The Cosmic Abundance of Molecular Hydrogen

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Introduction

The formation and evolution of galaxies is closely tied to the abundance of gas. Indeed, galaxy growth is regulated by the careful balance of its gas through inflows, outflows, star formation and the build up of its gas reservoir. It is therefore necessary to have a good understanding of the cosmic abundance of molecular gas Ω_{H2} throughout the history of the universe to understand galaxy growth and to constrain galaxy evolution models.

Previous research has derived Ω_{H2} using a biased sample of 200 galaxies, most of which are irregular galaxies (spirals and mergers) Keres et al. (2003). However, $\approx$ 85 % of the star formation budget of the Universe originates from normal main-sequence star forming galaxies.

COLD GASS is a survey that has charted the molecular gas content of local galaxies by measuring their CO(1-0) emission. Galaxies in the COLD GASS survey were selected based solely on their mass and redshift. Therefore, COLD GASS provides an unbiased and complete picture of molecular gas in local main-sequence star-forming galaxies. The purpose of this project is to use the COLD GASS sample to calculate a more representative estimate for Ω_{H2}.

COLD GASS Data

- The CO Luminosity L_{CO} is calculated from the integrated line flux S_{CO}
- The conversion factor was calculated using the prescription given in Genzel et al. (2012) for low mass, low metallicity galaxies whereas for high mass galaxies the galactic conversion factor was used.
- The molecular hydrogen mass function was calculated using just the detections and both the detections and the upper limits from the non-detections from the COLD GASS survey.

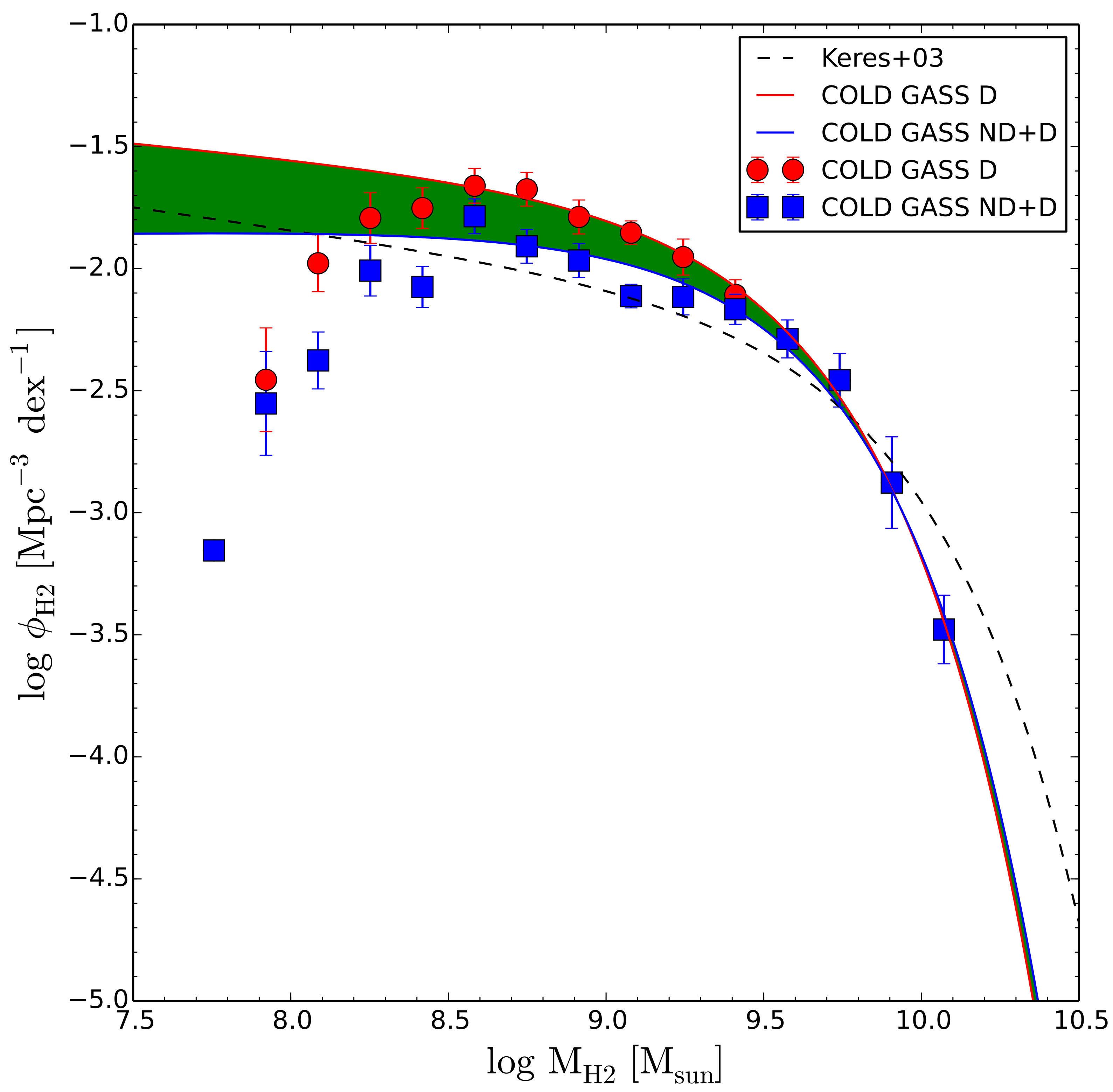


Figure 1 : Molecular gas mass function (M_{H2}). The blue squares represent the total number density of galaxies when only the detections from COLD GASS are used (D). The red circles show the number density when the upper limits from the non-detections are combined with the detections (ND+D). The dashed line is the best fit from Keres et al. (2003) and the blue and red solid lines show the best fit to the D and ND+D COLD GASS data respectively. The true answer lies somwehere within the green shaded region

In Keres et al. (2003) it was found that $\Omega_{H2} = 1.6 \pm 0.6 \times 10^{-4}$

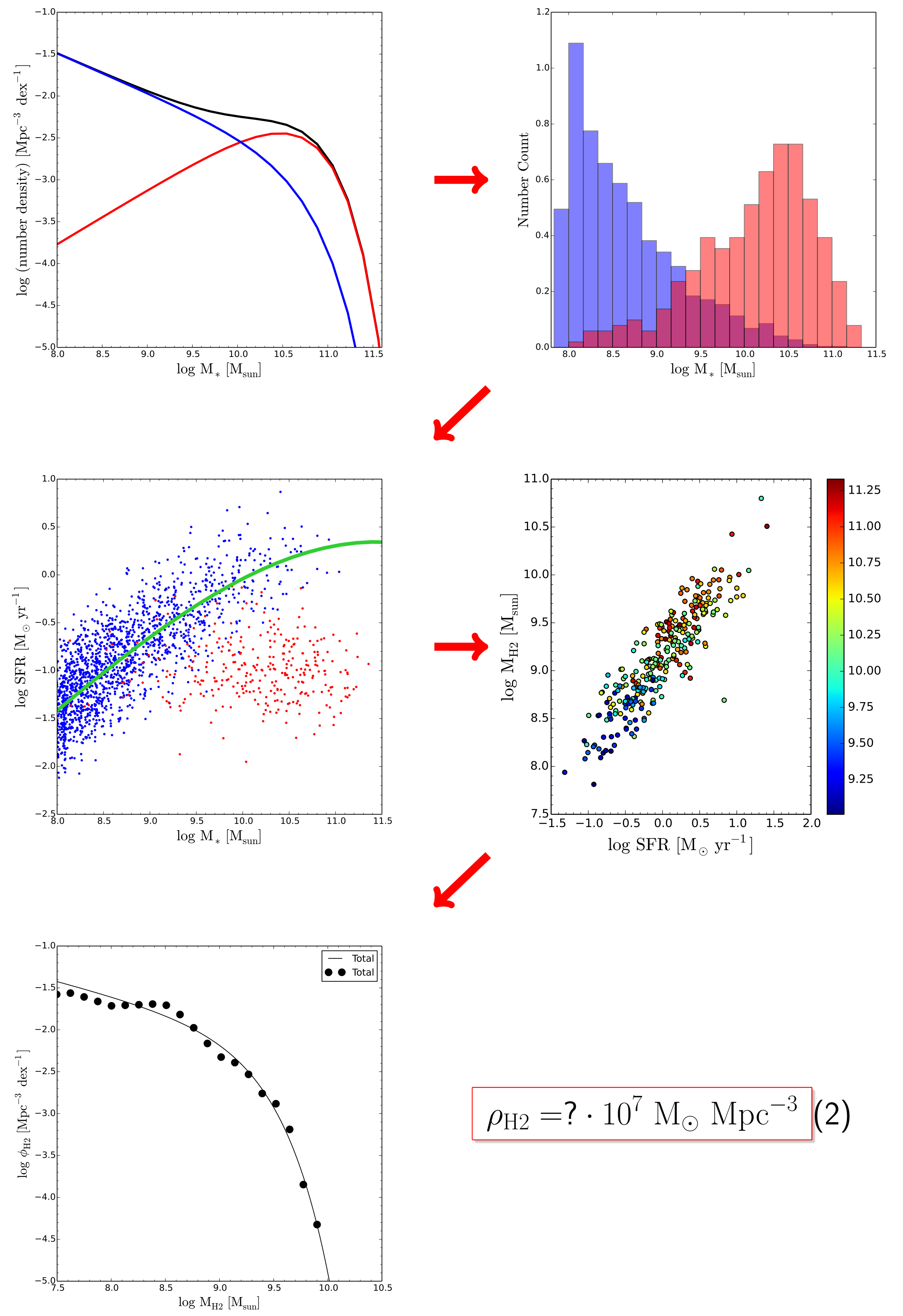
$$\boxed{\rho_{H2} = 2.7 \cdot 10^{7}\ M_{\odot}\ \mathrm{Mpc}^{-3}} \quad (1)$$

Conclusions

Scaling Relations

To circumvent the inherent Malmquist bias in the COLD GASS data a second method that takes advantage of the tight scaling relations in the $M_* - \mathrm{SFR}$ (Saintonge et al. 2016) and $M_{H2} - \mathrm{SFR}$ planes is used.

- **Step 1:** The double schechter fit (red and blue galaxies) for galaxy stellar mass function from the GAMA survey (Baldry et al. 2012) is used.
- **Step 2:** From this fit red and blue galaxy populations are constructed with a distribtuion across M_*
- **Step 3:** Main sequence galaxies are assigned a SFR using the prescription in Saintonge et al. (2016). Red galaxies are given a lower SFR with some spread.
- **Step 4:** The tight scaling relation between $M_{H2} - \mathrm{SFR}$ is used to calculate the molecular hydrogen gas mass for each galaxy
- **Step 5:** The molecular hydrogen mass function is then plotted and Ω_{H2} is calculated.



$$\boxed{\rho_{H2} = ? \cdot 10^{7}\ M_{\odot}\ \mathrm{Mpc}^{-3}} \quad (2)$$

References

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