Acoustic signatures in the Cosmic Microwave Background bispectrum from primordial magnetic fields

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Observation

Galaxy Cluster $B \sim \mu G \Longrightarrow$ Cosmological scale $B \sim nG$ as initial seed

motivation

- How does the primordial magnetic field affect the statistical property of CMB
- Whether there are some special signals from CMB if there exists primordial magnetic field

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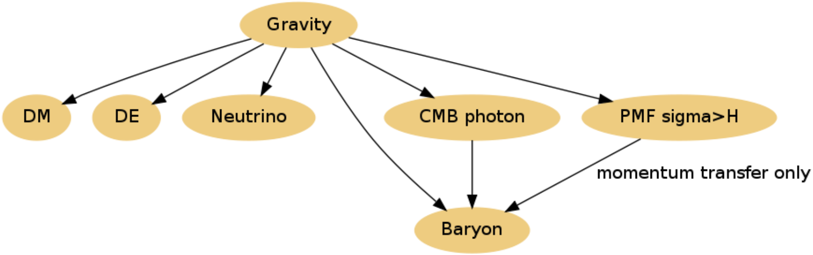

Figure: Diagram. $\sigma \gg H$ ideal MHD approximation

initial condition

- the density $\Delta_k^{(B)}$ sourced compensated magnetic mode
- the anisotropic stress tensor $\pi_k^{(B)}$ sourced mode

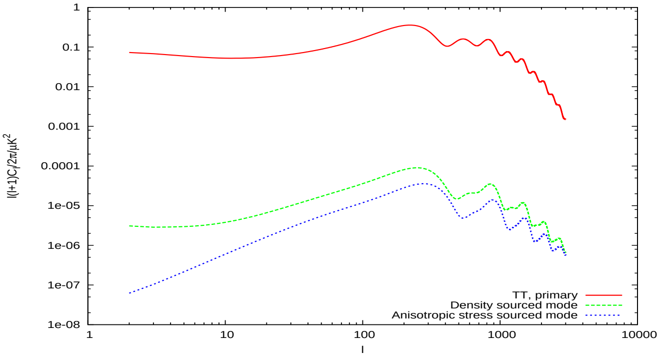

Figure: The CMB spectrum of TT mode. 4 order smaller

Estimator: reduced bispectrum

$$b_{l_1 l_2 l_3} = (8\pi)^3 \int_0^\infty x^2 dx \int_0^{k_D} d\ln k \int_0^{k_D} d\ln q \int_0^{k_D} d\ln p j_{l_1}(kx) j_{l_2}(qx) j_{l_3}(px) \times \underline{F_{\Delta_B}(k,q,p)} g_{Tl_1}(k) g_{Tl_2}(q) g_{Tl_3}(p)$$

where $F_{\Delta_B}(k_1, k_2, k_3)$ is

$$\left\langle \Delta^B(\vec{k}_1)\Delta^B(\vec{k}_2)\Delta^B(\vec{k}_3)\right\rangle \equiv F_{\Delta_B}(k_1,k_2,k_3)\delta\left(\vec{k}_1+\vec{k}_2+\vec{k}_3\right)$$

Reduced bispectrum can be decomposed [neglect angular part]

$$b_{l_1 l_2 l_3} = b^{(1)}_{l_1 l_2 l_3} + b^{(2)}_{l_1 l_2 l_3} + b^{(3)}_{l_1 l_2 l_3} \,,$$
$$b^{(1)}_{l_1 l_2 l_3} = \int_0^\infty x^2 dx \mathcal{N}_1 \left\{ b^{(\alpha)}_{l_1}(x) b^{(\beta)}_{l_2}(x) b^{(\gamma)}_{l_3}(x) + (l_1, l_2, l_3)\text{perm.} \right\}$$
$$b^{(2)}_{l_1 l_2 l_3} = \int_0^\infty x^2 dx \mathcal{N}_2 \left\{ b^{(\gamma)}_{l_1}(x) b^{(\delta)}_{l_2}(x) b^{(\gamma)}_{l_3}(x) + (l_1, l_2, l_3)\text{perm.} \right\}$$
$$b^{(3)}_{l_1 l_2 l_3} = \int_0^\infty x^2 dx \mathcal{N}_3 \left\{ b^{(\gamma)}_{l_1}(x) b^{(\gamma)}_{l_2}(x) b^{(\gamma)}_{l_3}(x) + (l_1, l_2, l_3)\text{perm.} \right\}$$

where

$$b^{(\alpha)}_l(x) \equiv \int_0^{k_D} dk k^{2n_B+5} j_l(kx) g_{Tl}(k), b^{(\beta)}_l(x) \equiv \int_0^{k_D} dk k^{n_B+2} j_l(kx) g_{Tl}(k)$$
$$b^{(\gamma)}_l(x) \equiv \int_0^{k_D} dk k^2 j_l(kx) g_{Tl}(k), b^{(\delta)}_l(x) \equiv \int_0^{k_D} dk k^{3n_B+5} j_l(kx) g_{Tl}(k)$$

Only show the plot of $b^{(1)}_{l_1 l_2 l_3}$, since it has the largest amplitude for large l.
Different asymptotic values

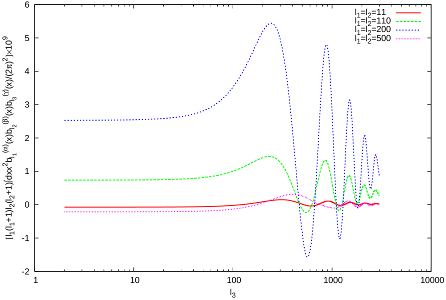

Figure: This figure shows the integral $l_1(l_1+1)l_2(l_2+1)\int dx x^2 b^{(\alpha)}_{i_1}(x) b^{(\beta)}_{l_2}(x) b^{(\gamma)}_{l_3}(x)/(2\pi)^2 \times 10^9$ as a function of l3 , with several parameter configurations ($l_1 = l_2 = 11, 110, 200, 500$)

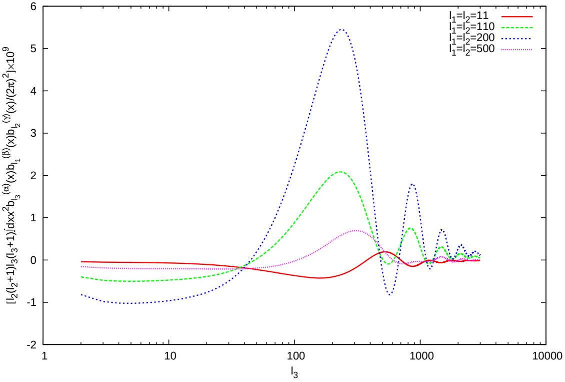

Figure: This figure shows the integral $l_2(l_2+1)l_3(l_3+1)\int dxx^2 b_{l_3}^{(\alpha)}(x)b_{l_1}^{(\beta)}(x)b_{l_2}^{(\gamma)}(x)/(2\pi)^2 \times 10^9$ as a function of l3 , with several parameter configurations ($l_1 = l_2 = 11, 110, 200, 500$)

THANKS