The H I – H₂ Transition Region at High Resolution across the Perseus Molecular Cloud

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Abstract: We investigate the agents of H₂ formation in the Perseus molecular cloud by focusing on regions with equal surface densities of H I and H₂ (ΣHI and ΣH₂). Using the H I data from the GALFA-H I survey and the 2MASS extinction map provided by the COMPLETE survey, we derive the RHI = ΣH₂/ΣHI image. Based on preliminary results, we find that RHI rapidly declines to 1.0 at the distance of 3 – 7 pc from the main body of Perseus. The rapid decline of RHI is correlated with the ΣHI + H₂ distribution. For RHI > 0.8, the RHI vs. ΣHI + H₂ relation follows the prediction from Krumholz et al. (2009) and there is no significant difference between dark clouds and star-forming regions.

1. Introduction: Krumholz et al. (2009; K09) found that RHI in an atomic-molecular complex is primarily determined by gas column density, secondarily by metallicity, and only weakly depends on the strength of radiation field. We investigate this prediction at high resolution (~0.6 pc) by focusing on the Perseus molecular cloud.

2. Constructing a map of RHI (Figure 1):
   (1) ΣHI: We use the H I data from the GALFA-H I survey (Stanimirović et al. 2006). The H I emission is integrated over -10 – 20 km s⁻¹ based on the spatial correlation between FIR and H I emission.
   (2) ΣH₂: The 2MASS extinction map provided by the COMPLETE survey (Ridge et al. 2006) is used. The following equation is adopted to estimate ΣH₂ (Pineda et al. 2008):
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   \frac{N(H_I) + 2N(H_2)}{A_v} = 1.9 \times 10^{21} \text{cm}^{-2} \text{mag}^{-1}
   \]

3. RHI distribution: Radial profiles centered at B5/B3 (dark clouds) and IC348/NGC1333 (star-forming regions) are made and two of them are shown in Figure 2:
   (1) RHI rapidly declines to 1.0 at 3 – 7 pc away from the center. This trend seems to be correlated with the ΣHI + H₂ distribution. We approximate the RHI and ΣHI + H₂ radial distributions with power-law functions and plot the corresponding power-law slopes in Figure 3. An almost linear relationship exists between RHI and ΣHI + H₂. This implies that ΣHI + H₂ plays an important role in determining RHI, consistent with K09.
   (2) We define the “H I – H₂ transition region” as a region where RHI = 0.8 – 1.2. Subsequently, the H I – H₂ transition region is located at 3 – 7 pc from the main body of Perseus. Across the H I – H₂ transition region, ΣHI + H₂ = 12 – 20 M_☉ pc⁻². This agrees with the prediction of K09 for Z = 1.5 – 3.0 Z☉.

4. RHI vs. ΣHI + H₂: Plots for B5 and NGC1333 are shown in Figure 4:
   (1) Good agreement in the shape of the curve with the prediction of K09 for RHI > 0.8.
   (2) No systematic difference in the shape of the curve between a dark cloud and a star-forming region. This implies that RHI most likely only weakly depends on the strength of radiation field, consistent with K09.

5. Future work: We will investigate the spatial distribution and geometry of the H I – H₂ transition region. We will estimate the level of turbulence across and around Perseus to search for a possible correlation between RHI and turbulent flows.

6. References: