

Baryon - Dark Matter Interactions:  
Cosmic-ray and Nucleosynthesis  
Constraints

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# Motivation

Possible *discrepancy* between:

Collisionless Dark Matter simulations  
& galactic scale observations



Strongly *Self-Interacting Dark Matter*

(Spergel & Steinhardt 2000 ; Kamionkowski talk )

Are strong interactions between  
*baryons & dark matter* allowed?

Interesting & fundamentally important question  
in itself

Phenomenological approach,  
considering observational consequences  
of baryon – DM interactions (BDMIs)

# Consequences of BDMIs

BDMIs can:

- ✓ Destabilize Galactic disc
- ✓ Show up in cosmic ray detectors

Relevant energies:  $\sim \text{keV}$

Considered by Wandelt et al (2000)

exclude  $M_D < 10^5 \text{ GeV}$ ,  
but for larger masses  
allow  $\sigma \sim \sigma_{\text{BB}}, \sigma_{\text{DD}}$

- ✓ Alter light element abundances

Relevant energies:  $\sim \text{MeV}$

- ✓ Overproduce  $\gamma$ -rays originating from cosmic rays

Relevant energies:  $\sim \text{GeV}$

this work

# BBN, Cosmic-Ray Constraints

Cannot constrain *both* mass and cross-section  
Instead, constrain:

$$s = \sigma / M_D$$

cross section per unit mass of DM particle

where

$$s_{DD}, s_{BB} \sim 1 \text{ cm}^2 / \text{g} \sim 1 \text{ barn} / \text{GeV}$$

# BBN Constraints

Side-Effect of BDMIs :

Deuterium destruction  $D + d \rightarrow D + n + p$



onset of BBN delayed

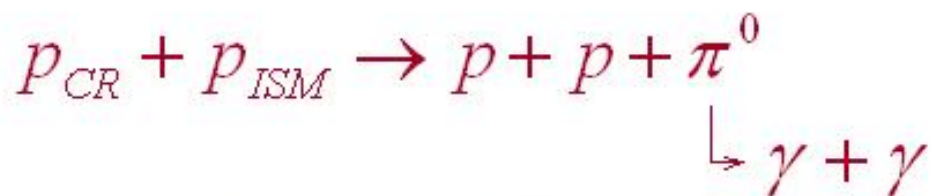


primordial element abundances altered

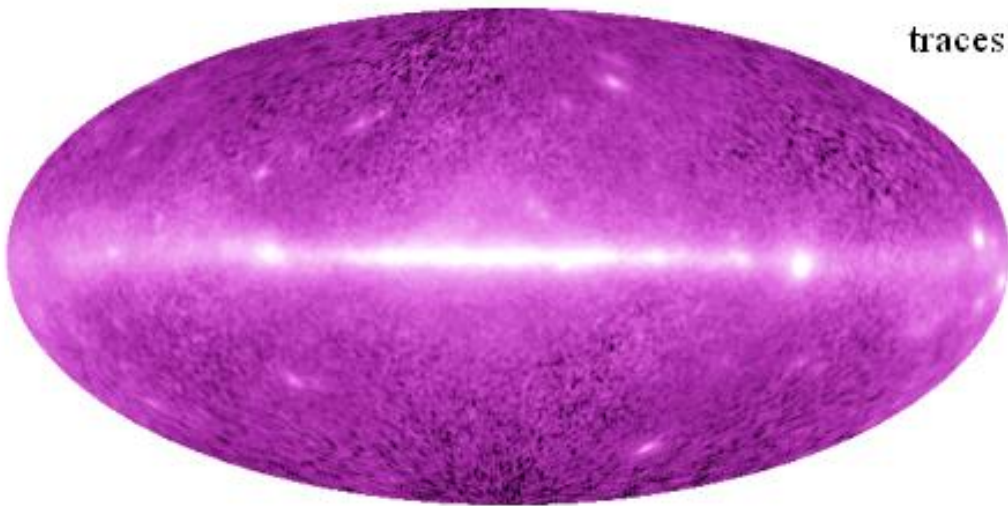
Result: very weak constraint,  $s < 10^8 \text{ cm}^2/\text{g}$   
BBN OK with baryon-interacting dark matter

# Cosmic Ray Constraints

**Cosmic Rays:** relativistic nuclei  
penetrating Milky Way  
manifest themselves through



traces ISM

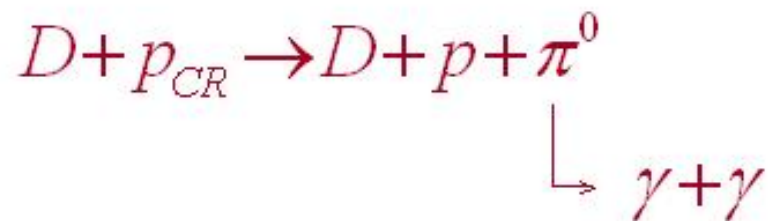


EGRET all-sky image for energies  $> 100$  MeV  
in Galactic coordinates (from Hunter et al 2001)

# Cosmic Ray Constraints

Side Effect of BDMI's :

$\gamma$ -rays now also produced by



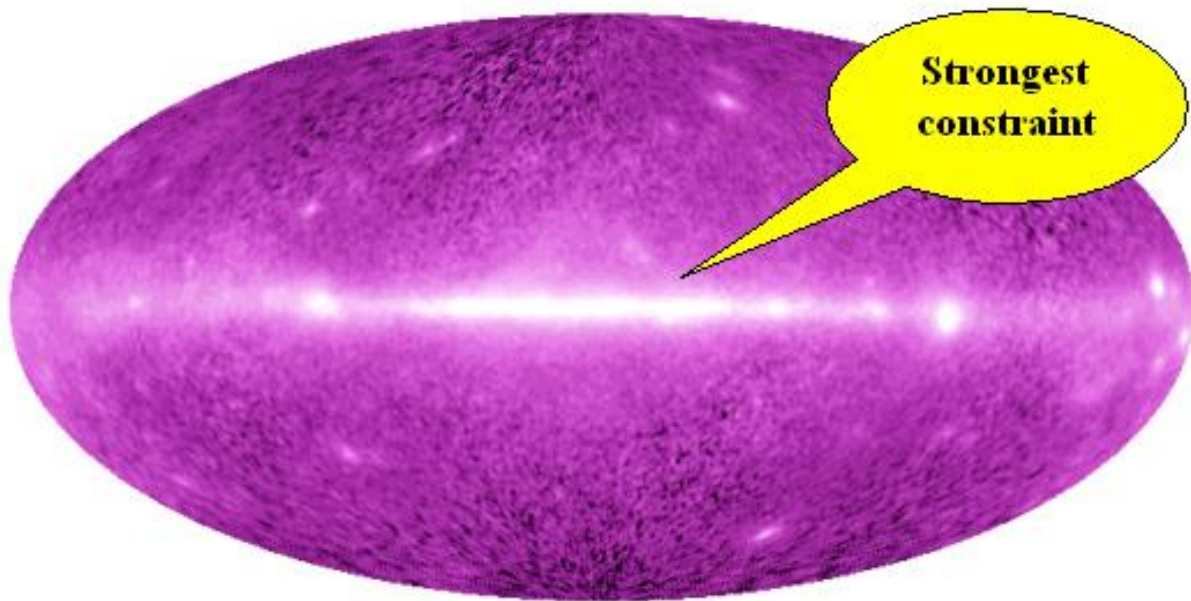
$\Downarrow$

If  $D + p_{CR}$  cross section too large:  
produce more  $\gamma$ -rays than observed

Result: Most conservative constraint  
if we attribute all  $\gamma$  flux  
to DM – CR interactions

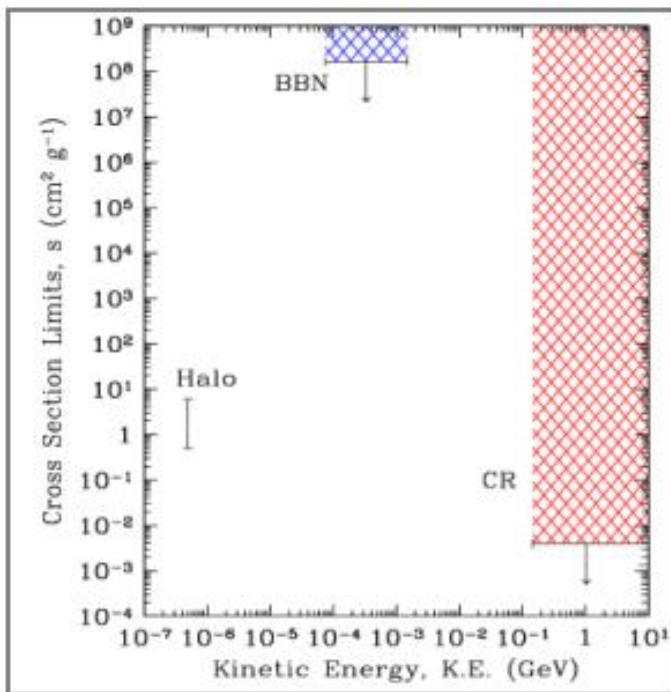
Even so,  $s < 5 \times 10^{-3} \text{ cm}^2/\text{g}$

# Cosmic Ray Constraints



EGRET all-sky image for energies  $> 100$  MeV in Galactic coordinates (from Hunter et al 2001)

# Conclusions



- Strongly interacting dark matter allowed by BBN

- Very strong limits on  $s$  from CR-DM interactions:

- ✓ If cross section indep. of  $E$ :

  - $s_{\text{BD}}$  1000 times smaller than  $s_{\text{DD}}$

- ✓ If we allow energy dependence:

  - need  $s \propto 1/v$  (or steeper) to have  $s_{\text{BD}} \sim s_{\text{DD}}$

- For other constraints: CMB, LSS

  - (see Chen e-poster ; Chen, Hannestad & Scherrer )