

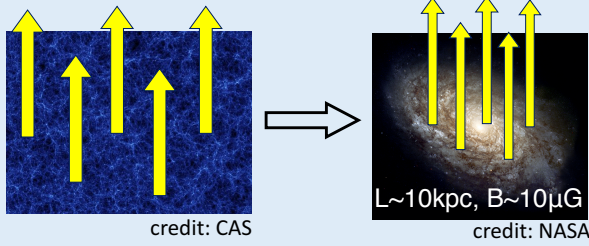
A novel constraint on the Primordial Magnetic Fields using 21-cm line absorption signal

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1. INTRODUCTION

What is the origin of magnetic fields with various astronomical objects?

Magnetic fields in the early universe?
(=Primordial Magnetic Fields, PMFs)



Amplification by adiabatic compression
--> The seed field $B_{1\text{Mpc}} \sim 1 \text{ nG}$ is needed.
PMFs with 1 nG heat up the IGM gas?

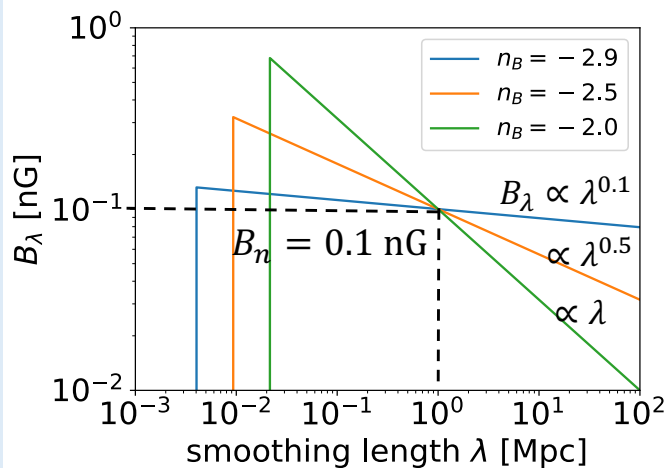
2. Model of PMFs

scale dependence

$$B_\lambda = B_n \left(\frac{\lambda}{1 \text{ Mpc}} \right)^{-(n_B+3)/2}$$

B_n : PMF amplitude smoothed on 1Mpc

n_B : spectral index of PMF strength



PMF has a cut-off scale because of the collision between baryon-photon plasma

$$\lambda_{\text{cut}}^2 = \frac{B_{\text{cut}}^2}{4\pi\rho_{\text{CMB}}\sigma_T} \int_0^{t_{\text{rec}}} \frac{c dt}{a^2 n_e}$$

5. Conclusion

- Calculate IGM gas temperature T_{gas} with PMFs fluctuation and dissipation
- Constrain the PMF strength from the 21-cm signal condition ($T_{\text{gas}} < T_{\text{CMB}}$)
- Suggestion for another amplification mechanism except for the adiabatic compression?

(References) Jedamzik+ 1998; Sethi & Subramanian 2005; Schleicher+ 2008; Marinacci & Vogelsberger 2016; Bowman+ 2018

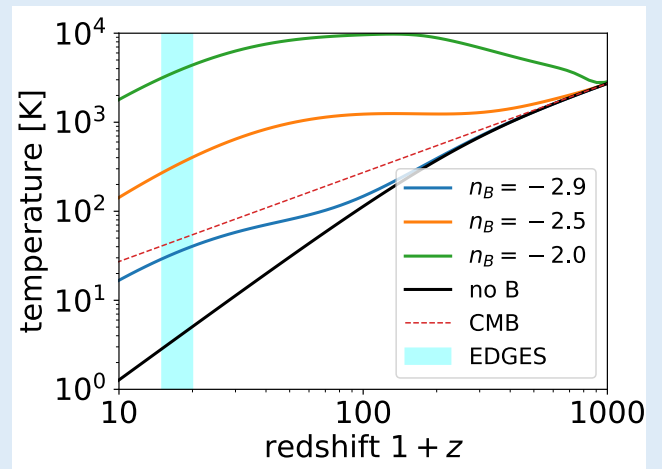
3. IGM thermal history

After decoupling from CMB ($z \lesssim 200$),

I. Adiabatic case $T_{\text{gas}} \propto (1+z)^2$

II. PMF heating case (this work)

- Ambipolar Diffusion (dominant)
collision between the neutral and ionized particles
- Ohmic dissipation (sub-dominant)
small-scale eddies from MHD turbulence

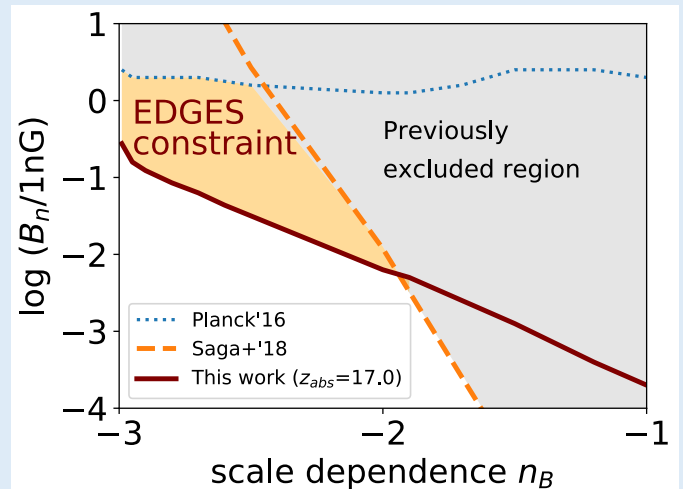


4. A constraint from 21-cm signal

EDGES 21-cm line observation suggests

$$T_{\text{gas}} < T_{\text{CMB}} \text{ (for } 15 < z < 20\text{)}$$

Calculate T_{gas} with various (B_n, n_B)



(T. Minoda *et al.*, arXiv:1812.00730)