Schmidt Star Formation Law in M33

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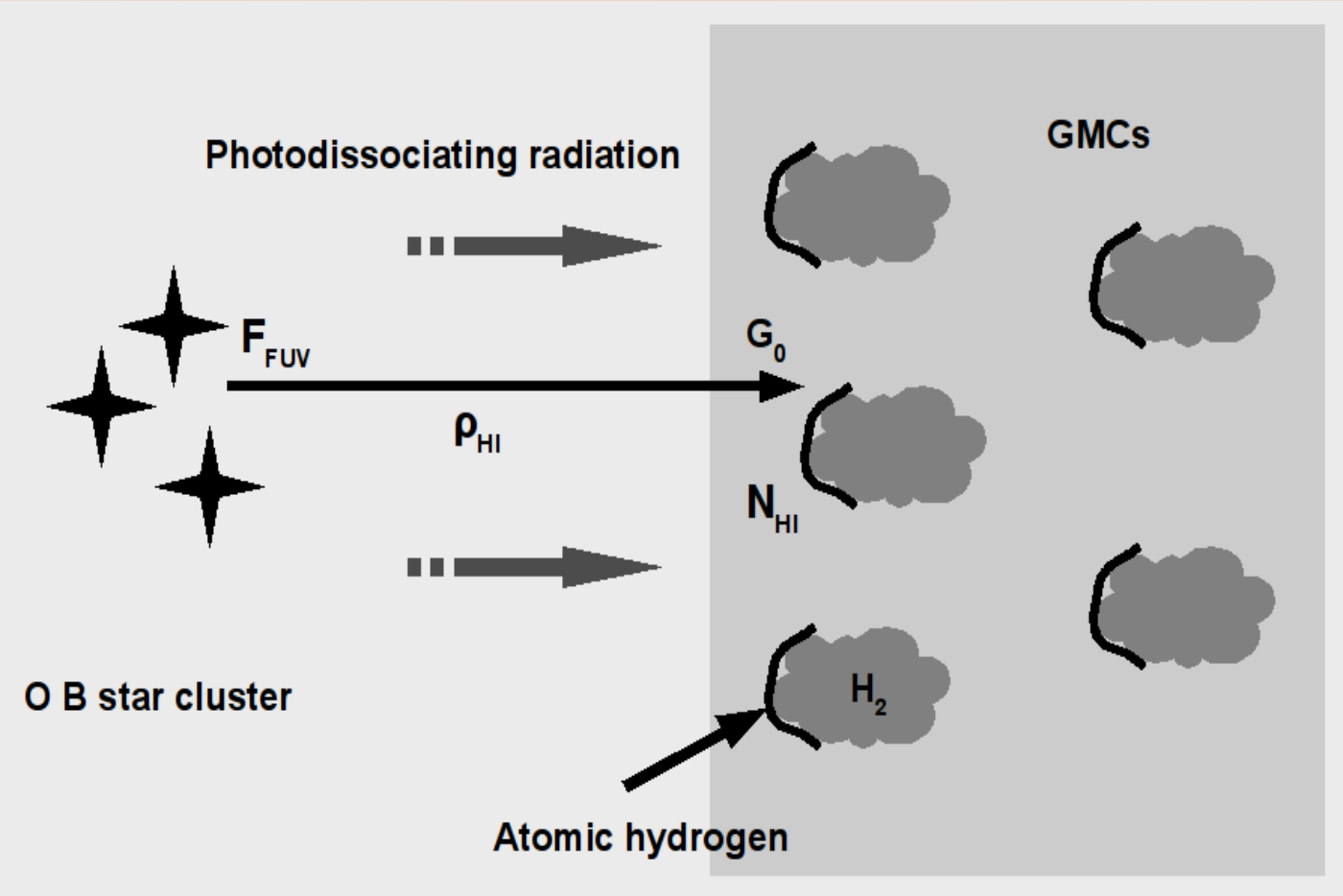
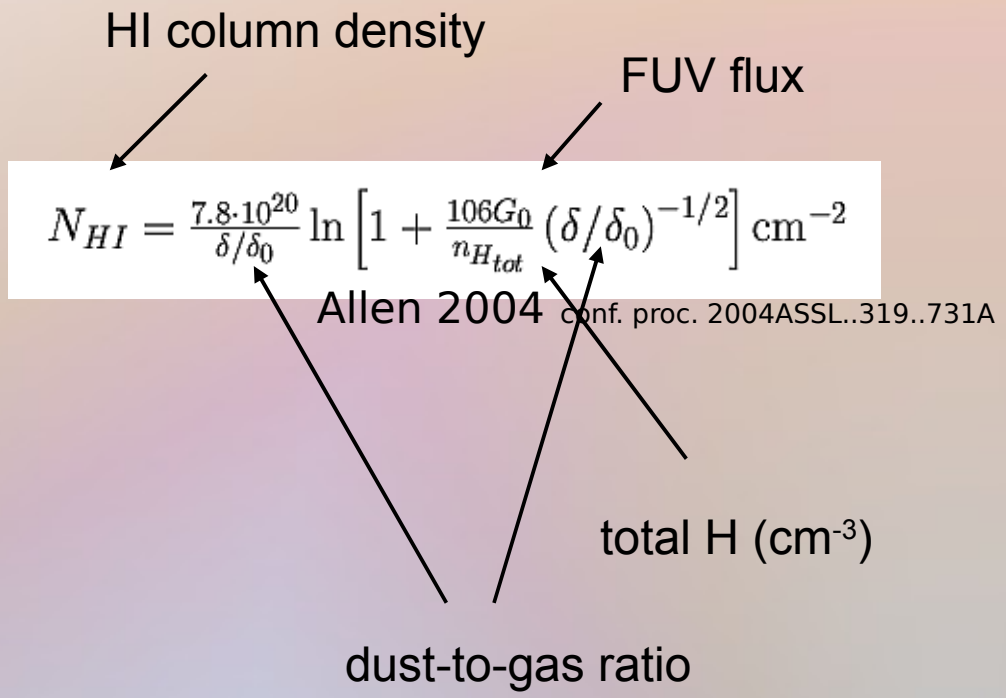
PDR method



...see also Heiner et al. 2009

Schmidt: SFR ∝ n^{α}



- Derive n_H – total hydrogen **volume** density
- L_{UV} ~ SFR
- Recover Schmidt Law

Schmidt Star Formation Law in M33

As obtained from the 'PDR method'

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Introduction

- Main goal: to examine the relation between GMC volume densities and the star formation rate - the essence of the Schmidt Law (Schmidt 1959, 1963).
- Basically, SFR $\propto n^{\alpha}$, where the power law slope α is sought, and more gas means more stars formed.
- Not to be confused with Kennicutt's surface density approach; $\Sigma_{SFR} \propto <\Sigma_{HI}>$. We use volume densities instead of surface densities.

Our approach

- Use 'PDR method': Observations of the atomic layer of photodissociated molecular gas in GMCs allow us to compute total hydrogen volume densities n.
- Relate n to L_{UV} of nearby OB associations.

Selection effects

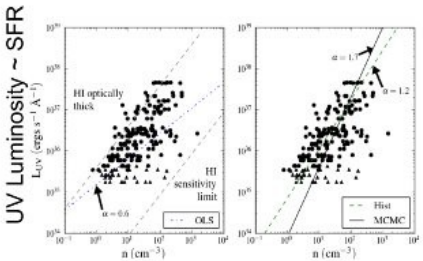
- The PDR method results are strongly censored, mainly due to HI optical depth and sensitivity limits. We attempt to understand and correct the bias in α.

PDR Method

- Photodissociation regions (PDRs) near star forming regions (SFRs) harbor a complex chemistry.
- HI is converted into H_2 – and the reverse.
- With PDR-produced HI, deduce underlying total hydrogen density.
- HI patches on the surface of GMCs surround every FUV source.
- HI – FUV distances separation are measured.
- Connect *HI column density, dust-to-gas ratio* δ / δ_0 *and incident FUV flux* G_0 to the *total hydrogen volume density* n_H. (Linear resolution ~100 pc in M33.)
- Dust catalyzes the formation of H_2 and attenuates the FUV radiation.

$$N_{HI} = \frac{7.8 \times 10^{20}}{\delta/\delta_0} \ln\left[1 + \frac{106 G_0}{n_H} (\delta/\delta_0)^{-1/2}\right]$$ Allen et al. 2004

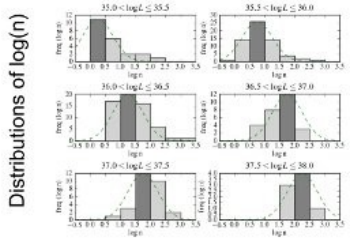
Preliminary Results



Total hydrogen volume density ~ gas

We plot L_{UV} vs. n and notice a strong observational selection due to HI optical depth and HI sensitivity limits (dashed lines). Most of the censoring occurs in the upper left corner. A 'blind' ordinary least squares fit yields a slope of 0.6.

We also plot histograms of n in different ranges of L_{UV} in order to show the censoring. Suggested normal distributions are indicated (dashed lines). Selection effects are strongest towards lower values of log(n). Assuming a normal distribution of log(n) we estimate a slope of ~1.2 (green dashed line). Using more robust Bayesian inference (a Monte Carlo Markov Chain method) we get a more accurate estimate of a **1.7** ± 0.2 power law slope (solid line). Schmidt's initial estimate of the slope was 2.



Conclusions

We analyzed 51 candidate PDRs in M33 and determined the total hydrogen volume density of their parent GMCs. Plotted against the UV luminosity of nearby OB associations, this reveals a Schmidt-law-like correlation with a slope of **1.7** ± 0.2. Note that this analysis involves the volume densities as in Schmidt's analysis, not surface densities as were introduced later by Kennicutt.

Future Work

Improve the PDR method to obtain a more accurate estimate of the effects of censoring on the power law slope.

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