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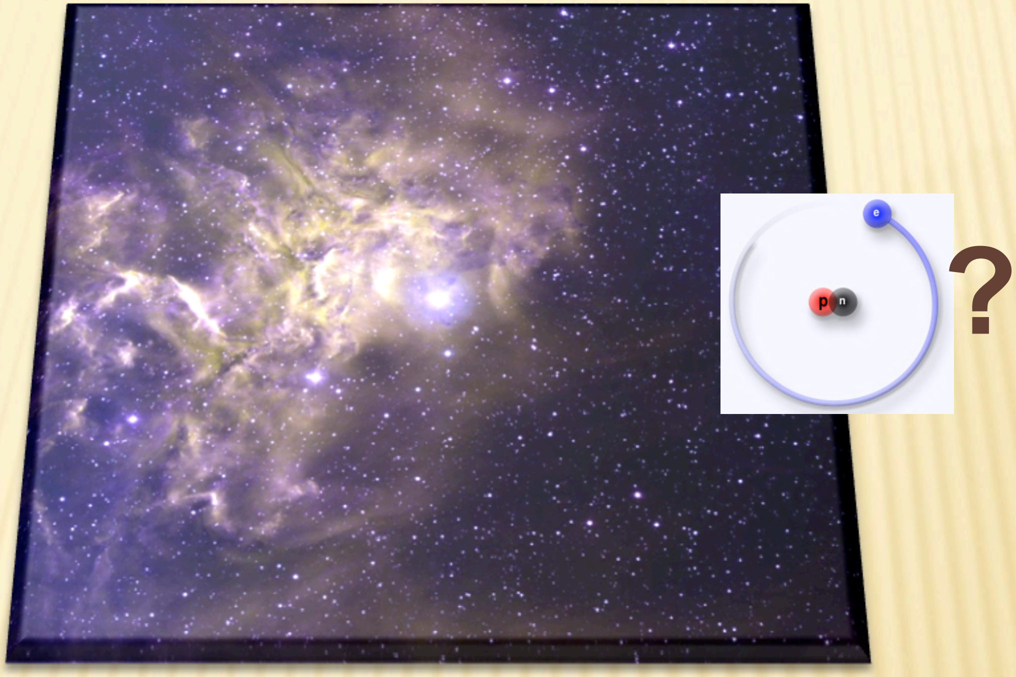

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THE (UN)TRUE DEUTERIUM ABUNDANCE IN THE GALACTIC DISK

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STORY ABOUT DEUTERIUM

- Only created in Big Bang (Boesgaard & Steigman 1985)
- All other processes destroy it (Epstein et al. 1976, Prodanović & Fields 2003)
- Should (?) decrease monotonically from high to low z
- Deuterium – a powerful tool in cosmology!
  - Cosmic baryometer! BBN success story
  - WMAP & BBN (blue) and high-z obs. (yellow) – a match!

Cyburt et al. (2008)

$$y_D \equiv (D/H) \times 10^5$$

$$y_{Dp} = 2.82^{+0.20}_{-0.19}$$

- Deuterium – a powerful tool in chemical evolution!
  - Probes virgin ISM fraction!

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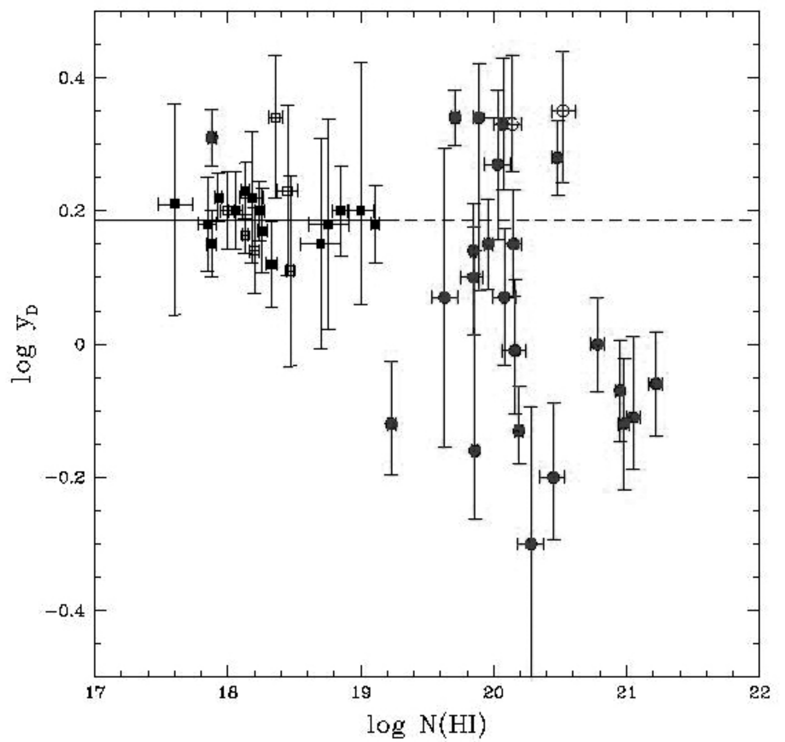
THE TROUBLE

- Large variations of D in local ISM over different lines of sight!

$$0.5 \leq y_D \leq 2.2$$



Data from
Linsky at al. (2006)

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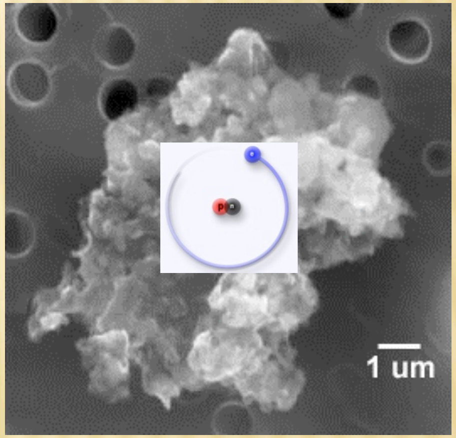
SOLUTION?

- Deuterium preferentially (compared to H) depleted onto dust! (Jura 1982, Draine 2004, 2006)



- Measure lower bound on the "true" D
- "True" ISM D abundance (Linsky at al. 2006)

$$y_{D,ISM+dust} \geq 2.31 \pm 0.24$$

- "True" ISM D = 82% of PRIMORDIAL!

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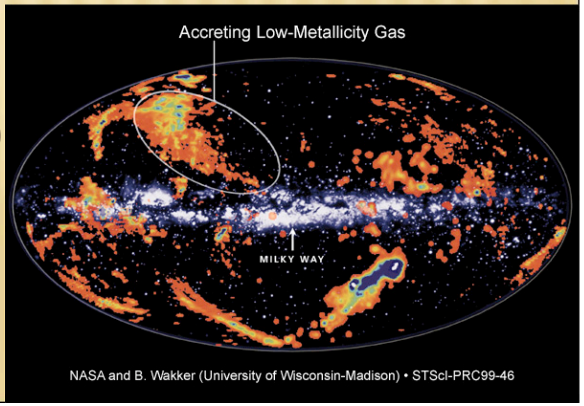
GALACTIC CHEMICAL EVOLUTUON

- Deuterium destroyed through stellar cycling
- Astration factor (Steigman et al. 2007) $1.4 \leq f_D \equiv y_{Dp} / y_{DISM} \leq 1.8$
- But new *FUSE* high ISM D $f_D \leq 1.22 \pm 0.15$
- Most gas still unprocessed?
- Gas observations say ~20% of present baryonic mass in ISM
- But D observations say ~80% initial gas unprocessed!
- Thus GCE says INFALL NEEDED



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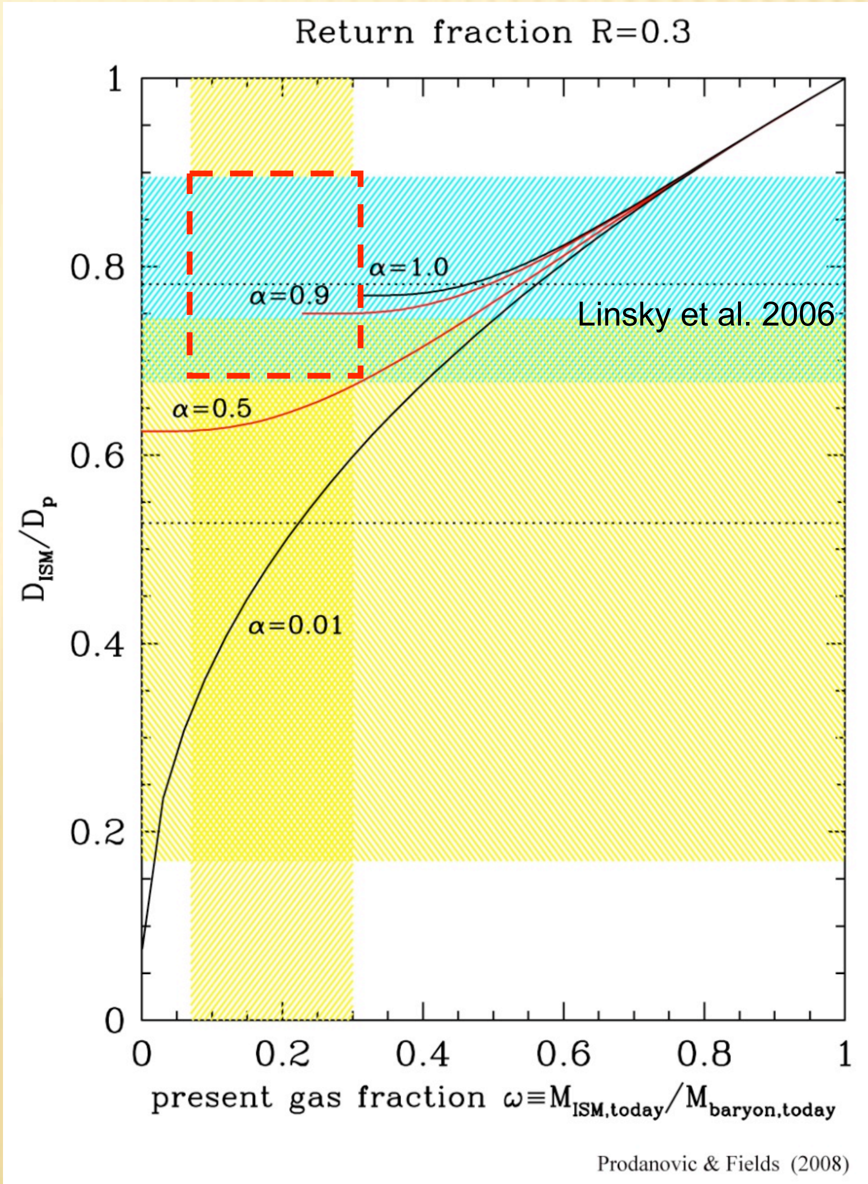
HOW MUCH INFALL?

- Assume infall rate ~ star form. rate $\alpha \propto \psi$
- D *vs.* gas fraction
- Shaded = observations
- Allowed infall rate

$$0.5 \leq \alpha \leq 1$$

- Almost balances out star-formation!
- Still tension with GCE
- Is ISM D really so high?



Prodanovic & Fields 2008

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A BAYESIAN APPROACH

- Try something different – make (almost) no assumptions
- Bayesian analysis (introduced by Hogan et al. 1997)
  - Use all available LOS
  - Assume only a possible (dust) depletion
  - Find 2-parameter maximum likelihood $\{y_{D,\max}, w\}$
    - $y_{D,\max}$ - Max. D abundance consistent with observations; a lower limit to true ISM D $y_{D,\max} \leq y_{D,ISM}$
    - $w \equiv y_{D,\max} - y_{D,\min}$ - Depletion parameter

Prodanovic, Steigman & Fields (2009)
arXiv:0910.4961

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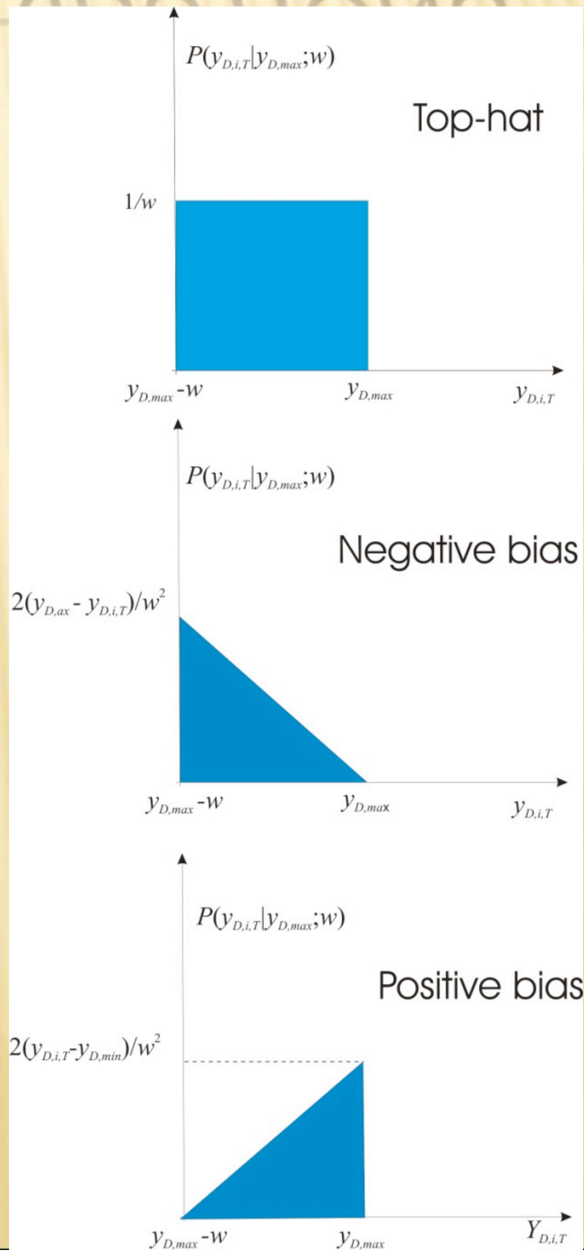
CHOICE: DEPLETION DISTRIBUTIONS

- Know nothing about (dust) depletion distribution
- Make as little assumptions

1) Top hat – all levels of depletion equally probable
2) Negative bias – favors large depletion
3) Positive bias – favors low depletion



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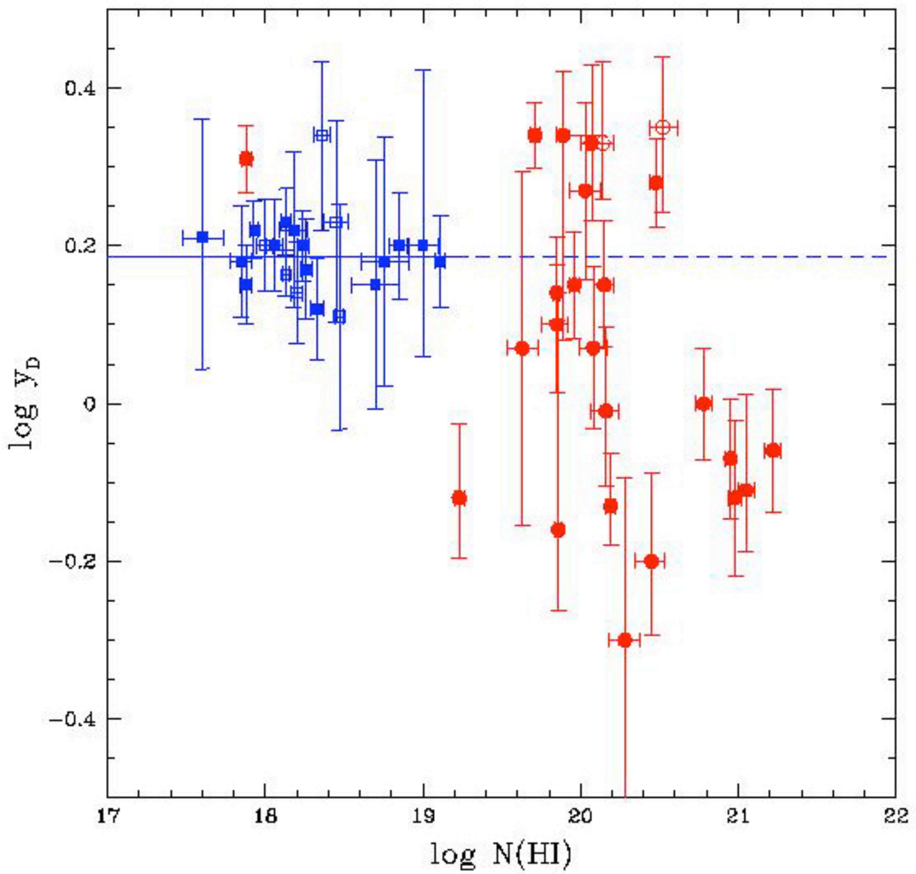
LB VS. NON-LB

- Local Bubble very different from non-Local Bubble
- LB – blue
  - Uniform
- nLB – red
  - Large scatter
- First treat separately

Prodanovic, Steigman & Fields (2009)
arXiv:0910.4961



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RESULTS: LIKELIHOOD CONTOURS

- Top-hat depletion distribution

- 21 Local Bubble LOS

$y_{D,LB} \cong 1.5 \quad w \cong 0 \quad f_{D,LB} \leq 1.8$

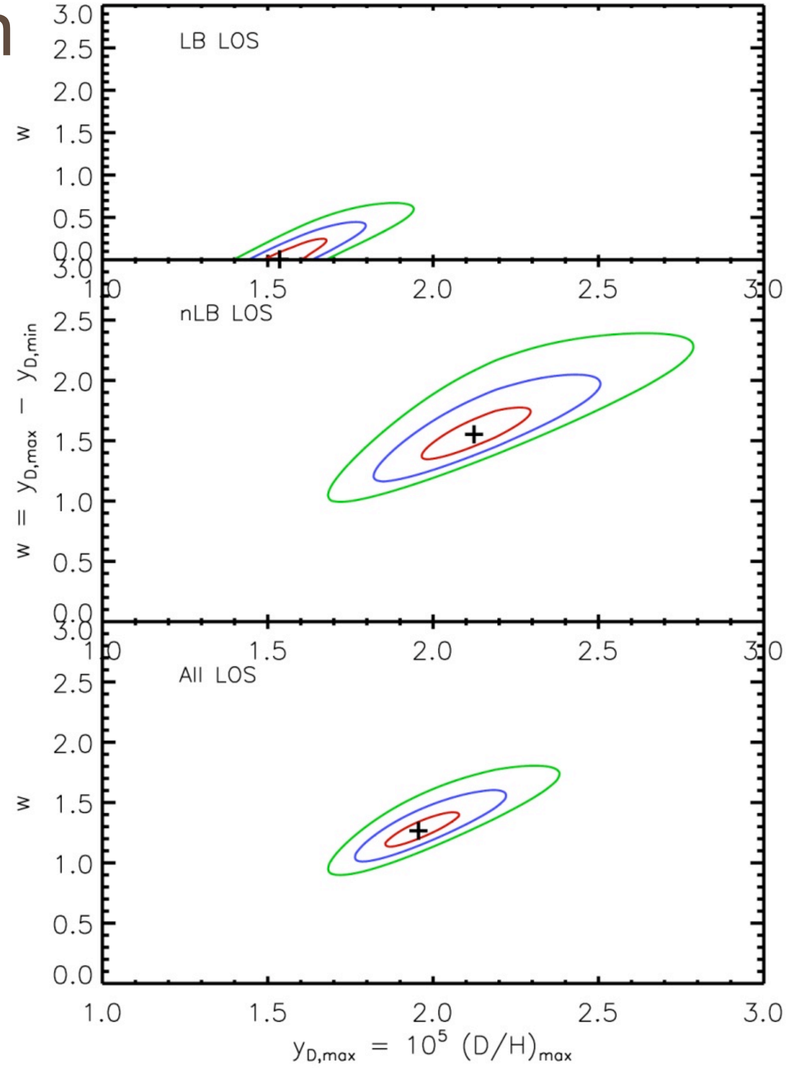
- 25 non-Local Bubble LOS

$y_{D,nLB} = 2.1 \quad w = 1.6 \quad f_{D,nLB} \leq 1.3$

- All 46 LOS

$y_{D,\max} = 2.0 \quad w = 1.3 \quad f_{D,\max} \leq 1.4$

Prodanovic, Steigman & Fields (2009)
arXiv:0910.4961



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RESULTS: TRUE ISM D ABUNDANCE

- Use all 46 LOS
- Top-hat depletion distribution – highest max likelihood value

$$y_{D,ISM} \geq y_{D,\max} = 2.0 \pm 0.1$$

- Marginally consistent with $y_{D,ISM+dust} \geq 2.31 \pm 0.24$

Linsky et al. (2006)

- Releases tension with GCE models $f_D \leq 1.4 \pm 0.1$

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SUMMARY & CONCLUSIONS

- If Local ISM D abundance close to primordial – problems with most GCE models
- Bayesian analysis following Hogan et al. (1997)
- Assume all variations due to (dust) depletion
- Analyze all LOS
- Tested 3 simple depletion distributions
  - Top-hat gives max likelihood value
  - "True" ISM D abundance new estimate:

$$(D/H)_{ISM} \geq (D/H)_{\max} = (2.0 \pm 0.1) \times 10^{-5}$$

Prodanovic, Steigman & Fields (2009)
arXiv:0910.4961

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PROBLEMS

- Uniform LB D abundance vs. large scatter in nLB?
  - LB - no depletion? $y_{D,LB} = 1.5 \quad w = 0$
  - nLB – large depletion? $y_{D,nLB} = 2.1 \quad w = 1.6$
- Is LB uniformily depleted?
- Is nLB enriched with unmixed infall?
- How do we discriminate?
- Is Fe really a good depletion indicator for D?
- Steigman & Prodanović (2009/10) in preparation

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THANK YOU!