feature along the G20 sightline that challenges our understanding of the WIM. Assuming that this feature is dominated by thermal broadening, we place a strong upper limit of $\sim 4,000$ K on the plasma temperature. We highlight the sensitive GBT observations that enabled this discovery, discuss the implications of this discovery on our understanding of the WIM, explore possible explanations for this cool ionized gas, and motivate the need for sensitive RRL surveys of the Galactic plane in order to constrain the range of WIM physical conditions.