

The Extended Ionized Halos and Bridge of the Magellanic Clouds

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Abstract

The Wisconsin H-Alpha Mapper (WHAM) has revealed ubiquitous ionized emission throughout the gas complexes formed by the dynamic history of the Magellanic Clouds. We present an overview of the immediate environment around the galaxies themselves, including ionized halos of the Small and Large Magellanic Clouds (SMC & LMC) as well as the bridge of material between them. Using WHAM, Barger et al. (2013) found H α emission extending throughout and beyond H I in the Bridge. We add these new maps of the SMC and LMC to provide the first complete view of the diffuse ionized gas near the interacting system. At $R \sim 30,000$, WHAM can cleanly separate diffuse emission at Magellanic velocities from the Milky Way and terrestrial sources to the limit of atmospheric line confusion (~ 10 s of mR). We find that ionized gas extends at least 5 degrees beyond the traditional boundary of the SMC when compared to recent deep-imaging surveys (e.g., MCELS; Smith et al. 2005). The diffuse ionized emission extent is similar to the neutral gas extent as traced by 21 cm emission. We compare the kinematic signatures between the neutral and ionized components throughout the region. Comprehensive multi-wavelength surveys are also underway to examine how physical parameters and ionization processes vary in these extended systems.

Observations

The map we present (Figure 1) contains a combination of three separate sets of data observed with WHAM. The Magellanic Bridge was surveyed in detail primarily over the local standard of rest velocity range of +100 to +300 km s⁻¹ (Barger et al. 2013). The SMC was surveyed over the velocity range of +50 to +250 km s⁻¹. A new filter was installed in 2013 to allow for observations of the LMC to be made at the higher velocity range of +200 to +400 km s⁻¹. To minimize the different systematics still present in each dataset, the data were integrated across a gradient range of velocities (Figure 2) so that the bulk of the diffuse ionized gas (DIG) across the Magellanic Bridge scales properly alongside the bright galaxies. We then combine the three disconnected velocity windows together into a comprehensive map of the DIG around both Magellanic Clouds. Some example spectra are also shown alongside neutral HI emission spectra (Figure 3), demonstrating our ability to find individual ionized gas components at different velocities.

Figure 2: Effective Velocity Map.

Data were sliced and integrated across specific velocity intervals to trace the gradient of velocities across the Magellanic System. The colors correspond to the average velocity that data were integrated over in the corresponding region. Each velocity window extends 175 ± 25 km s⁻¹.

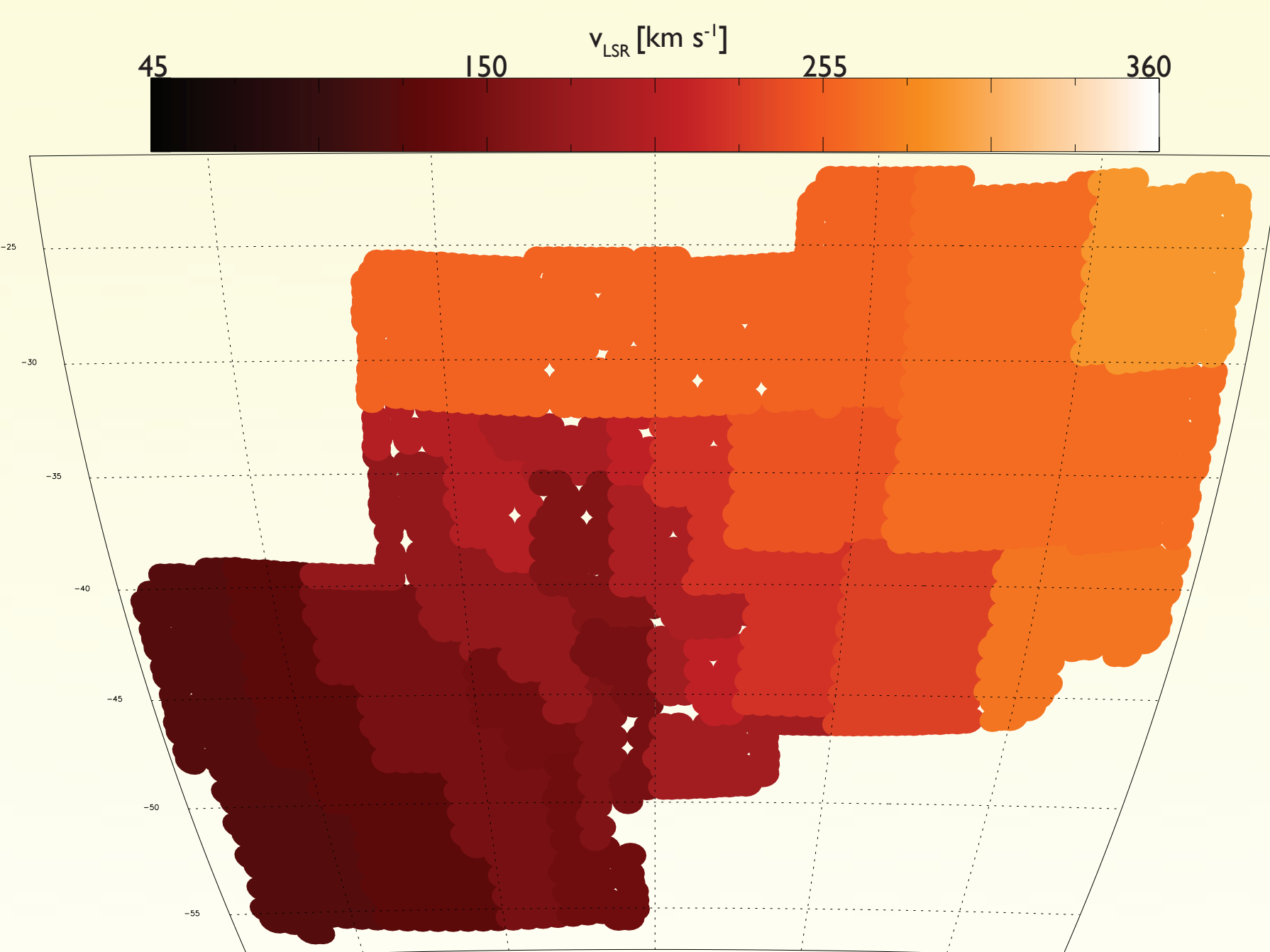


FIGURE 2

Figure 3: Select H α and HI Spectra.

H α emission generally traces the neutral HI emission (LAB, Kalberla et al. 2005). 3a shows HI emission revealing more obvious internal structure of the SMC than the H α data alone. 3b highlights a region of increased H α emission with very little to no HI emission. 3c and 3d show some areas of good correlation between both data sets.

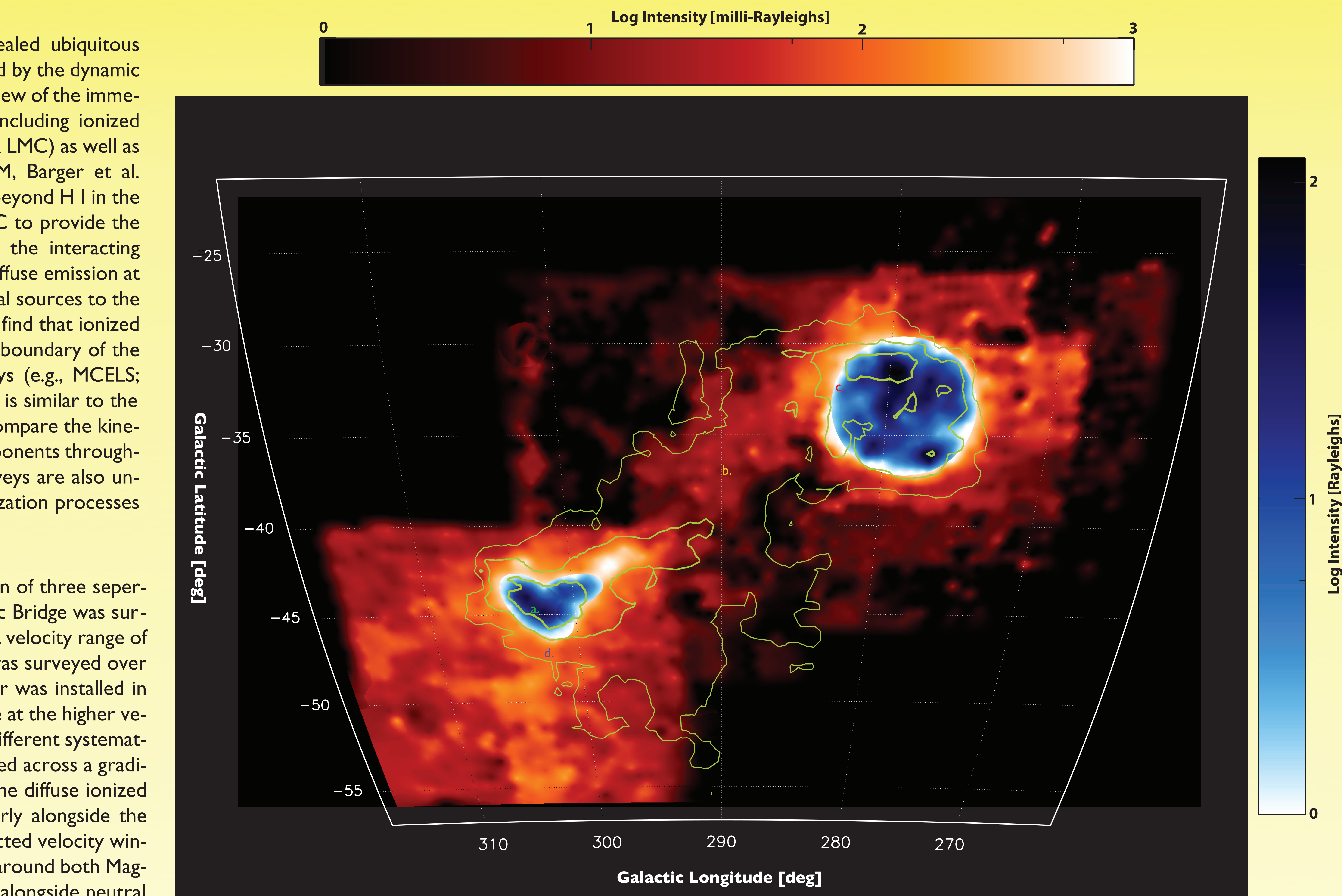
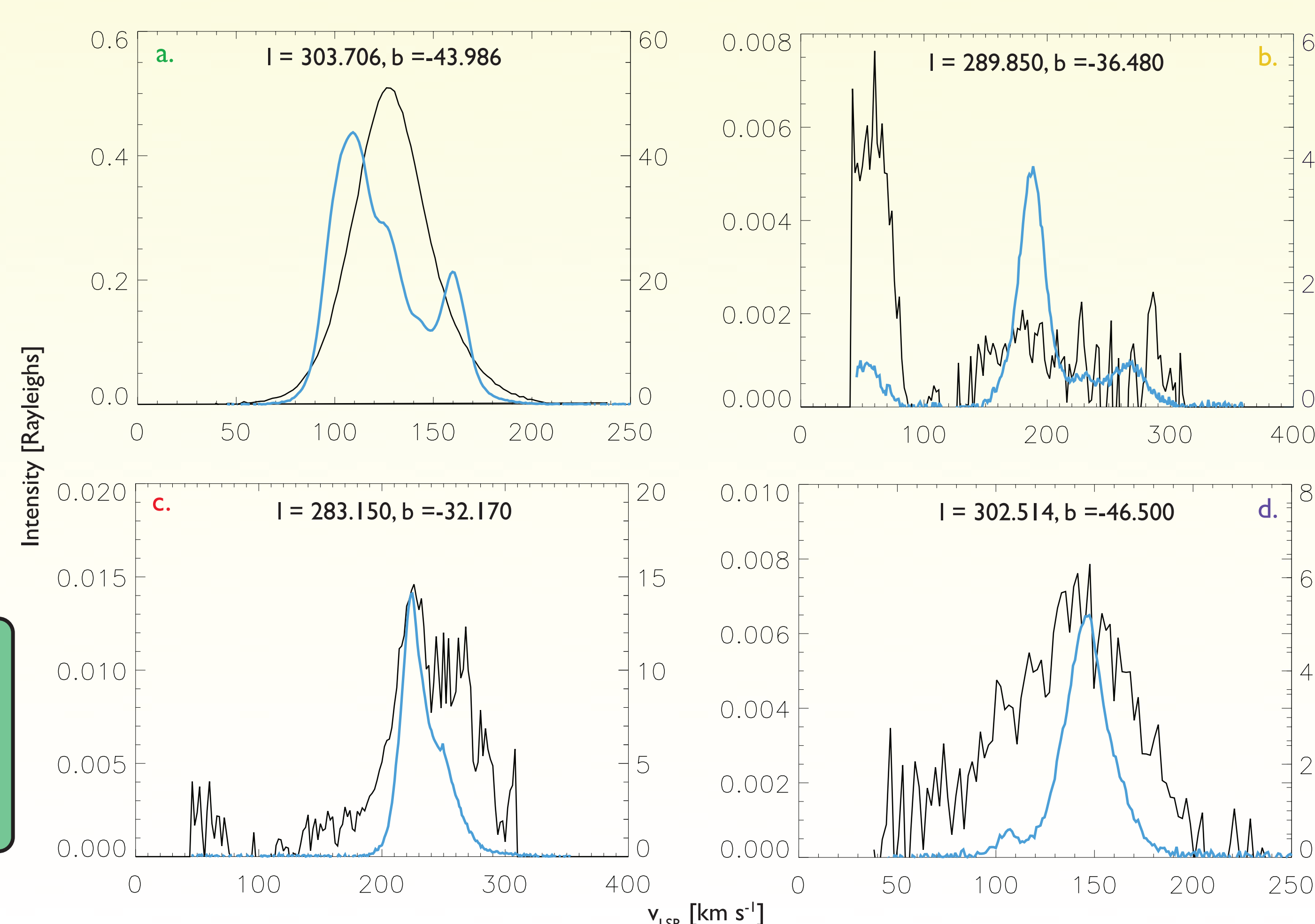


Figure 1: Diffuse Ionized Gas around the SMC and LMC.

H α emission toward the SMC, LMC, and Bridge are shown above in two different Intensity scalings. The red gradient image shows the relatively faint halo ranging in intensity from 30 to 1000 mR. The blue gradient image shows some structure inside the brightest portions of the SMC and LMC, ranging in intensity from 1 to 120 Rayleighs. The contours in green trace the HI column density from the LAB survey (Kalberla et al. 2005) at $N_H = 1, 5, 20 \times 10^{20}$ cm⁻². Locations of the letters correspond to the spectra seen below in Figure 3.

FIGURE 3



Small Magellanic Cloud

Removal of atmospheric lines allows us to reliably detect faint H α emission at Intensities below 0.1 R, showing DIG extends beyond the boundary of neutral HI (See Figure 1 contours). The block-like residual structure near the bridge and SMC boundary is primarily the result of a change in the velocity window of the observed data. Future work will focus on reducing these residual features with additional observations and more careful data reduction.

Large Magellanic Cloud

The atmospheric line template for the LMC data requires further improvement to fully remove faint atmospheric emission (visible as the slight block-like residual structure in that area). However, the ionized gas from the LMC data merges smoothly with the well characterized Bridge region and generally traces the HI contours throughout. Additionally, much of the structure seen within the LMC (in blue) closely follows the HI column density contour of $N_H = 5 \times 10^{20}$ cm⁻².

References

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