Kenji Kadota
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Cross-correlation between 21-cm radiation and CMB B modes from the cosmic birefringence in the presence of a light scalar field

Phys.Rev.D100(2019) 1906.00721[astro-ph]

In collaboration with: Junpei Ooba, Hiroyuki Tashiro, Kiyotomo Ichiki, Guo-Chin Liu

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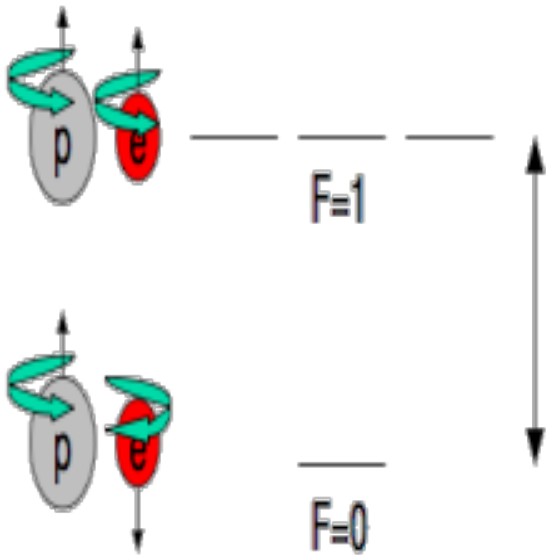
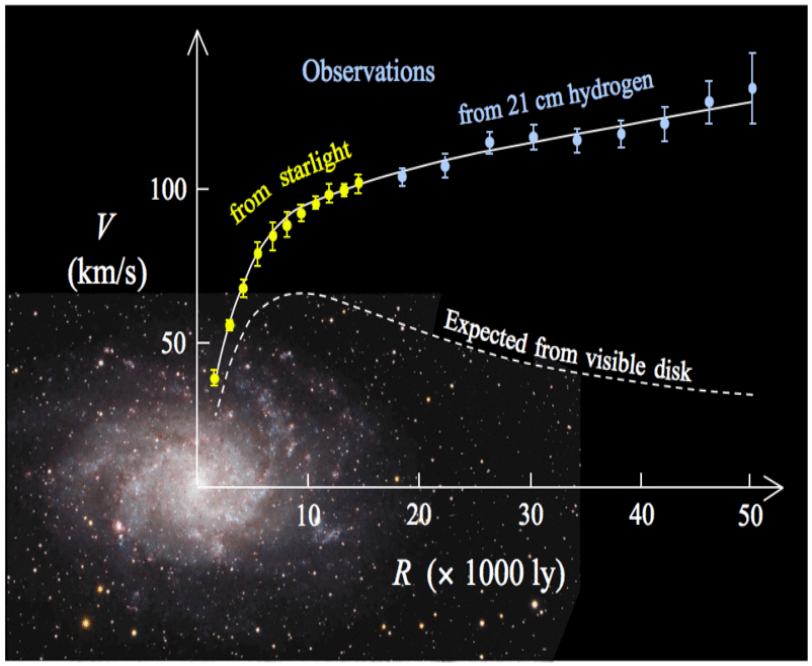
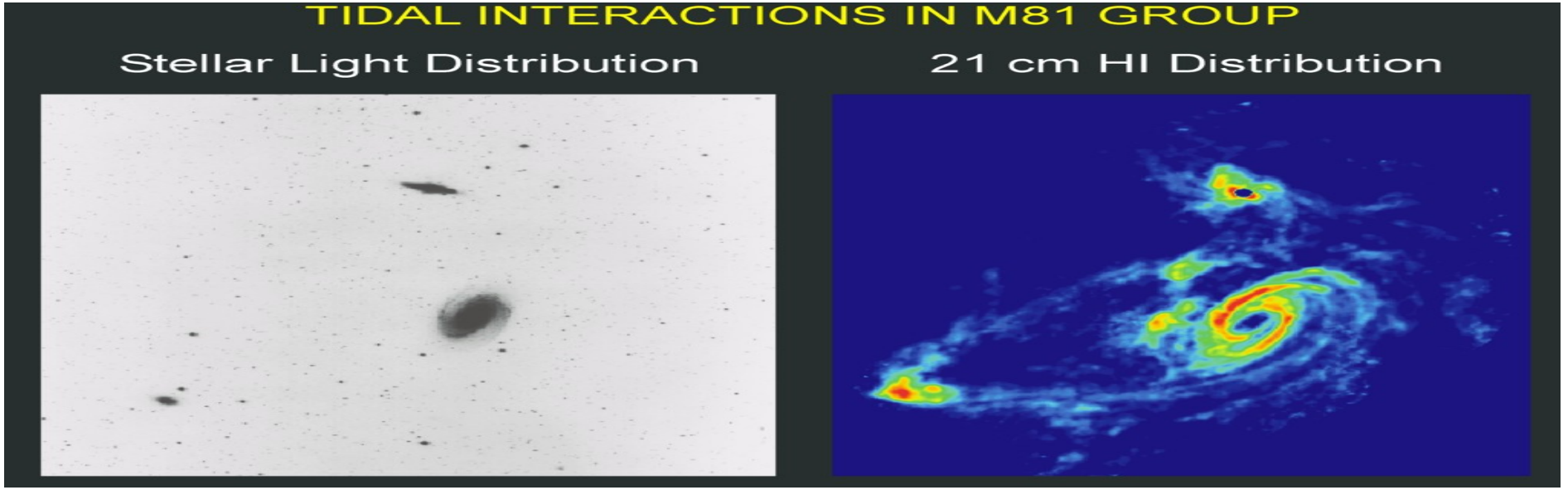
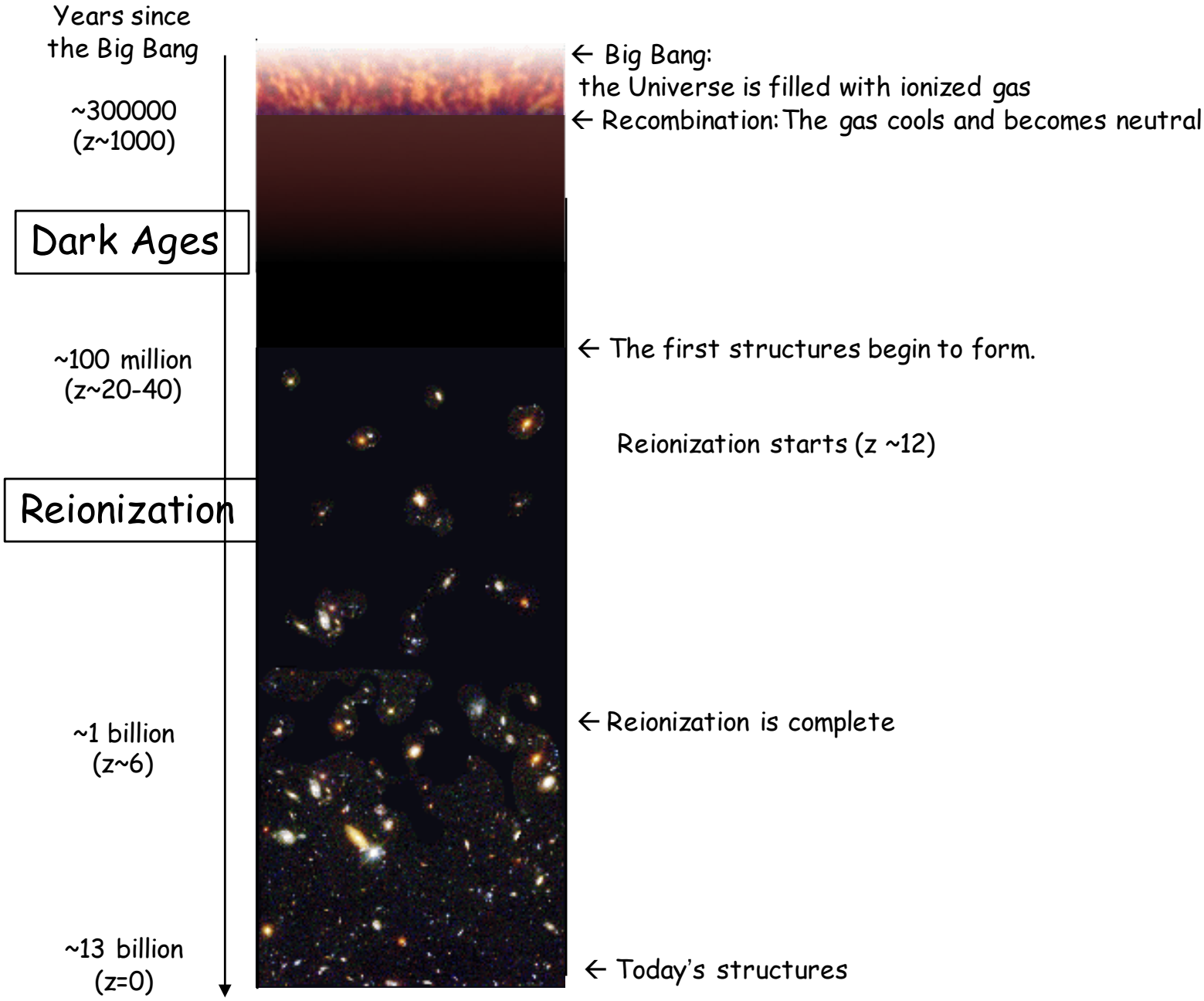


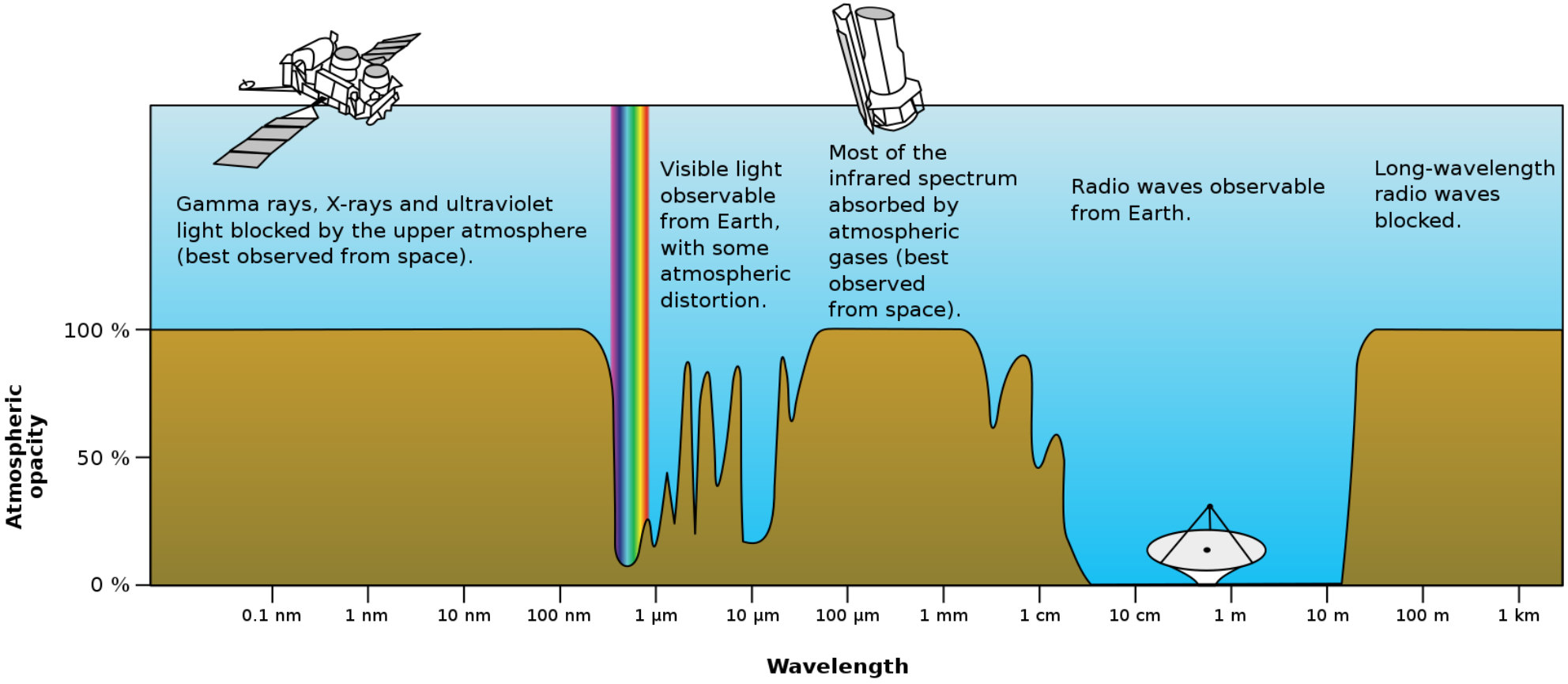
21cm signals
1420MHz





Brief History of the Universe





Australia: SKA low: 50-350 MHz

S. Africa: SKA mid: 350 MHz-14GHz

Axion mass: $0.2{\sim}60\ \mu eV$

QCD axion as a CDM candidate :

Mass µeV ~ meV(0.1GHz ~ 100GHz)

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Model: ALP (Axion-like particles) i.e. Ultra-light scalars

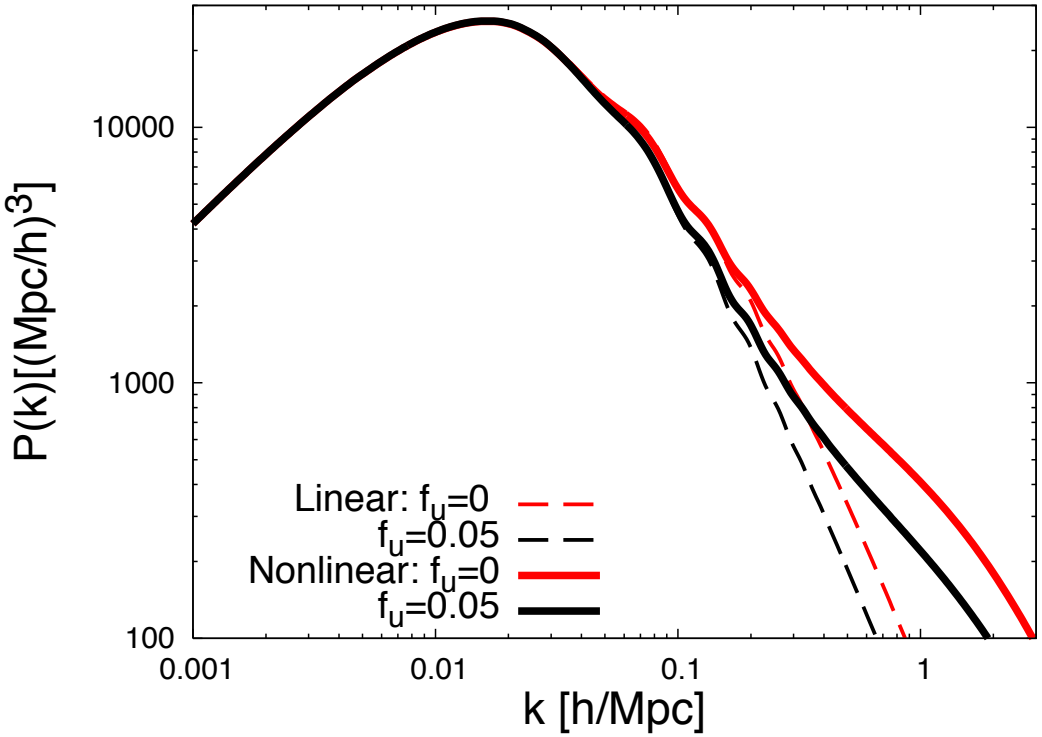
Ultra-light mass :

$m_u \sim H_0 \sim 10^{-33} eV$ DE (Barbieri et al (2005),…)

$m_u \sim \sim 10^{-22} eV$ Fuzzy DM (Hu (2000),…)

$m_u \sim \sim 10^{-22} eV - 10^{-10} eV$ String axiverse (Arvanitaki et al (2009),...)

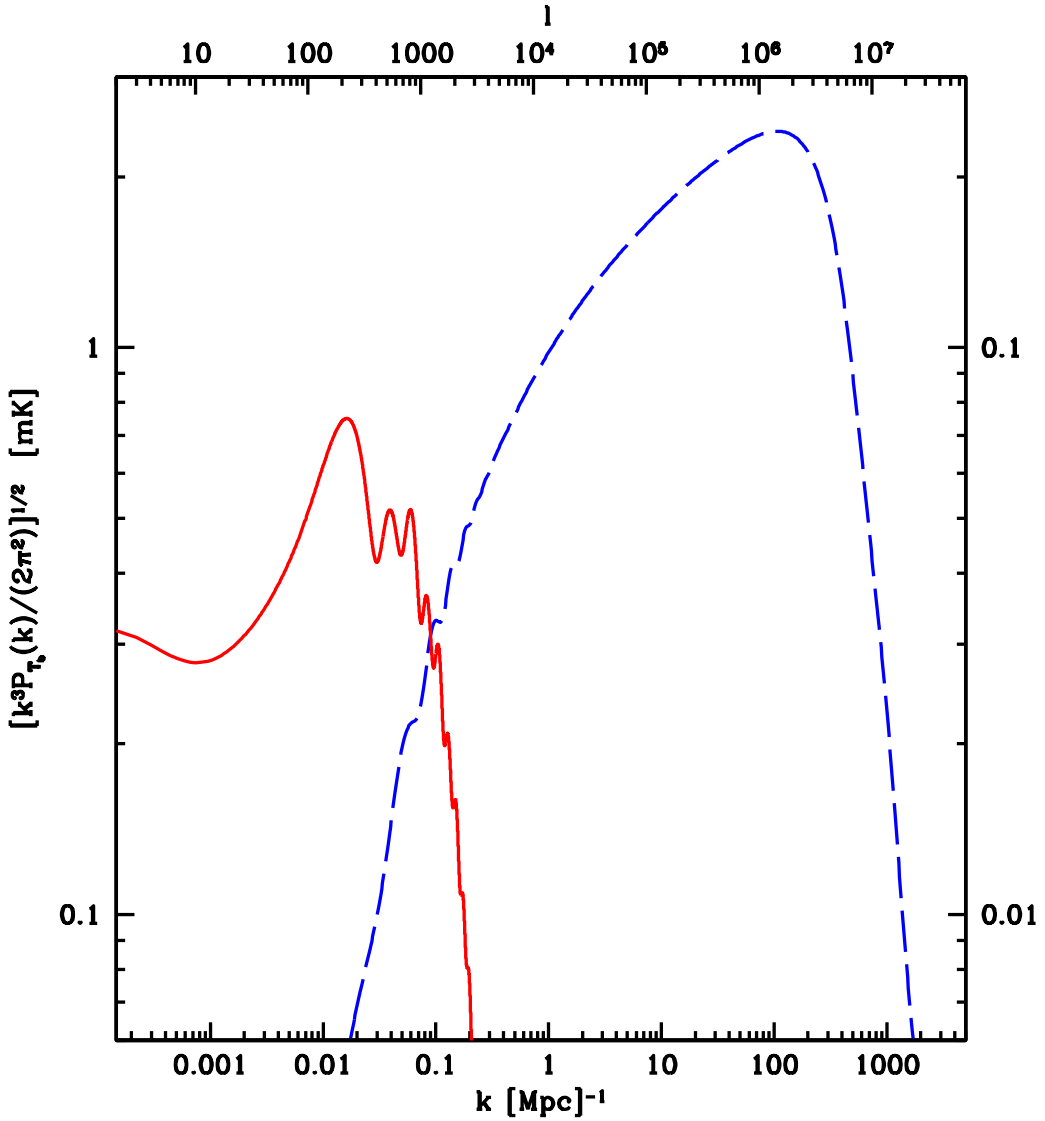
KK, Yi Mao, Kiyomoto Ichiki, Joseph Silk (2014)
"Cosmologically probing ultra-light particle dark matter using 21 cm signals"



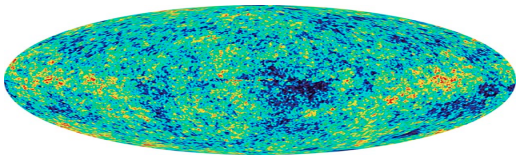
KK, Mao, Ichiiki, Silk (2014)

What can we do with 21cm?

$$\Delta P/P \sim 1/\sqrt{N}$$



Kleban+(2007)



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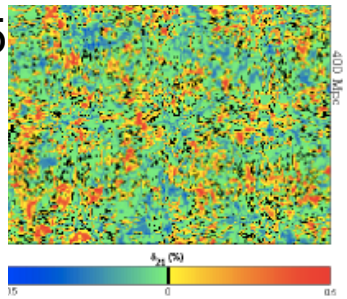

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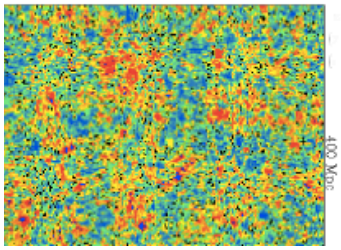

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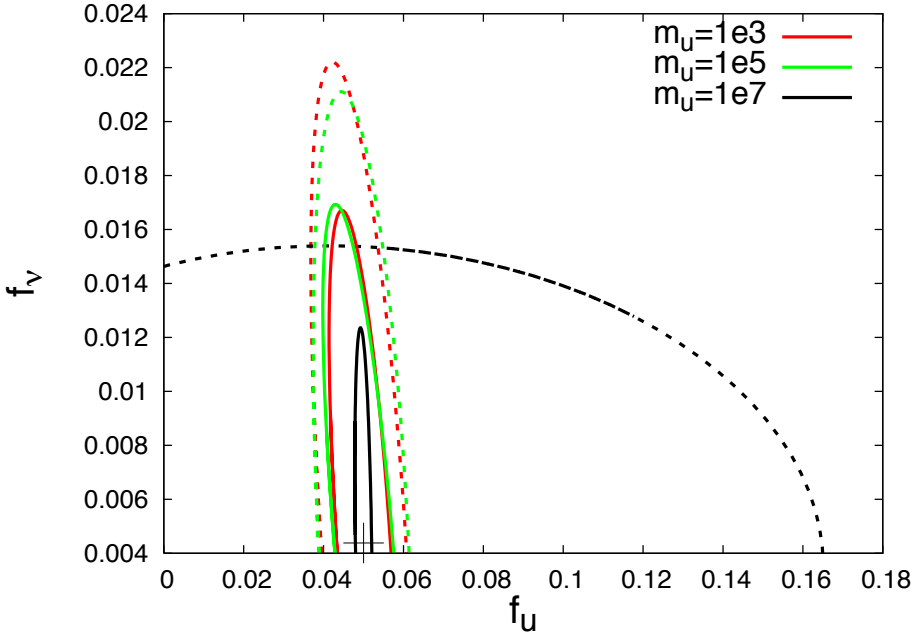

KK, Mao, Ichiki, Silk (2014)

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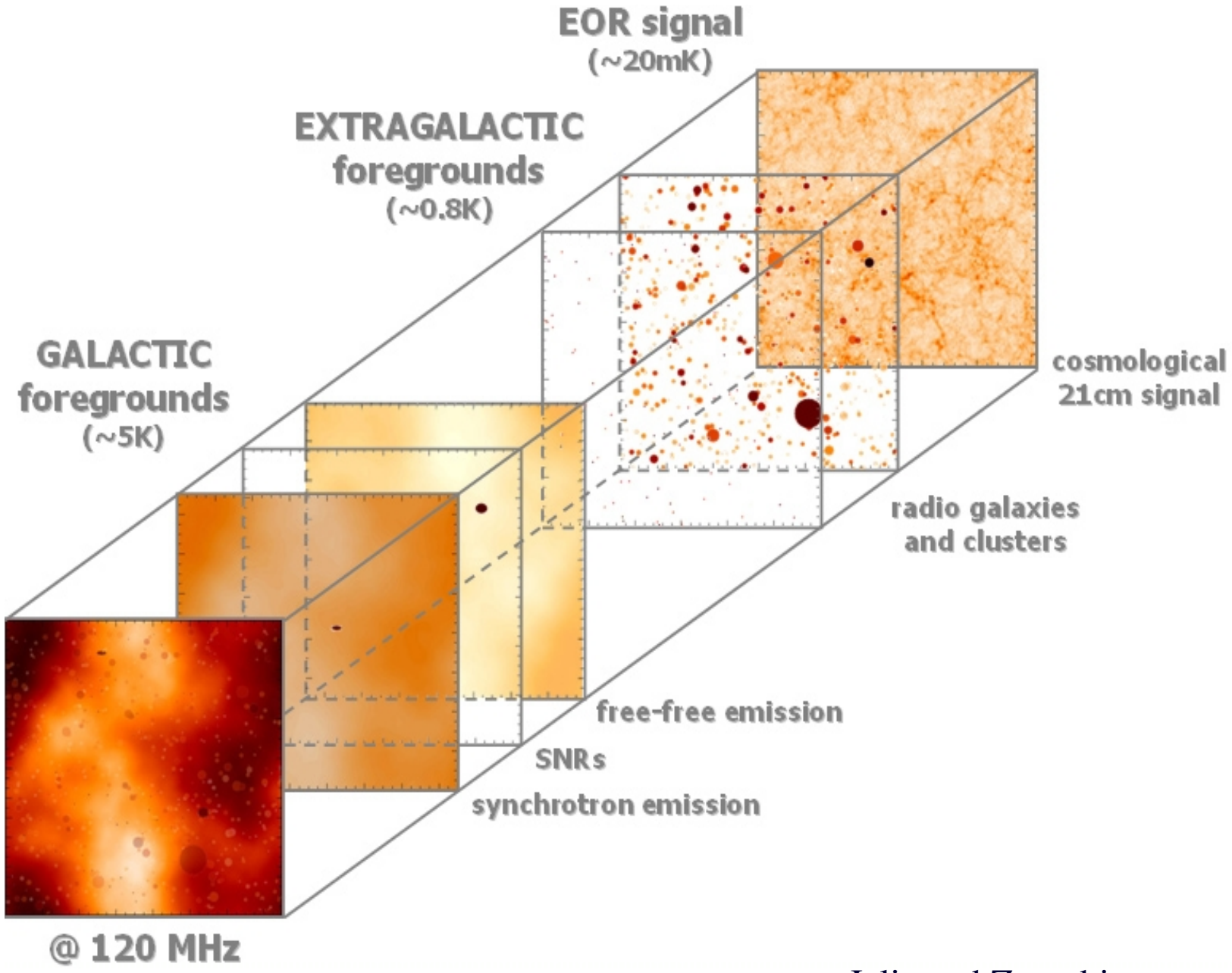
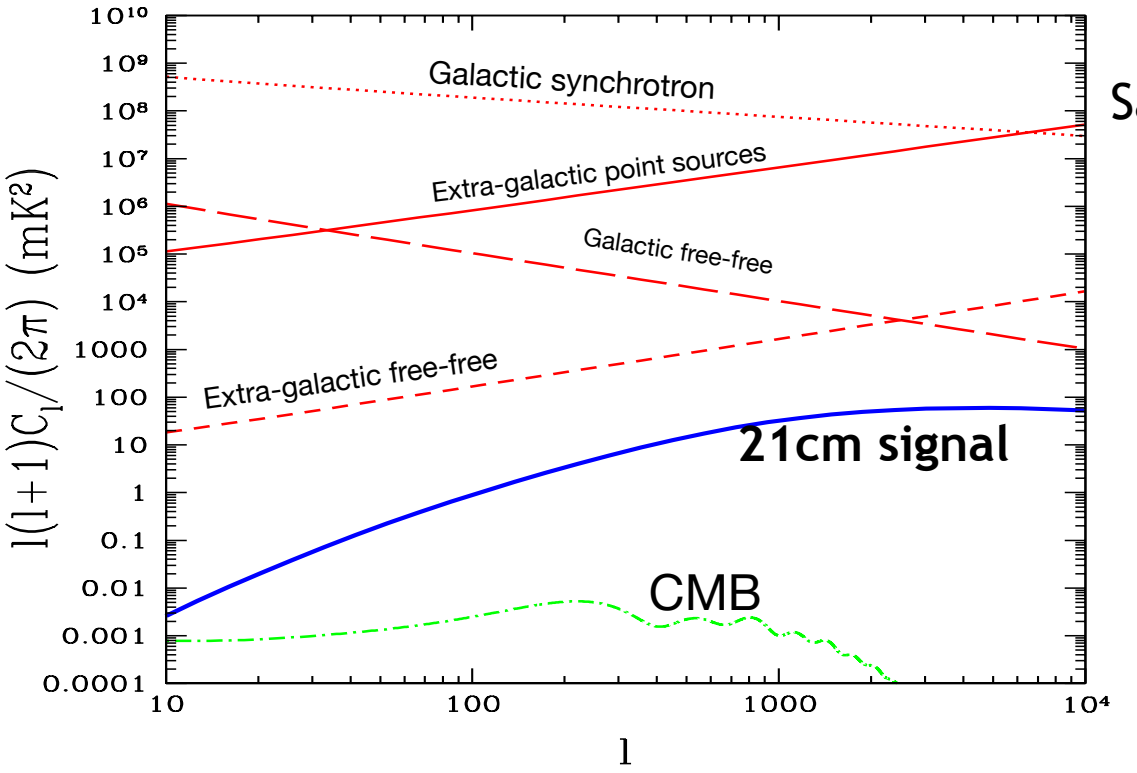
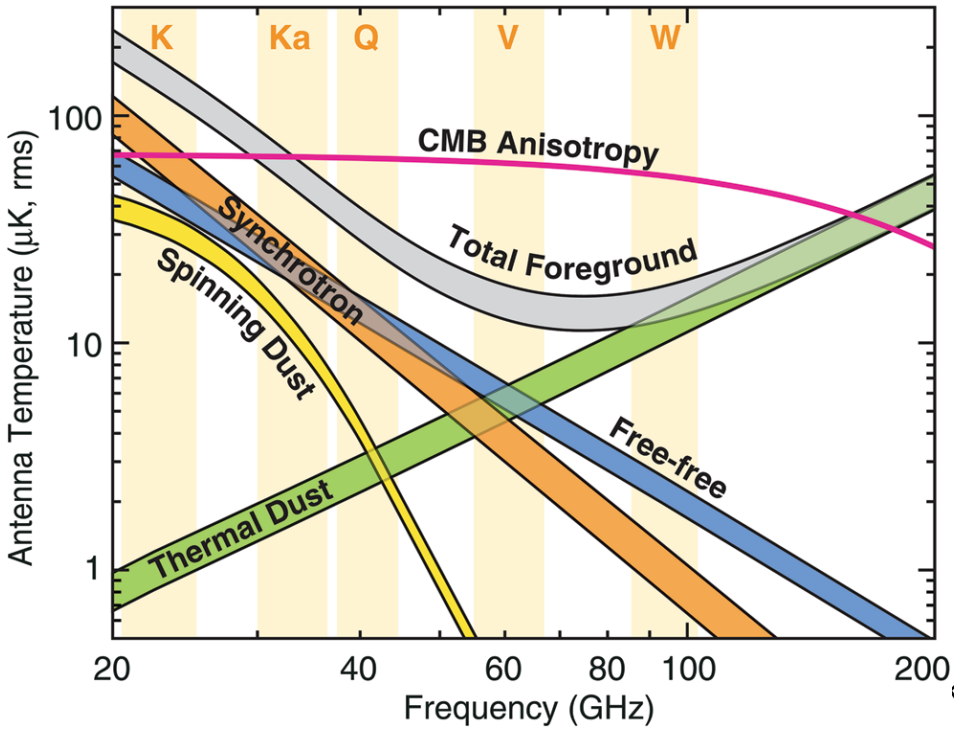


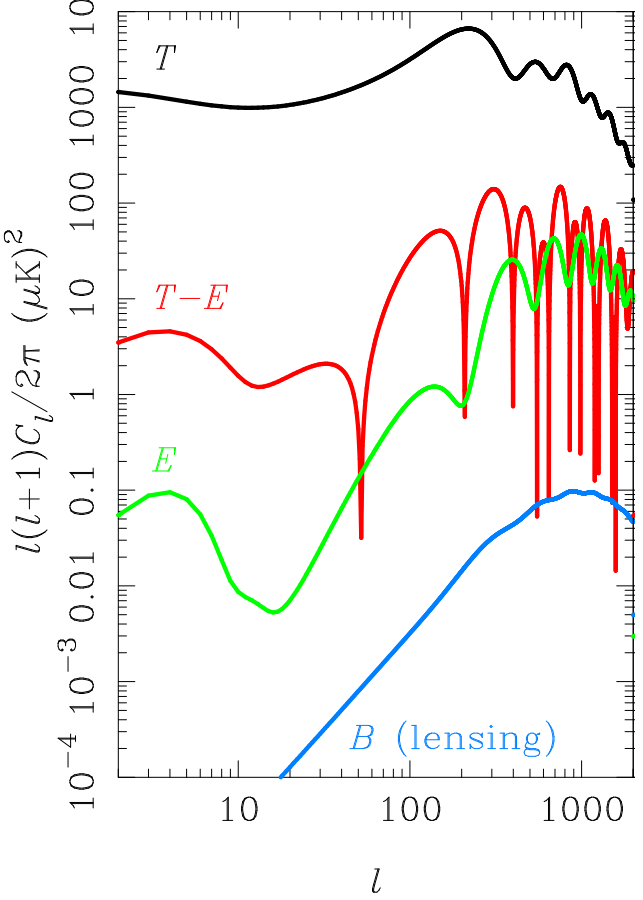
Jelic and Zaroubi



Santos et al (2014



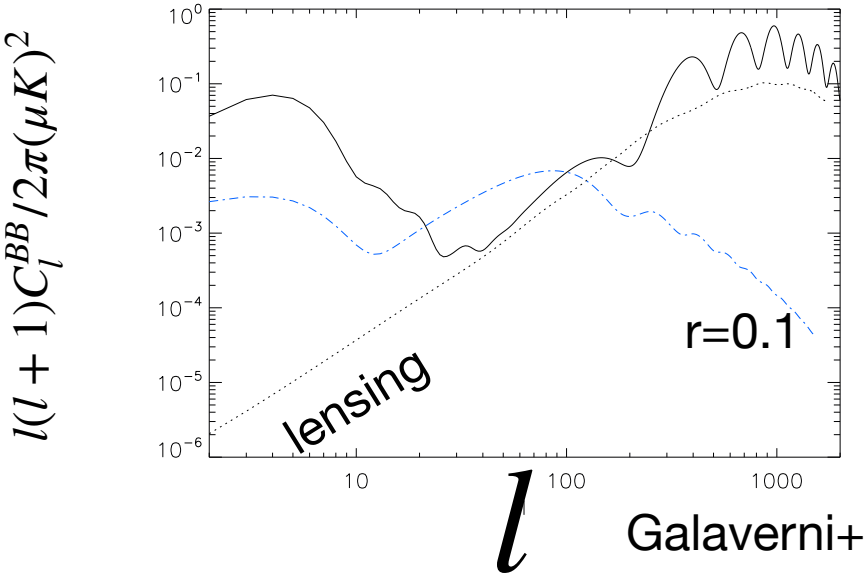
C.L. Bennett + (2013)



Motivations for cross correlation

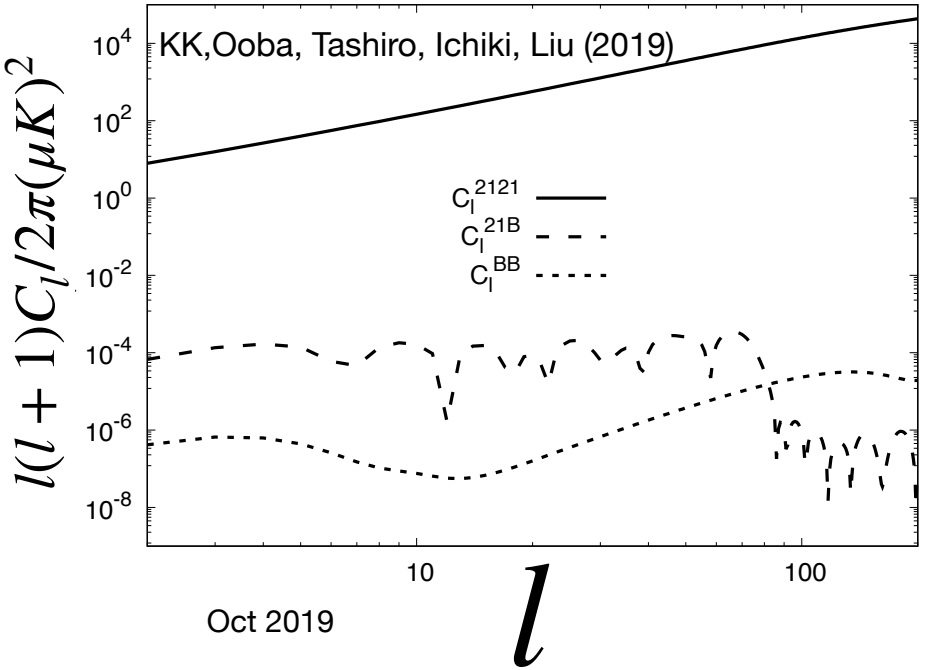
The different systematics

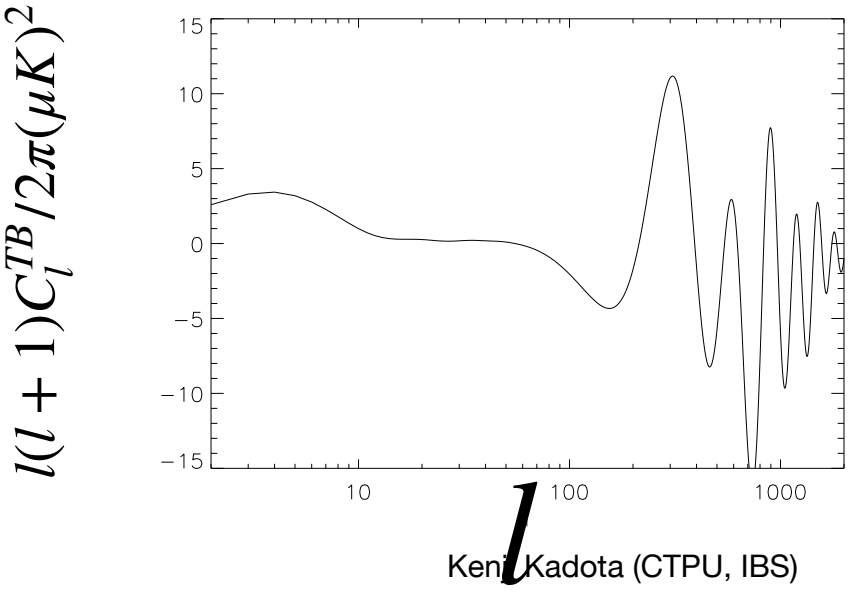
21cm fluctuations >> B mode fluctuations



Galaverni+(2008)

$m = 10^{-22}eV, \beta = 10^{-20}eV^{-1}$





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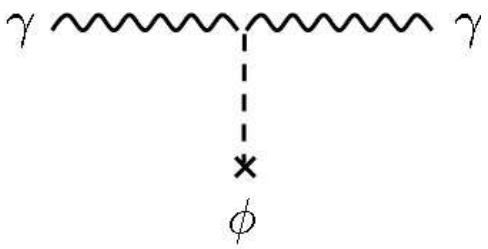
Cosmological Birefringence

(Carroll, Field, Jackiw (1990), Harari,Sikivie (1992),Lue, Wang,Kamionkowski (1999), …)

$$L_{\phi\gamma} = -\frac{\beta}{4}\phi F_{\mu\nu}\tilde{F}_{\mu\nu} = \beta\phi\mathbf{E}\cdot\mathbf{B}$$



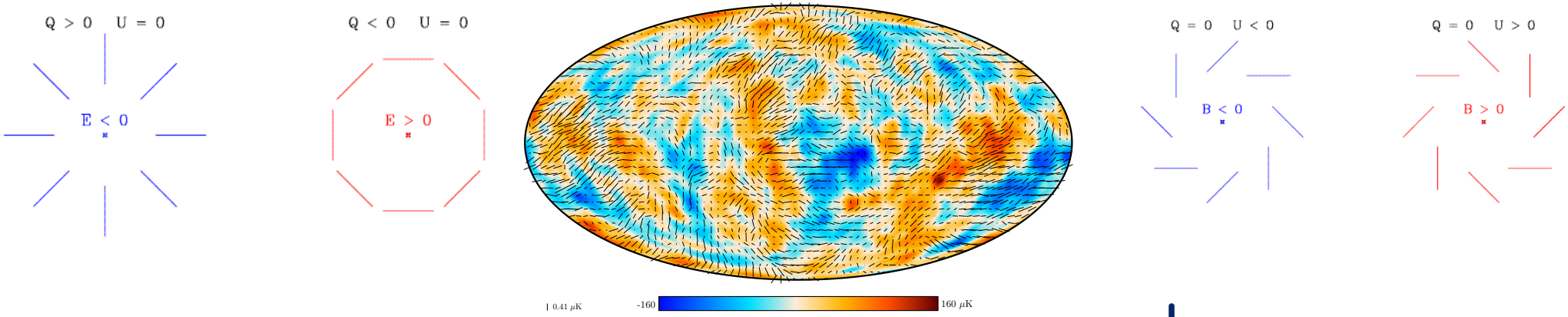
$$\omega_{\pm} \sim k \pm \frac{\beta}{2}\left(\frac{\partial\phi}{\partial t} + \nabla\phi\cdot\frac{\mathbf{k}}{k}\right)$$

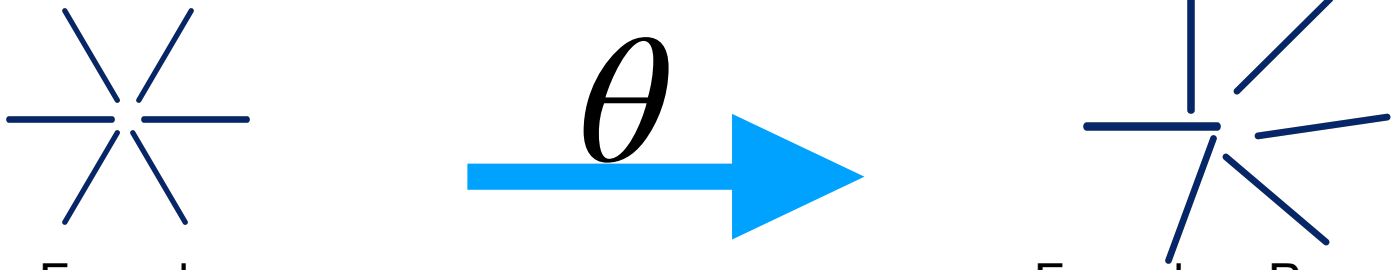
$$\theta(\eta) = \frac{1}{2}\int(\omega_+ - \omega_-)dt = -\frac{\beta}{2}\left(\phi(\eta_0) - \phi(\eta)\right)$$

$$\left(Q \pm iU\right) \to e^{\mp 2i\theta}\left(Q \pm iU\right)$$

e.g. For the time-indept constant rotation

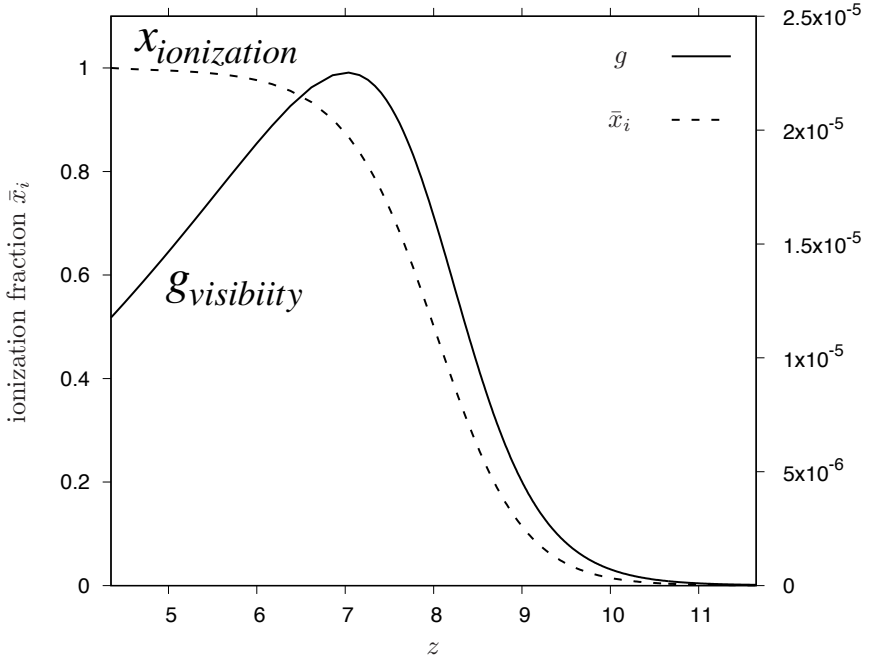
$$E^{observed} = E\cos(2\theta) - B\sin(2\theta)$$
$$B^{observed} = E\sin(2\theta) + E\sin(2\theta)$$



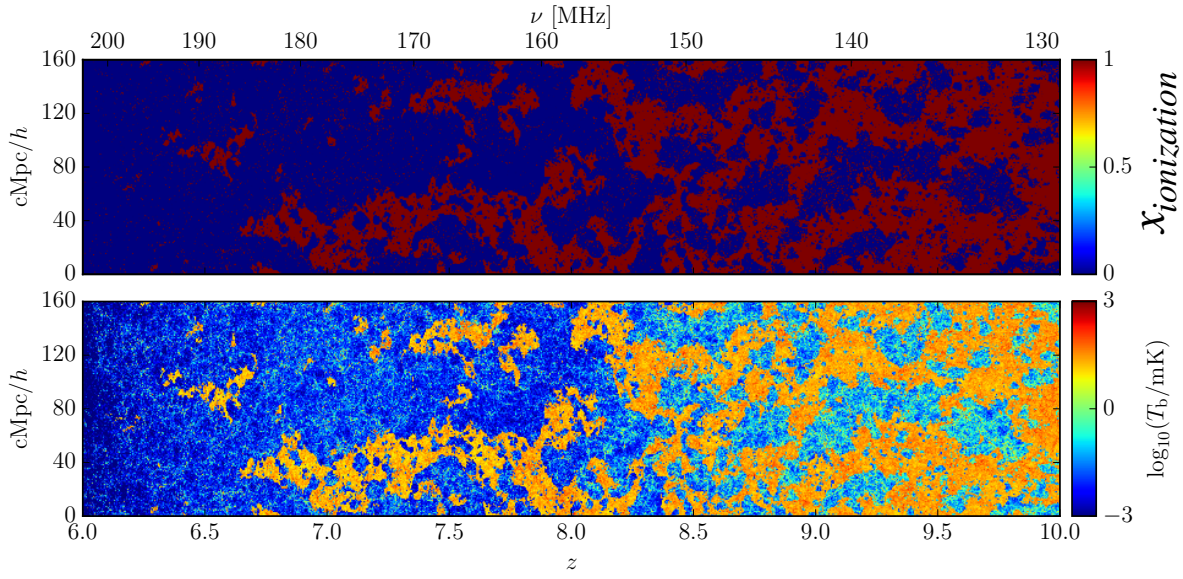


E-mode

E-mode + B-mode

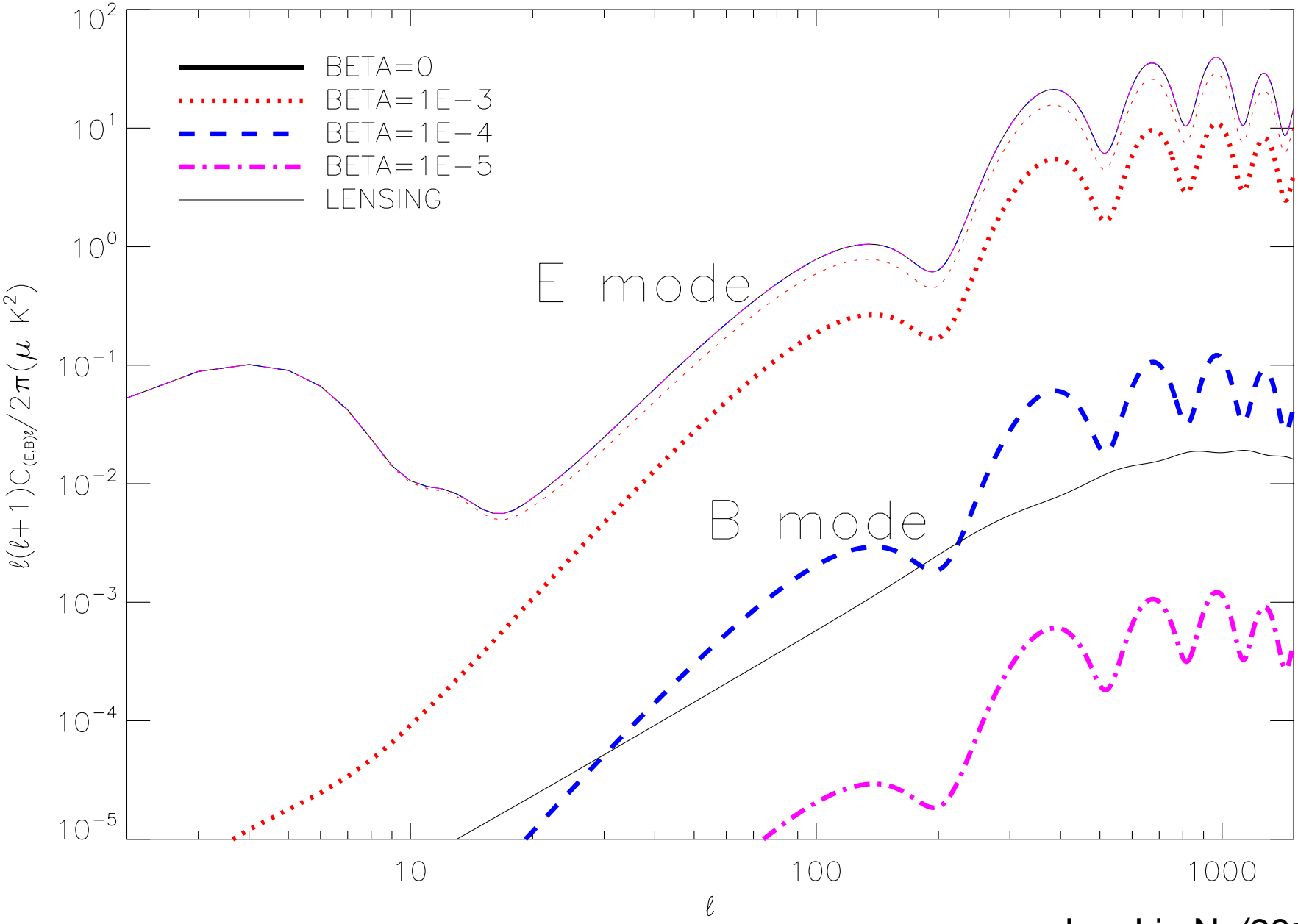


KK, Ooba, Tashiro, Ichiki, Liu (2019)

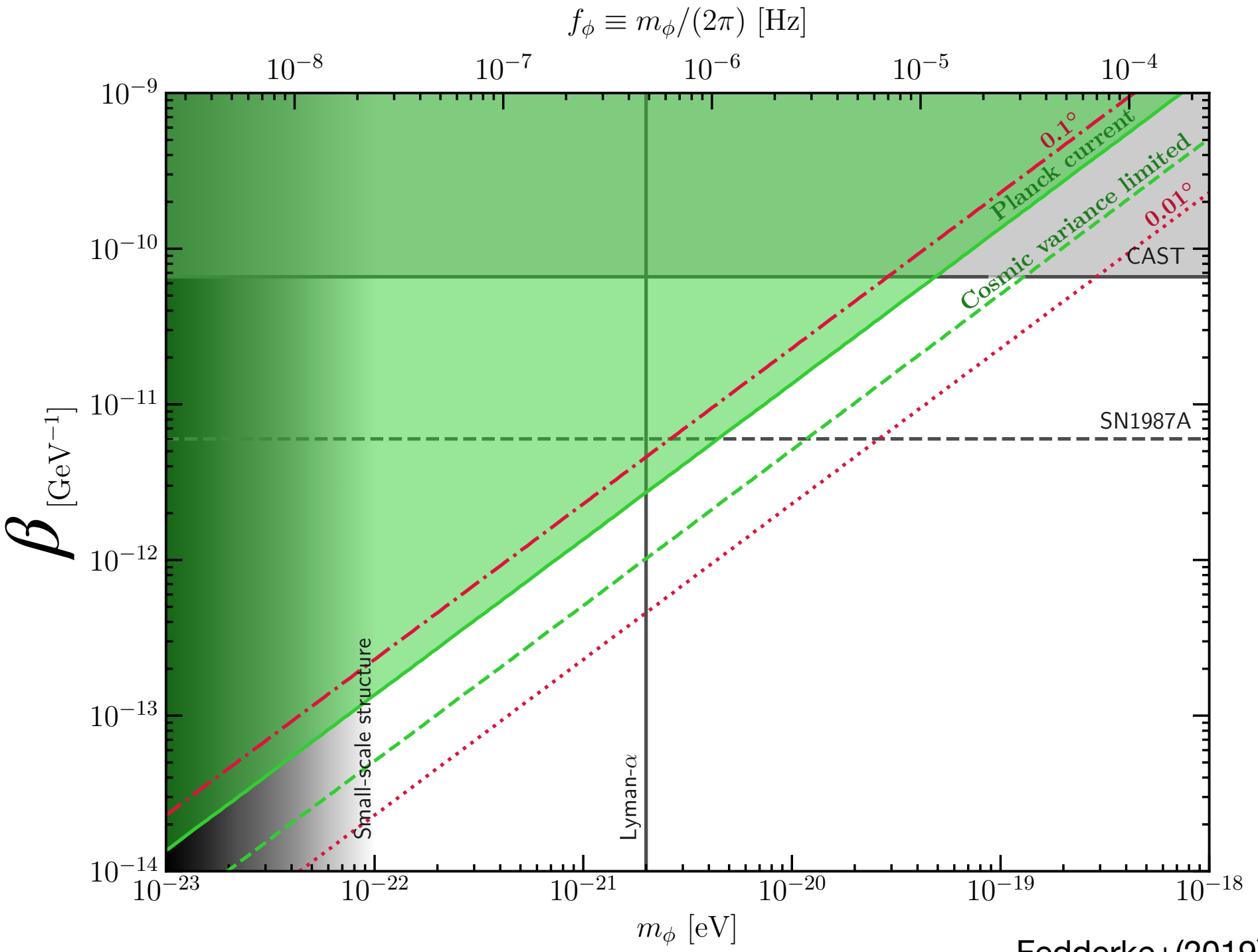


Kulkarni+(2016)

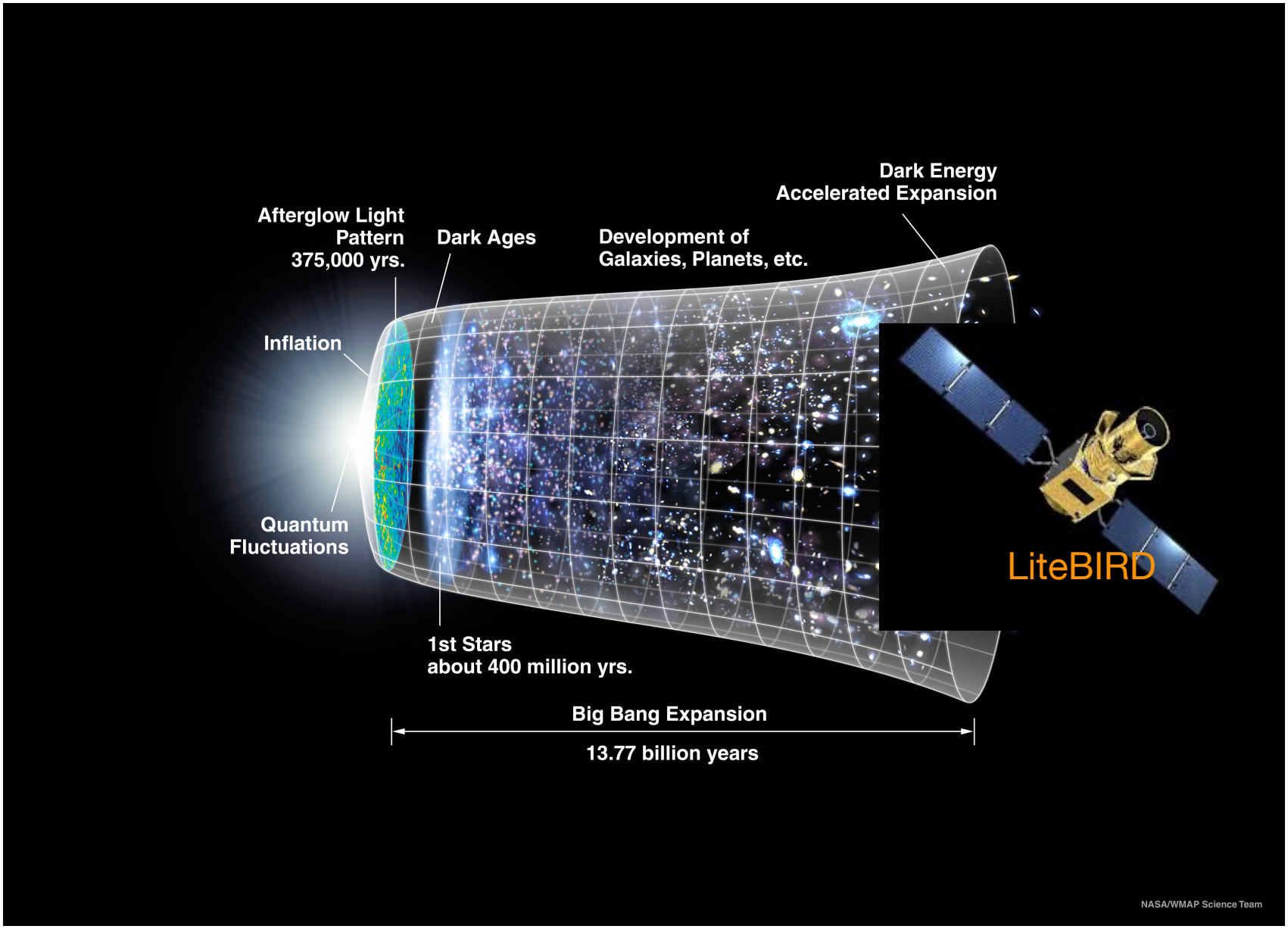
Kenji



Lee,Liu,Ng(2016)



Fedderke+(2019)



Officially approved May 2019
Launch in 2028
Sensitivity $r \sim 10^{-3}$

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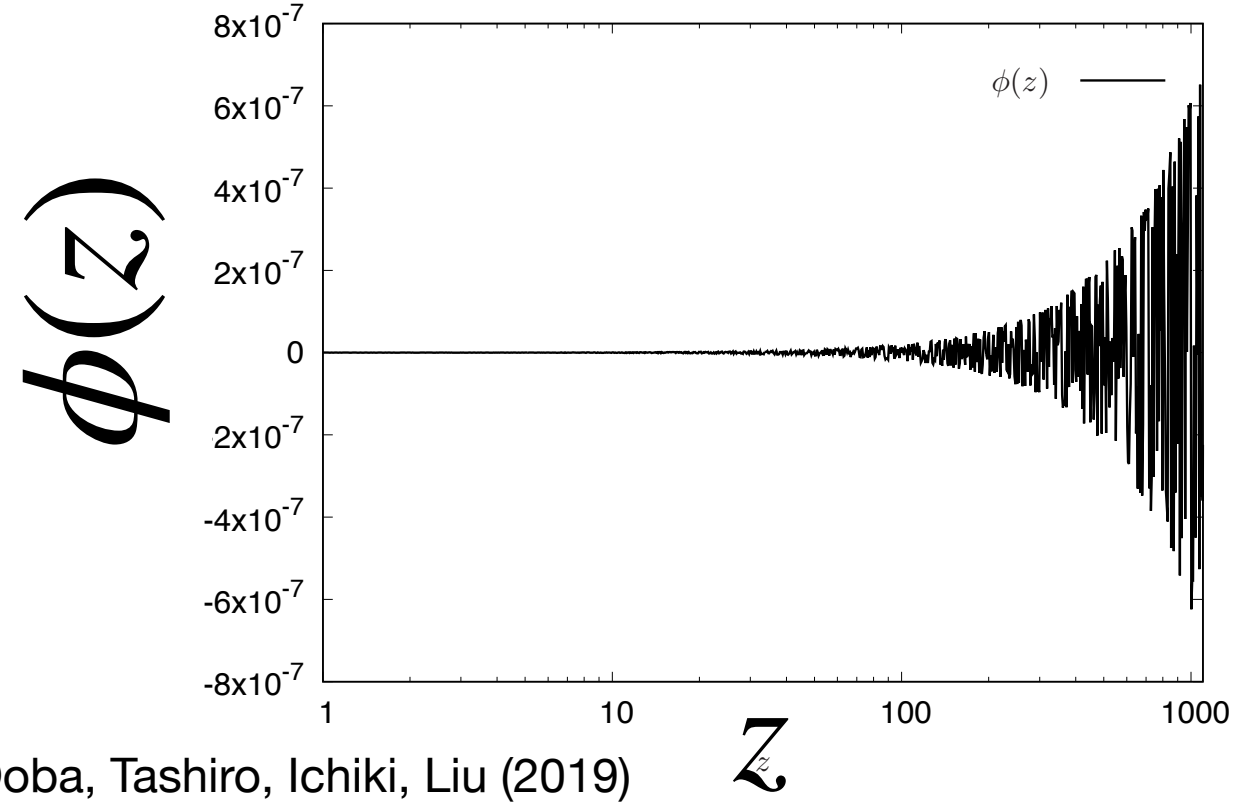
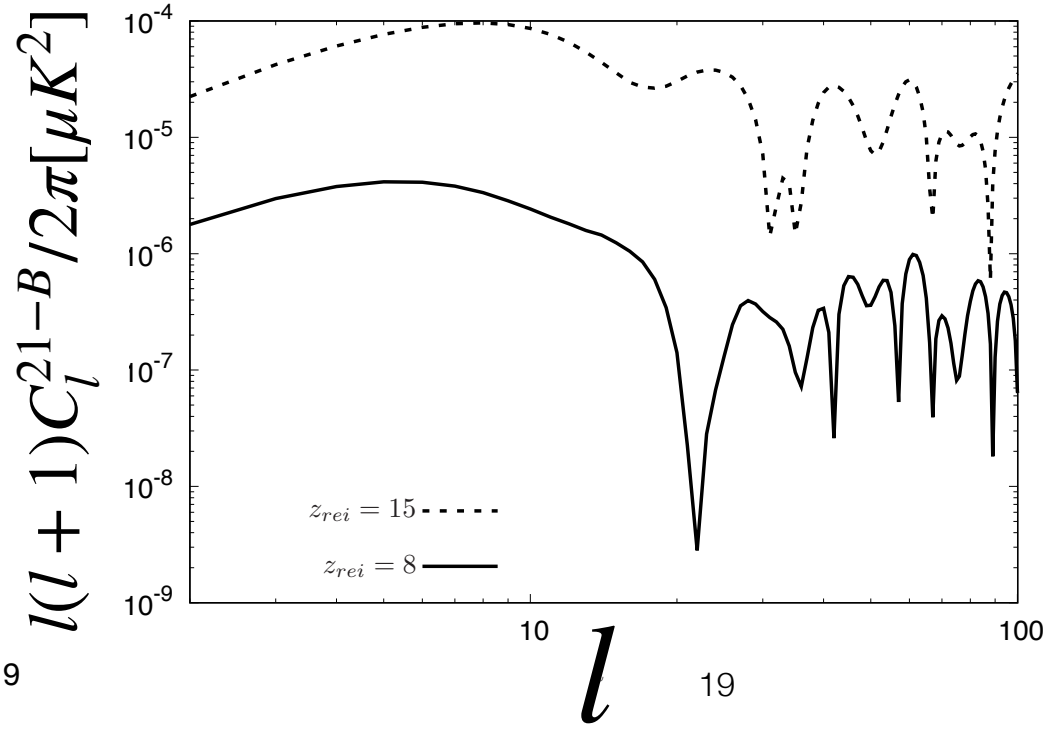


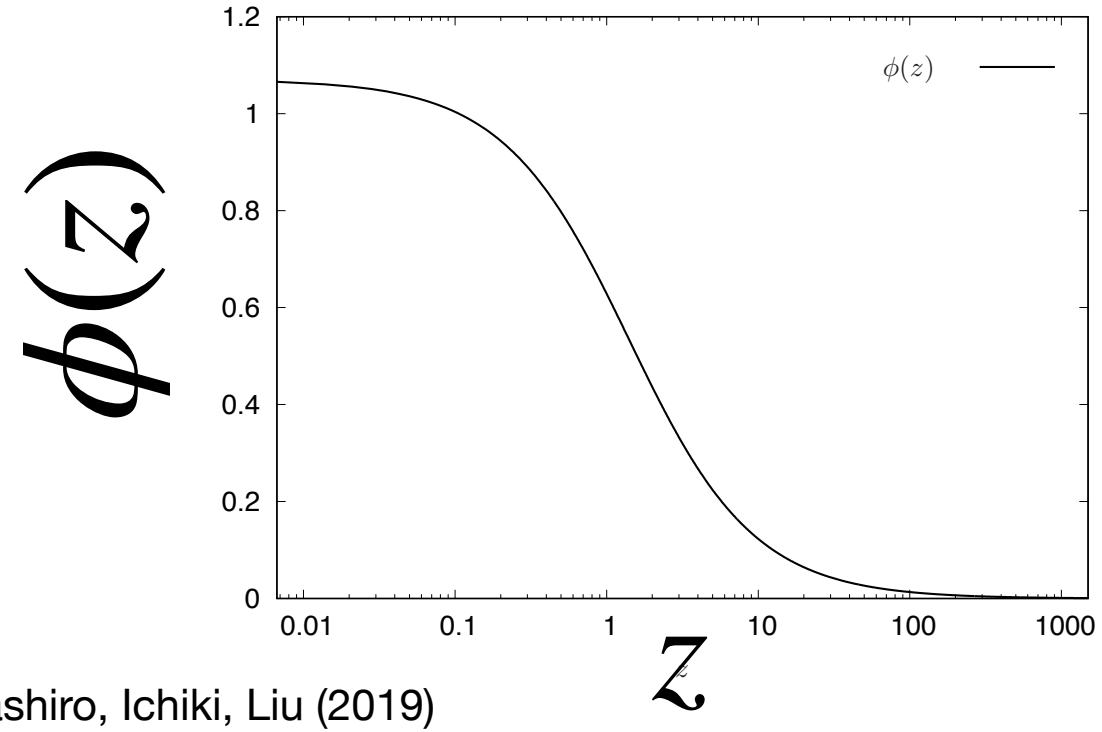
$$V = m^2\phi^2$$

$$m_\phi = 10^{-22} eV$$

$$\beta = (10^{13} GeV)^{-1}$$

KK,Ooba, Tashiro, Ichiki, Liu (2019)





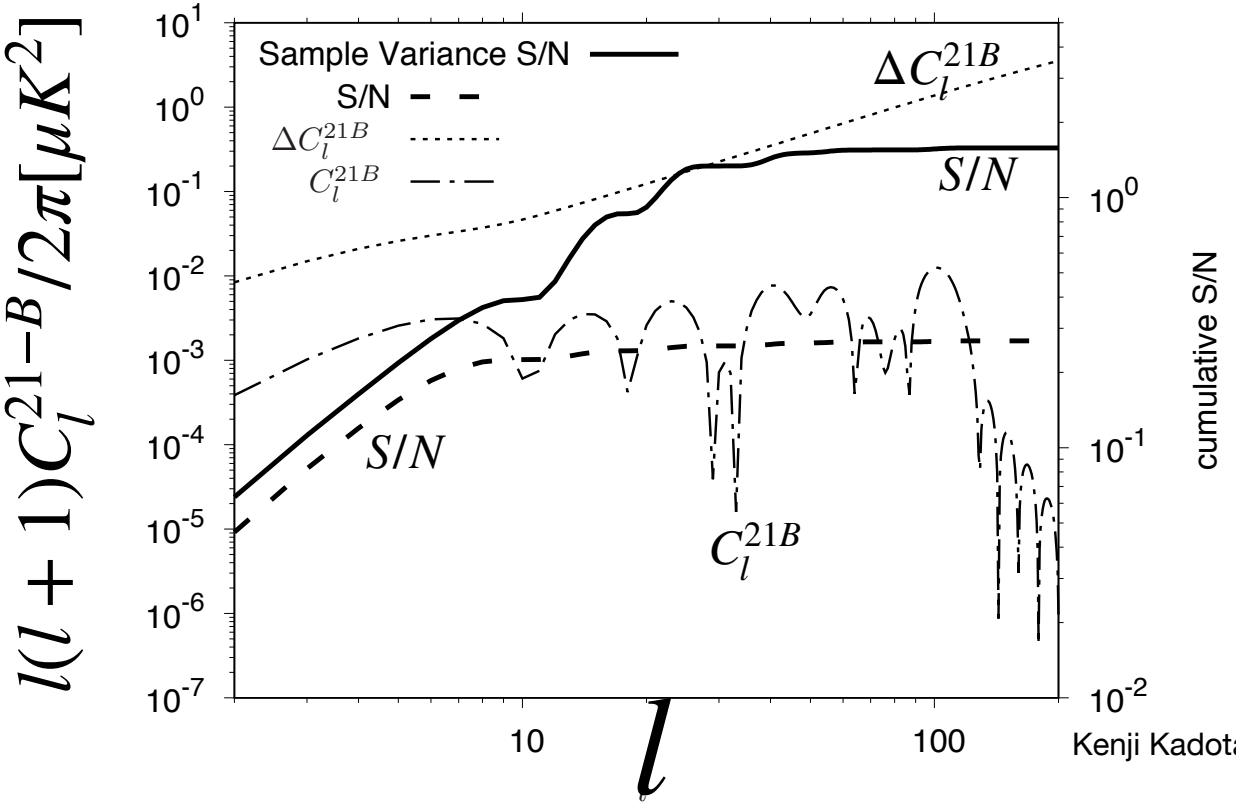
Ratra-Peebles Quintessence model

$$V(\phi) = \Lambda^{4+\alpha}\phi^{-\alpha}$$

$$\alpha = 1$$

$$\beta = 0.01/M_p$$

KK,Ooba, Tashiro, Ichiki, Liu (2019)



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