Cosmo 02, Chicago

Cosmological Constraint on Dark Matter-Baryon Interaction

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Interaction of Dark Matter

Self Interacting Dark Matter (SIDM)

SIDM->halo core (Spergel & Steinhardt 1999)

$$\frac{\sigma/\mathrm{cm}^2}{m/\mathrm{GeV}} = 8.1 \times 10^{-25} \left(\frac{\lambda}{1\mathrm{Mpc}}\right)^{-1}$$

Strongly Interacting Massive Particle (SIMP)

$$8 \times 10^{-25} < \frac{\sigma/\mathrm{cm}^2}{m/\mathrm{GeV}} < 10^{-23}$$

(Wandelt et al 2000)

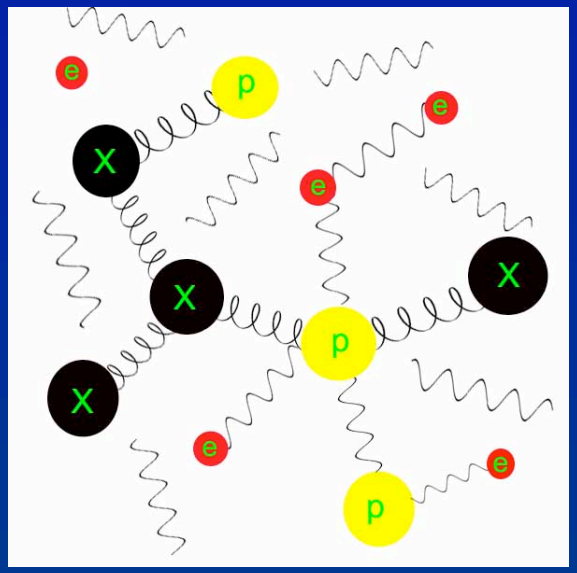
SIMP: interact with baryons, with a strength comparable to strong interaction, but no electromagnetic interaction.

WIMP search won't find SIMP because it lost energy when enter atmosphere

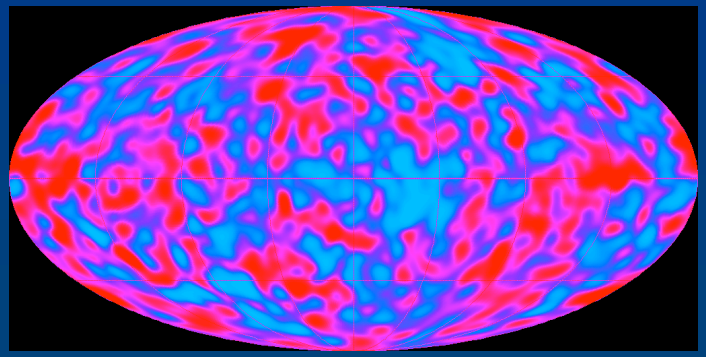
Candidates:

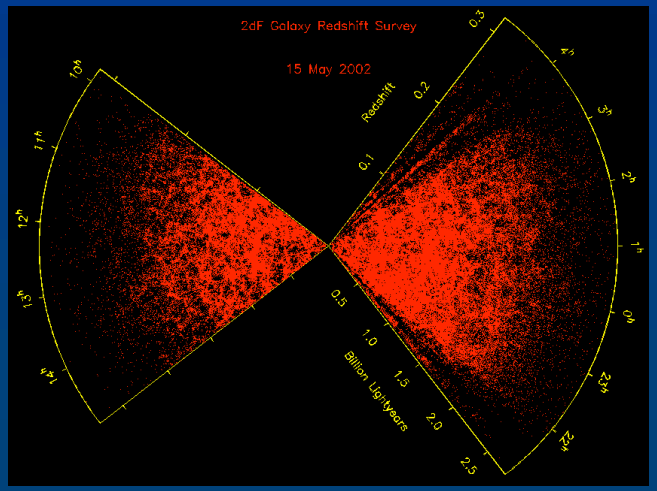
- quark-gluino bound state
- gauge-singlet meson
- Q ball (Kusenko & Steinhart 2001)
- Mirror matter (Mohapatra 2001)

SIMPs affect CMB and large scale structure.



SIMPs induce additional damping of acoustic oscillations in photon-baryon fluid before recombination





SIMP effect on CMB and power spectrum

black: fiducial CDM model

red: increased baryon density

blue: SIMP model

The effect of baryons:

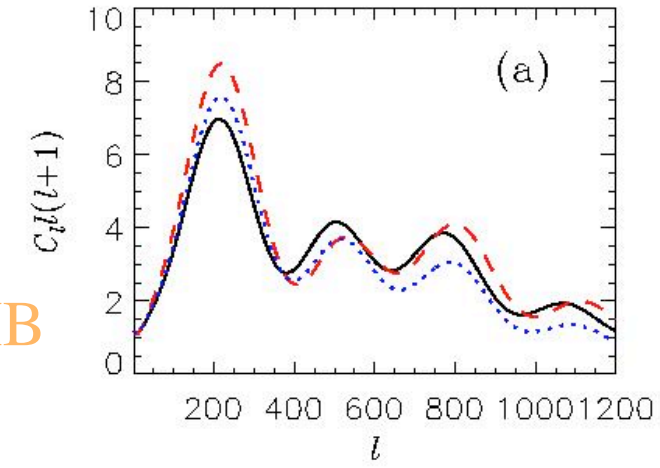
introduce a greater oscillator mass

shift balance position and induce larger amplitude

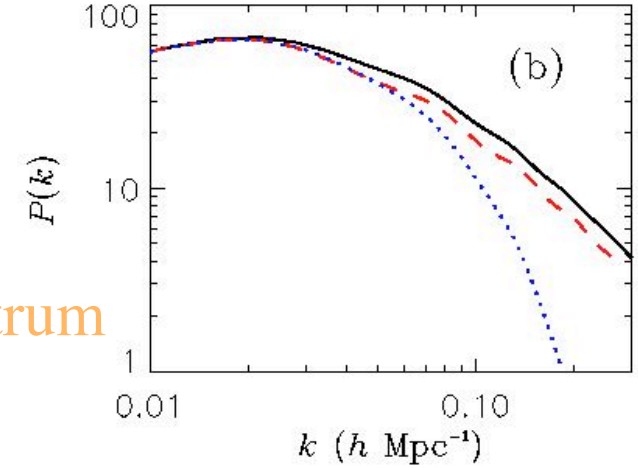
The effect of SIMPs:

introduce a viscosity term

CMB



power spectrum

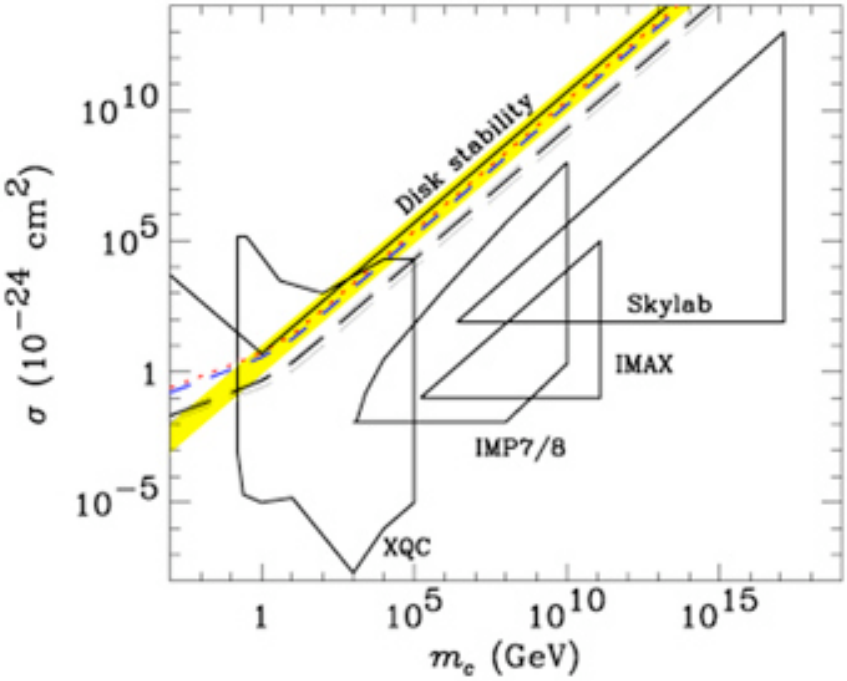


Results:

Calculated with modified version of CMBFAST

Assumptions of calculation:

- Short Range interaction
- S wave elastic scattering (velocity-independent)
- Non-relativistic velocity
- Two-body interaction
- The dark matter and baryons behave as two coupled fluids
- In thermo-equilibrium
- No significant dark matter-lepton interaction



constraint on cross section

$$\frac{\sigma}{10^{-24}\mathrm{cm}^2} < \frac{0.63x^{1/2} + 0.22x^{3/2}}{1 + x^{1/2}}$$

prior type	Ω_m	$\Omega_b h^2$	h	n	τ	Q	b
CMB	Ω_b-1	0.008 - 0.040	0.4-1.0	0.66-1.34	0-1	free	not used
CMB + BBN + H_0	Ω_b-1	0.020 ± 0.002	0.72 ± 0.08	0.66-1.34	0-1	free	not used
CMB + BBN + H_0 + LSS	Ω_b-1	0.020 ± 0.002	0.72 ± 0.08	0.66-1.34	0-1	free	free

Conclusion

Cosmic microwave background anisotropy and large scale structure can be used to constrain dark matter-baryon interaction. Using current data (Boomerang, MAXIMA, 2dF), SIMPs with an interaction cross section comparable to "Spergel-Steinhardt" cross section are ruled out. However, this method does not constrain self-interaction of dark matter.