Thermal Sunyaev-Zel'dovich effect in the IGM with Primordial Magnetic Fields

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1. INTRODUCTION

Origin of the cosmic magnetic fields?

PMFs(Primordial Magnetic Fields) affect high-z IGM **density** & **temperature**

observe the CMB anisotropy through **SZ effect**

2. MODEL of PMFs

Two free parameters > $(B_{1\mathrm{Mpc}}, n_B)$

$$B_\lambda^2 = B_n^2 \left(\frac{k_\lambda}{k_n}\right)^{n_B+3} \quad \text{if } \mathrm{k}_\lambda < \mathrm{k}_\mathrm{c}$$

There is a cut-off scale $\lambda_c = 2\pi/k_c$ due to the baryon-photon scattering.

We set

model	$B_{1\mathrm{Mpc}}$ [nG]	n_B	λ_c [kpc]
1	0.5	0.0	250
2	0.5	-1.0	162
3	0.1	0.0	131
4	0.1	-1.0	72.4

3. IGM PHYSICS

➢ Density evolution

- linear approximation

$$\frac{\partial^2\delta_c}{\partial t^2} + 2H\frac{\partial\delta_c}{\partial t} - 4\pi G(\rho_c\delta_c + \rho_b\delta_b) = 0$$

$$\frac{\partial^2\delta_b}{\partial t^2} + 2H\frac{\partial\delta_b}{\partial t} - 4\pi G(\rho_c\delta_c + \rho_b\delta_b) = S(t)$$

$$S(t) = \frac{\nabla\cdot(\nabla\times\mathbf{B})\times\mathbf{B}}{4\pi\rho_b}$$

➢ Thermal history

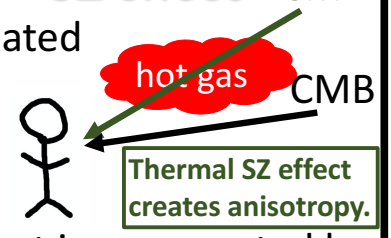
- cosmic expansion
- local expansion (or compression)
- scattering with CMB photons
- magnetic dissipation heating

$$\Gamma(t) \propto \frac{|(\nabla\times\mathbf{B})\times\mathbf{B}|^2}{\rho_\mathrm{b}^2}\frac{(1-x_\mathrm{i})}{x_\mathrm{i}}$$

- cooling from atomic transition

4. OBSERVABLE > SZ effect

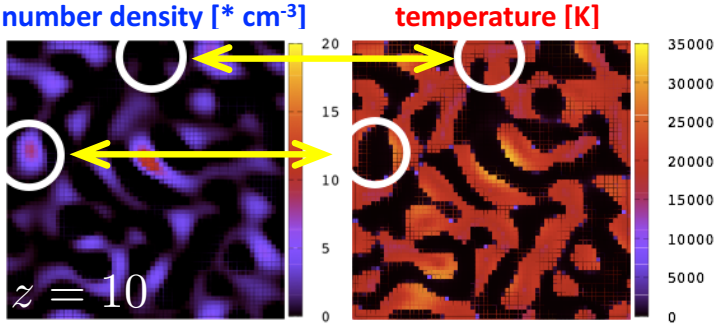
CMB photons are heated when they come through hot gas = **thermal SZ effect**



The degree of SZ effect is represented by

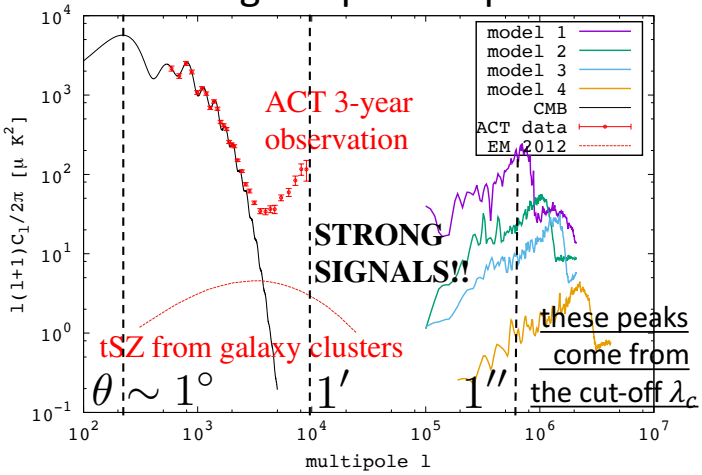
$$y(\hat{n}) \equiv \frac{k_B\sigma_T}{m_e c^2}\int dl x_e n_\mathrm{b}(T_\mathrm{IGM} - T_\gamma)$$

5. RESULTS



IGM **density** and **temperature** are anti-correlated!

CMB angular power spectrum



6. CONCLUSION

- We consistently solve the IGM **ρ** and **T** with PMFs for the first time.
- We estimate **tSZ signal** from high-z IGM with PMFs for the first time.
- Possible to observe? > The next work!

T. Minoda et al., https://arxiv.org/abs/1705.10054