Primordial non-Gaussianities from bounce models in the Horndeski theory

(In preparation)

Rikkyo University

Shingo Akama
赤間 進吾

Collaborators

Shin'ichi Hirano
Tsutomu Kobayashi

Our study

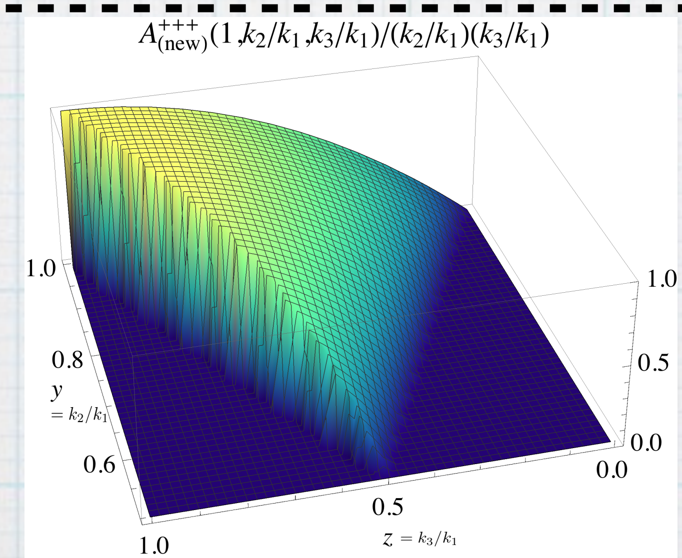
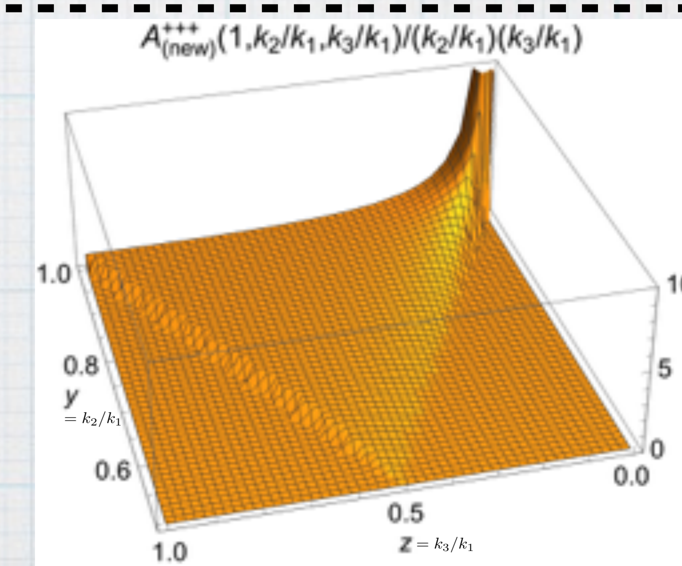
Cosmological perturbations generated during a contracting phase of bouncing universes

Results

1. Planck constraints

consistent with tensor-to-scalar ratio $r \leq \mathcal{O}(10^{-1})$
primordial non-gaussianity $f_{\rm NL}^{\rm local} \leq \mathcal{O}(1)$,..

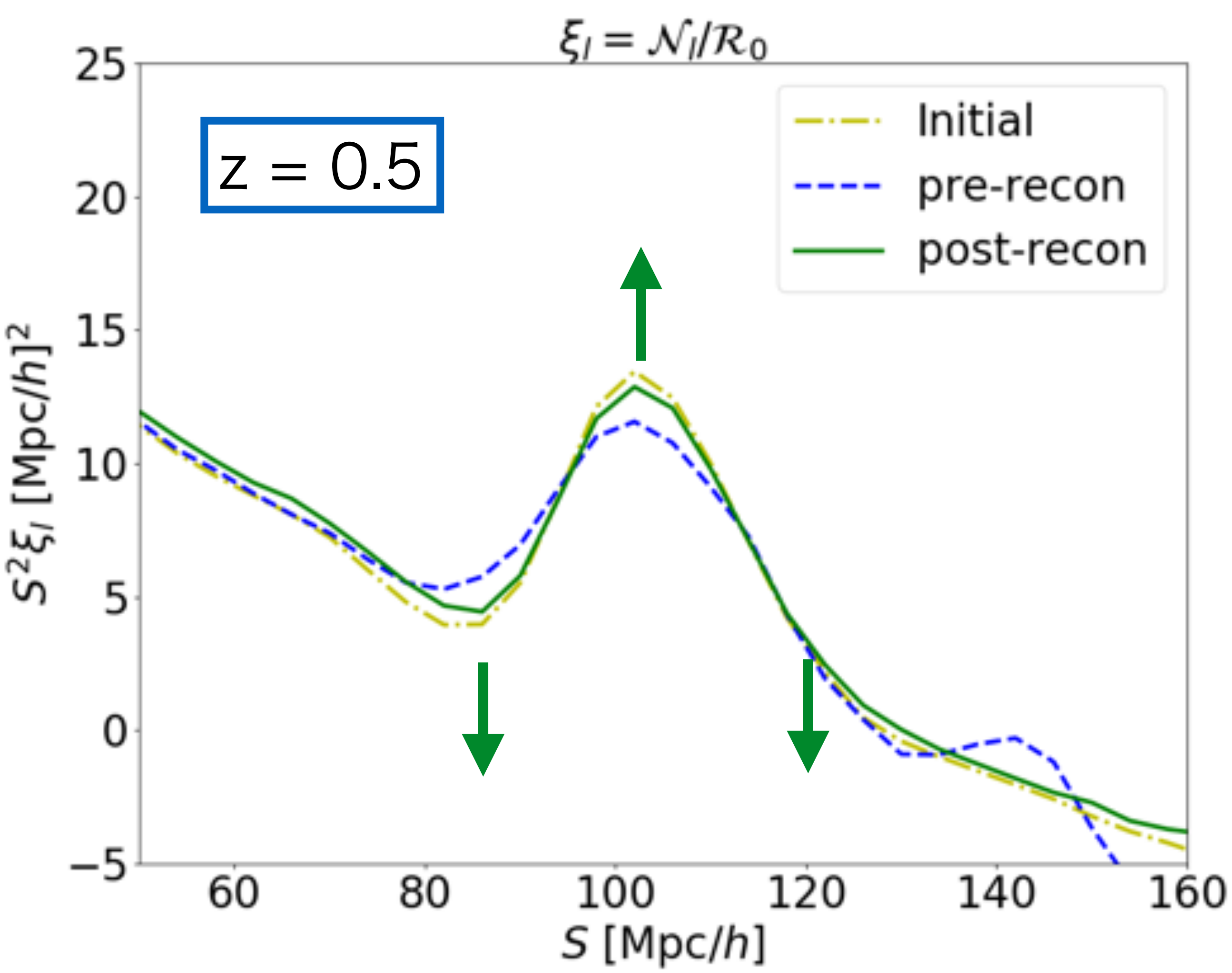
2. Primordial non-gaussianities of GWs

	Inflation Gao et al. (2011)	Bounce **Our results**
Amplitude (**GR-type** $\sim hh\partial_i^2 h$)	model-independently fixed	**model-independently suppressed**
Shape (**New-type** $\sim \dot{h}^3$)		

An iterative reconstruction of cosmological initial density fields

Ryuichiro Hada (Tohoku / Harvard) and Daniel Eisenstein (Harvard)

Galaxy (matter) correlation function



BAO peak in the galaxy correlation is widely used as a standard ruler

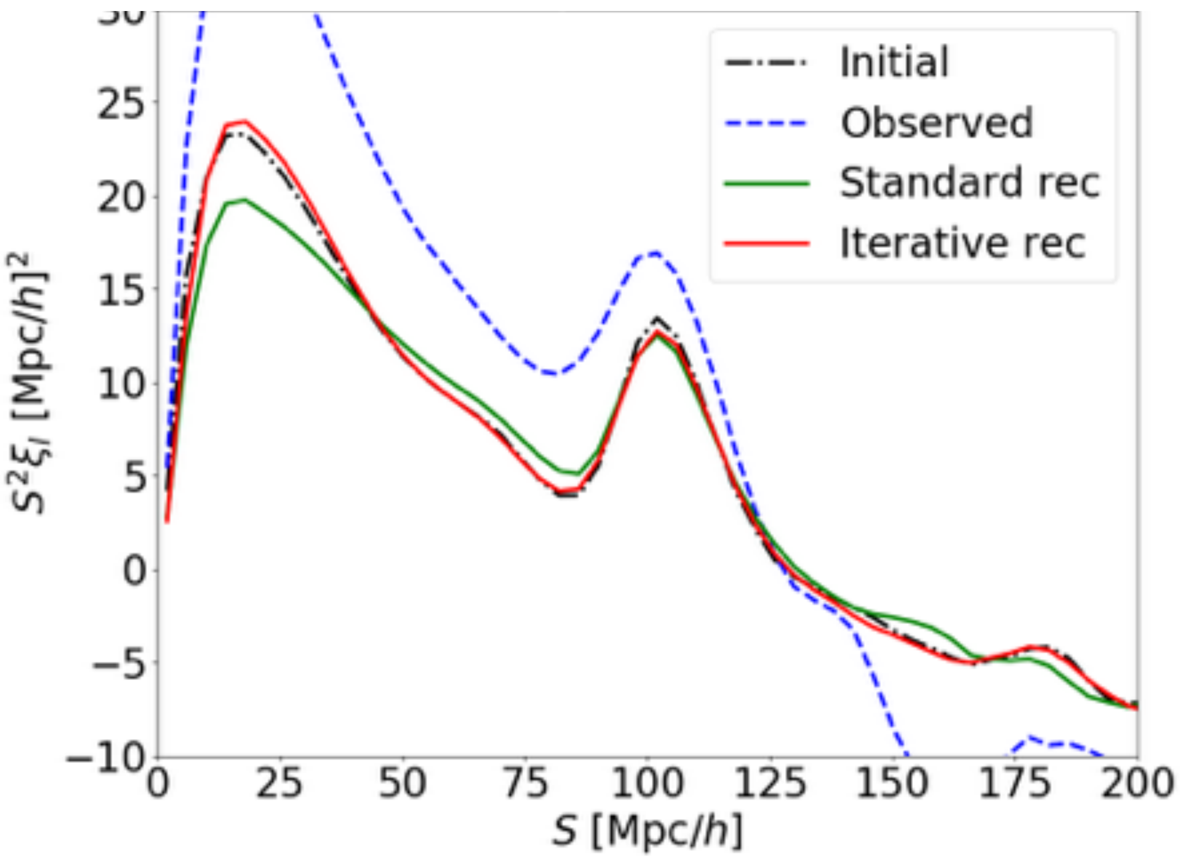
→ Dark energy, etc.

but, BAO feature is smoothed by large-scale flow

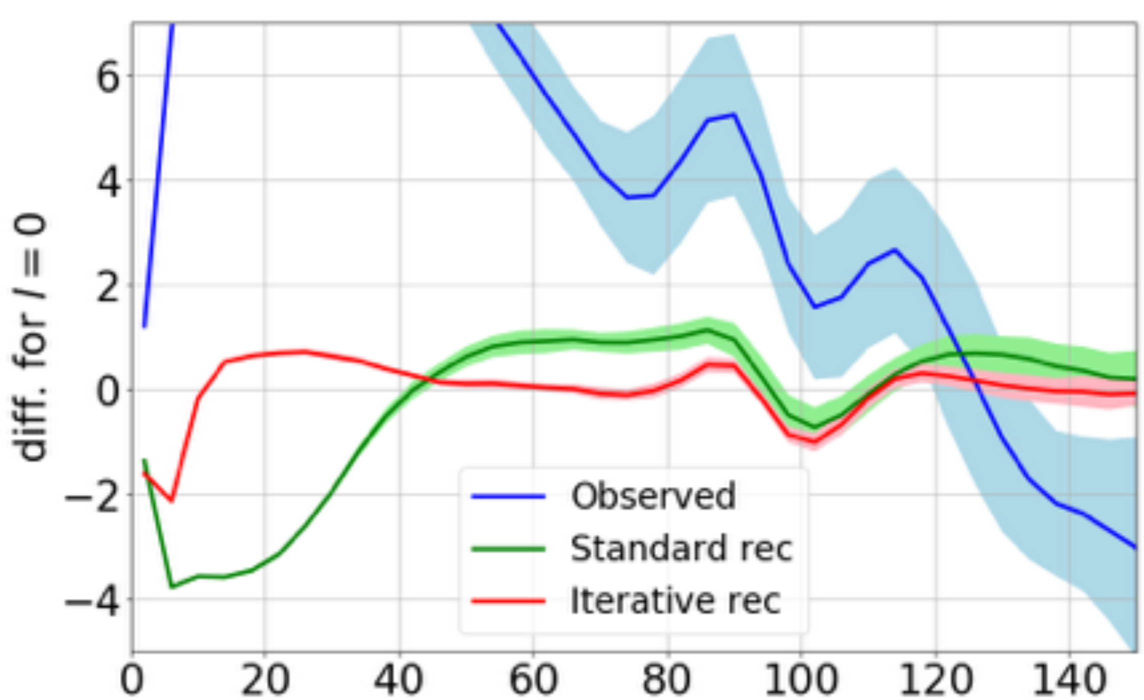
↓

moving back galaxies by the estimated displacements, we can restore the initial density field

Reconstructed correlation function



Difference with the initial



we propose a new iterative reconstruction method

Features

$$\tilde{\delta}_{\rm L}(\mathbf{k},t) = \tilde{\delta}_{\rm L}(\mathbf{k},t)G(k) + \tilde{\delta}_{\rm res}(\mathbf{k})$$

large-scale part residual part

- consistent in Lagrangian PT
- not create fake density contrasts

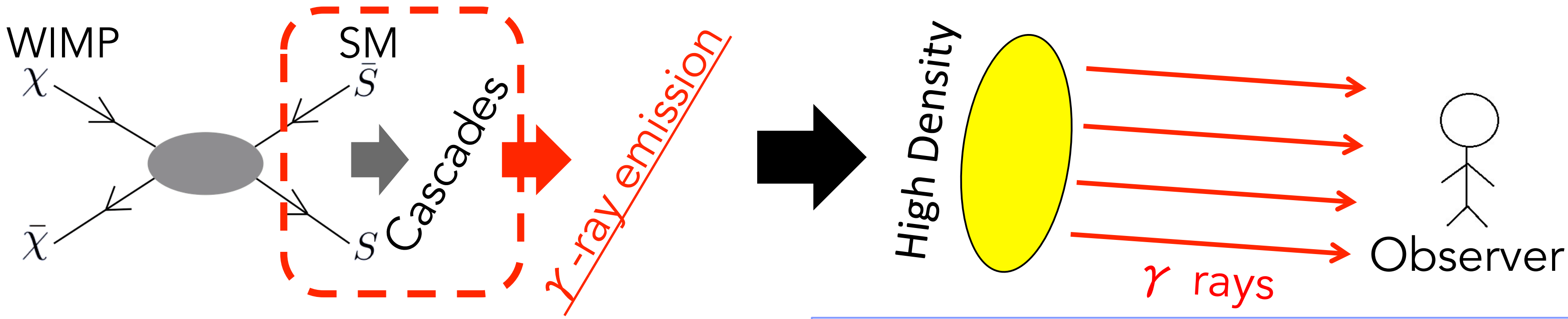
reconstruction is improved

- smaller chi-square values
- stable against changes

  in the smoothing scale

Constraint on Nature of Annihilating Dark Matter with *Gamma-ray Sky* & *Lower Surface Brightness Galaxies*

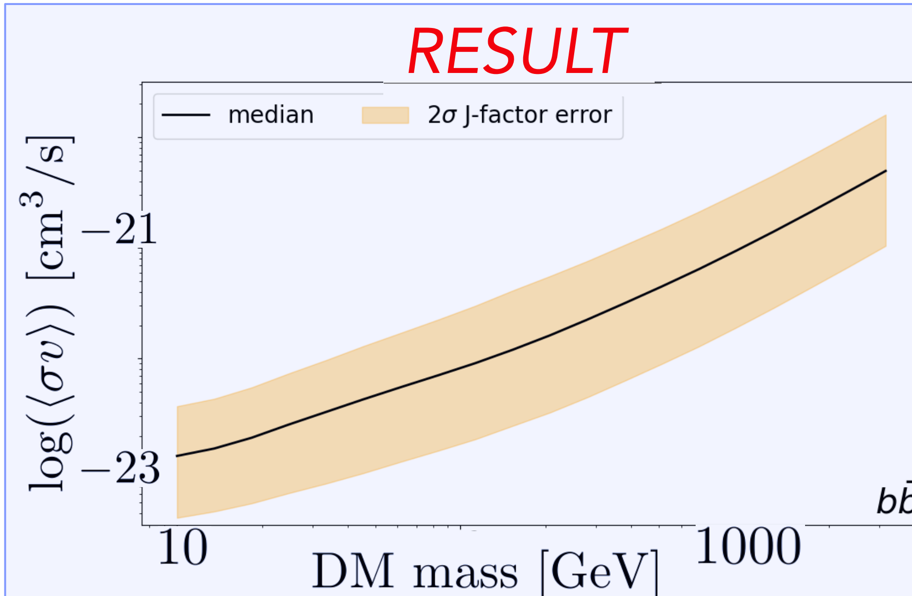
Indirect Research for Dark Matter Particles (WIMPs)



WHY are LSBGs considered as desirable targets for DM annihilation?

HOW tight …
the constraint can be in the future obs.?

In the poster session,
Let's talk about the details!



D. Hashimoto, A. J. Nishizawa (Nagoya U.), O. Macias (Amsterdam & IPMU)
K. Hayashi (ICRR), M. Takada (IPMU), Y. Inoue (Riken), M. Shirasaki (NAOJ)
J. P. Greco, M. A. Strauss, J. E. Greene (Princeton U.)

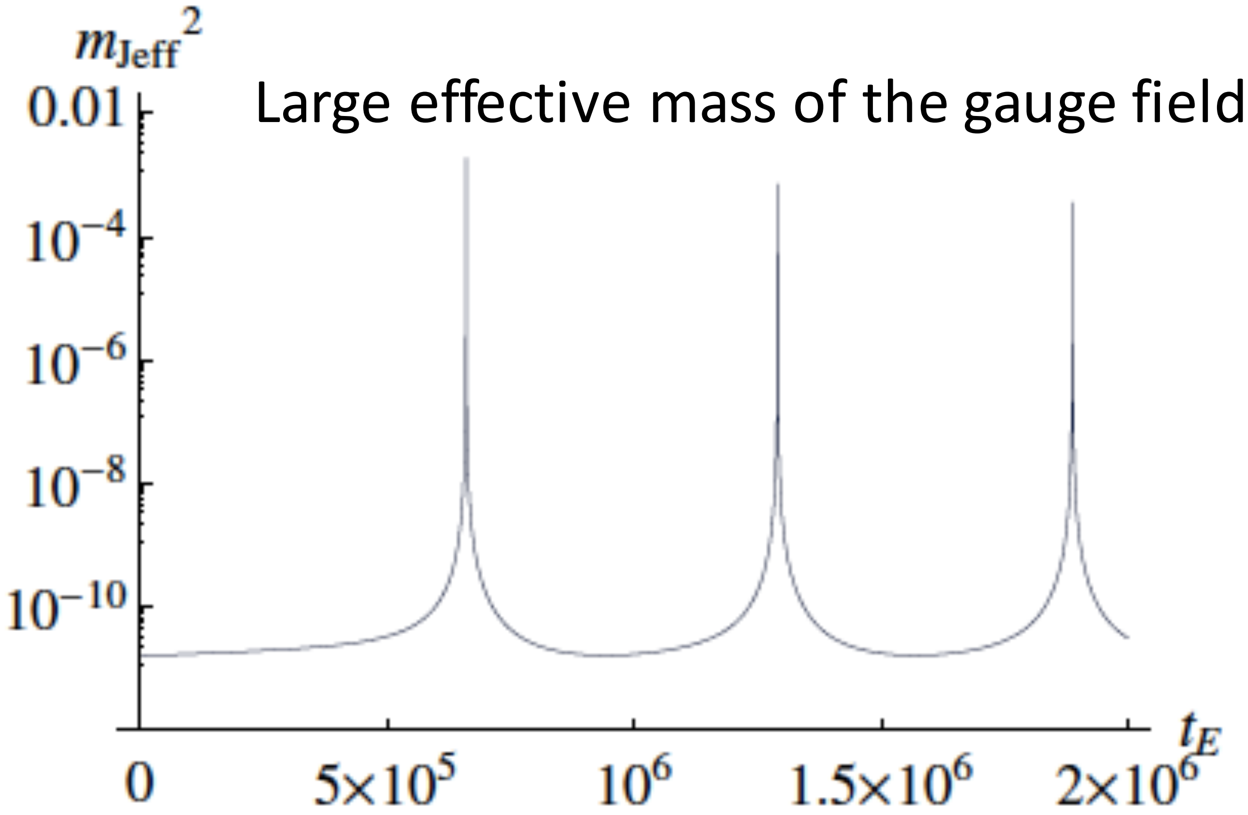
Preheating in the Mixed Higgs-R^2 Model

MH, R. Jinno, K. Kamada, S. C. Park, A. A. Starobinsky, J. Yokoyama, PLB791 (2019) 36-42

Minxi He

Pure Higgs inflation

- Cutoff scale problems during inflation and preheating
- Violent preheating might be possible to stop reheating immediately

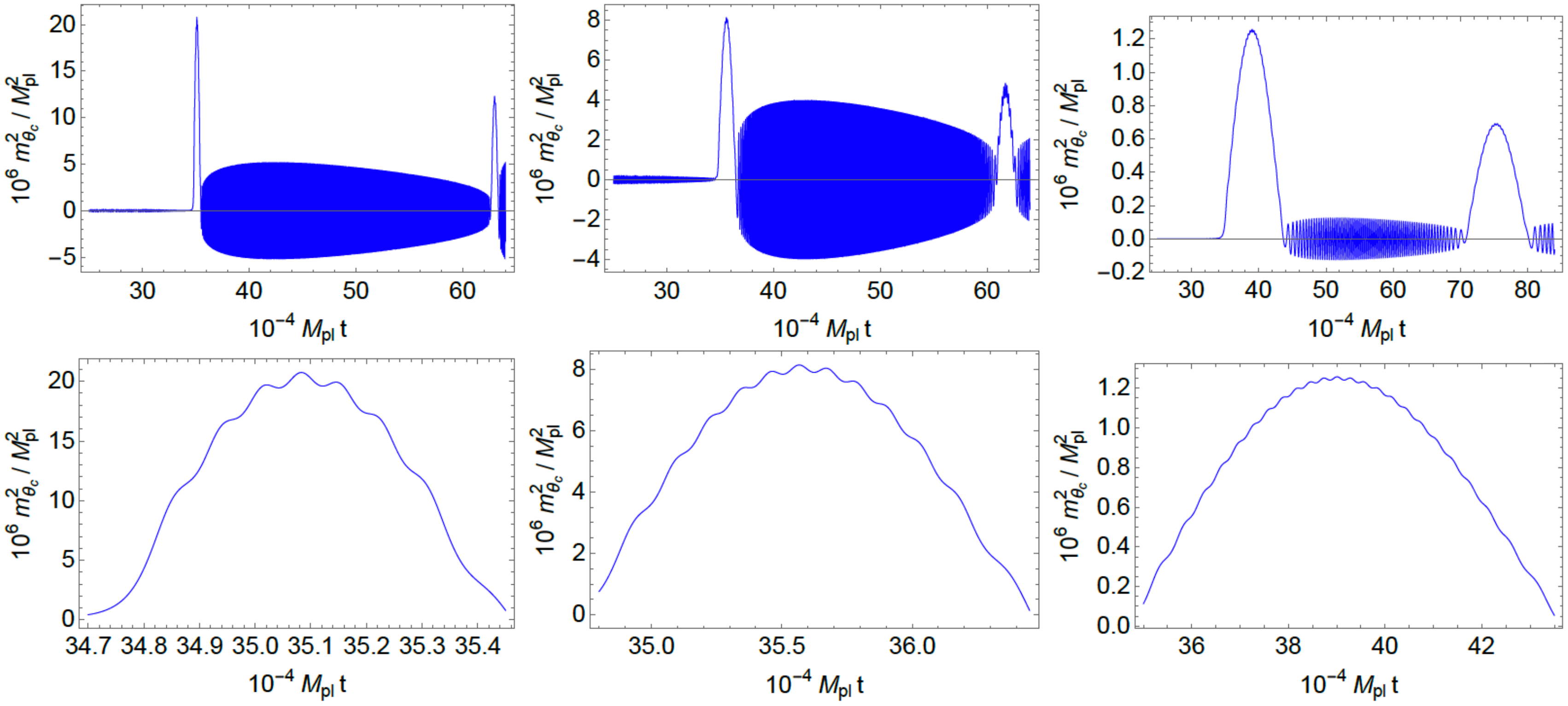


JCAP 1702 (02):045, 2017

Mixed Higgs-R^2 model

Phys. Lett. B 770 (2017) 403-411
Phys. Lett. B 788 (2019) 37-41
Phys. Lett. B 91 (1980) 99-102

- The cutoff scale is lifted to be Planck scale
- The new scale degree of freedom is introduced naturally
- R^2 itself can realize successful inflation in the very early universe



Effective mass is below the cutoff scale and standard reheating process can occur.

Experimental Search for New Gravity-like Interactions using Slow Neutrons

Yoshio Kamiya, the Univ. of Tokyo
kamiya@icepp.s.u-tokyo.ac.jp

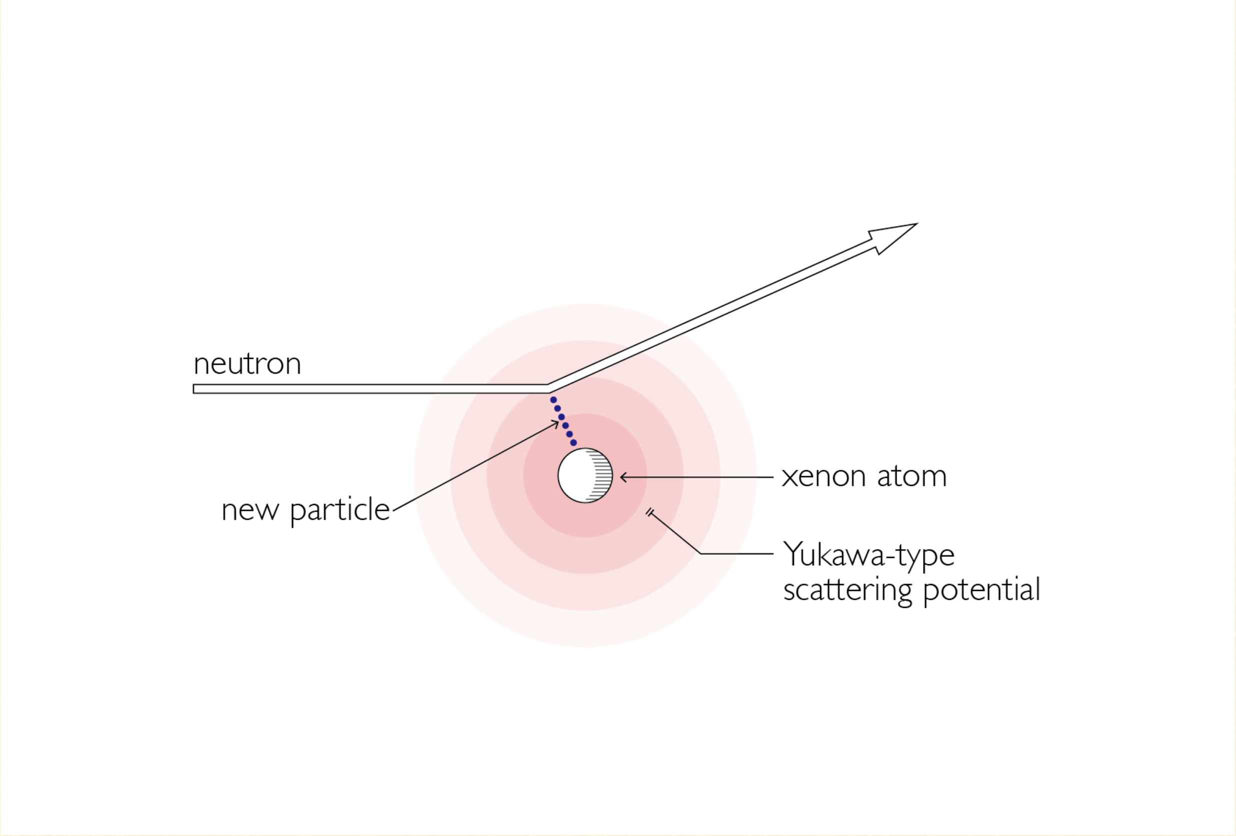
Neutron-Atomic Gas scattering processes are clearly understood by V.F. Sears, Phys. Rep. 141, 281 (1985), therefore, precision measurement of the scattering features can provides an experimental search for anomalies from the known interactions in the nanometer range.

We focus on a gravity-like interactions such as coupling to the mass or Baryon number.

This anomaly search can be interpreted as the test of the inverse square law of Newtonian Gravity.

Yukawa-type Scattering potential is used as the model of new interactions.

$$V_\phi(r) = -\frac{1}{4\pi} g^2 m_1 m_2 \frac{e^{-m_\phi r}}{r}$$



We improved the current limits for interaction ranges between 4 to 0.04 nm by a factor of up to 10. (YK, K. Itagaki, M. Tani et al., PRL 114, 161101 (2015))

The poster is presented about this work.

This results can be evaluated for the other model such as the chameleon fields of scalar-tensor theory.

Some theoretical papers cited it for discussions.

S. Knapen et al., PRD 96, 115021 (2017)

"Light Dark Matter: Models and Constraints"

Y. Farzan et al., JHEP 05, 066 (2018)

" Probing Neutrino Coupling to a Light Scalar with Coherent Neutrino Scattering"

S. Fichet, PRL 120, 131801 (2018)

"Quantum Forces from Dark Matter and Where to Find Them"

P. Brax et al., PRD 97, 115034 (2018)

"Bounding Quantum Dark Forces"

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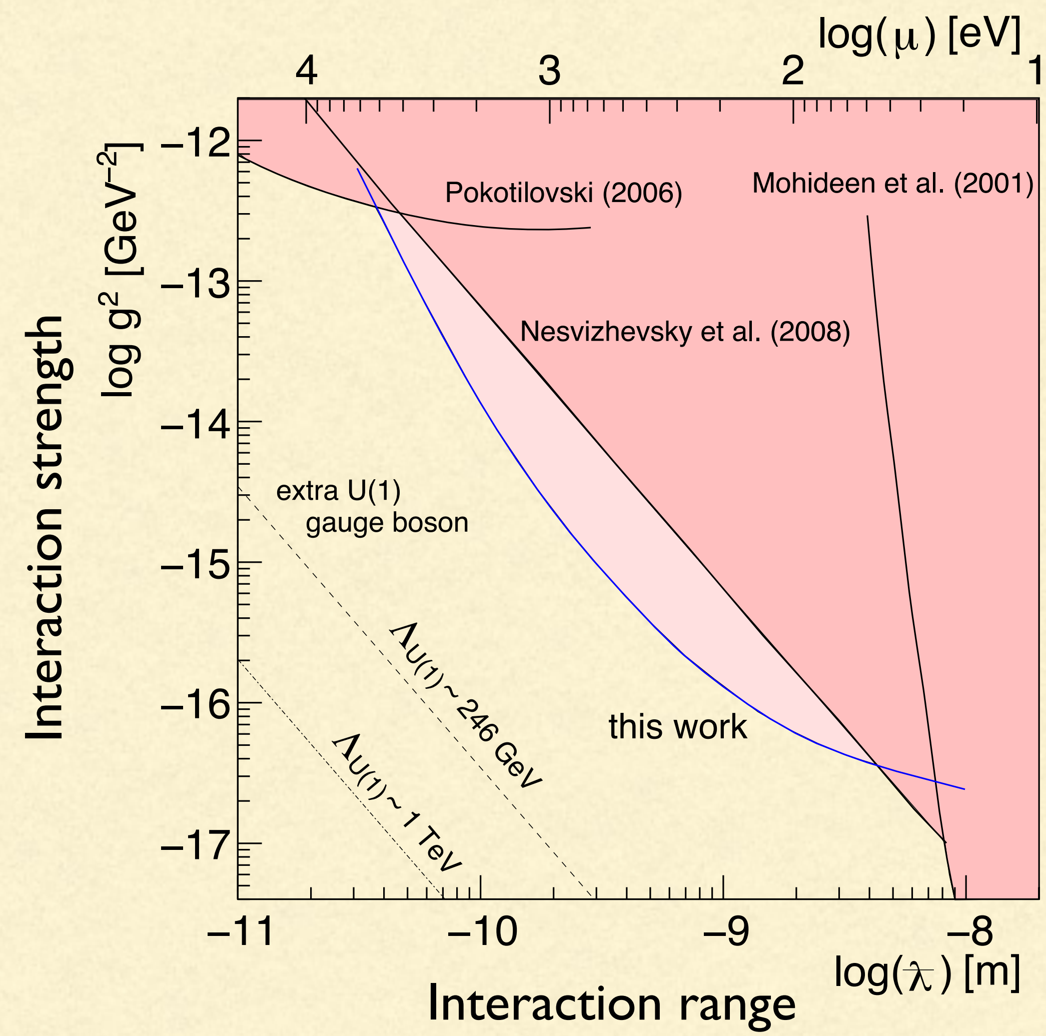


My poster number is "6".

Please come to see it.

Dark energy constraint from bispectrum of weak lensing field

Issha Kayo (Tokyo Univ. of Tech)

- How large can we recover the information by considering the bispectrum?

Equivalent to 40% larger survey region

IK & Takada (2013)

⇔

Bispectrum is much more powerful

Sato & Nishimichi (2013)

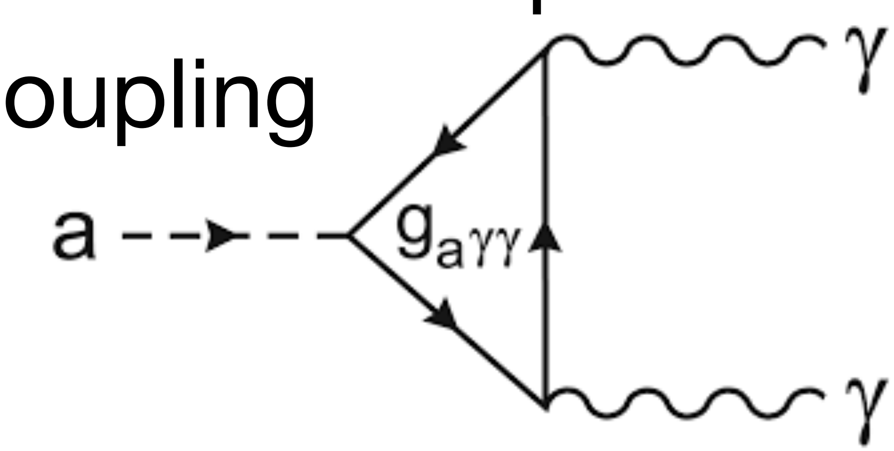
#7. Dark photon dark matter production from axion oscillations

Naoya Kitajima

NAGOYA UNIVERSITY

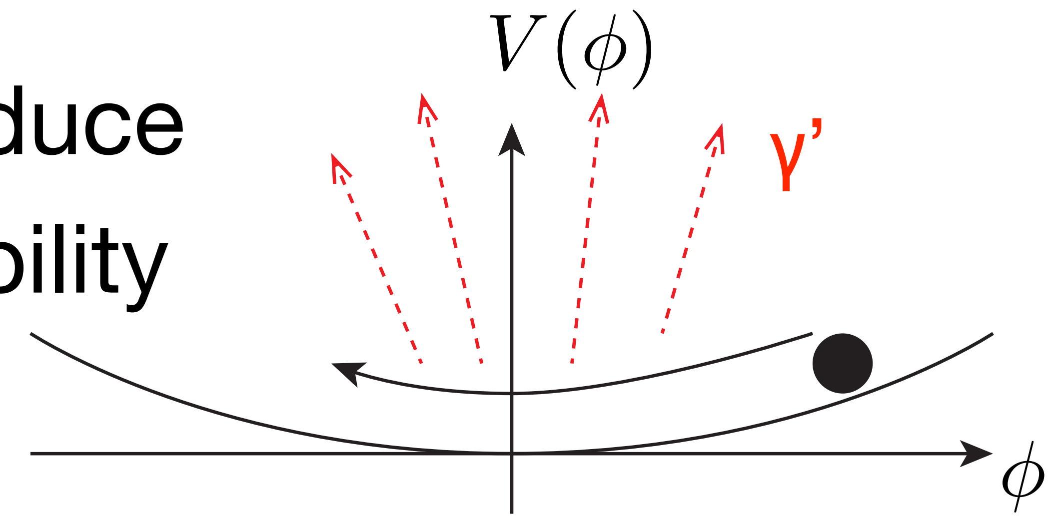
$$\mathcal{L} = \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - V(\phi) - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{2}m_{\gamma'}^2 A_\mu A^\mu - \frac{\beta}{4f_a}\phi F_{\mu\nu}\widetilde{F}^{\mu\nu}$$

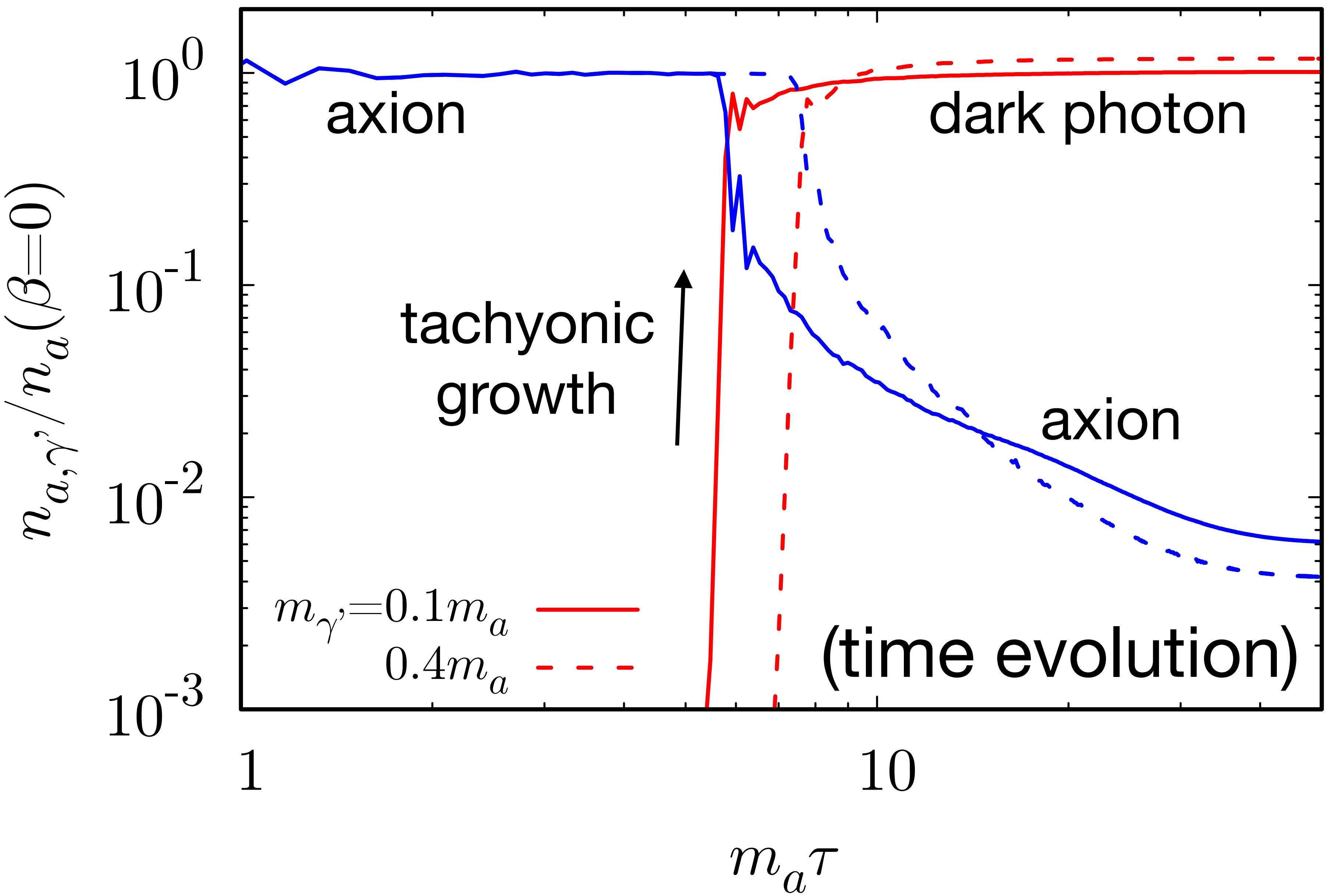
axion-dark photon coupling



Accelerating Universe in the Dark, YITP, 2019 March 4–8

Initially misaligned axion can produce dark photons via tachyonic instability

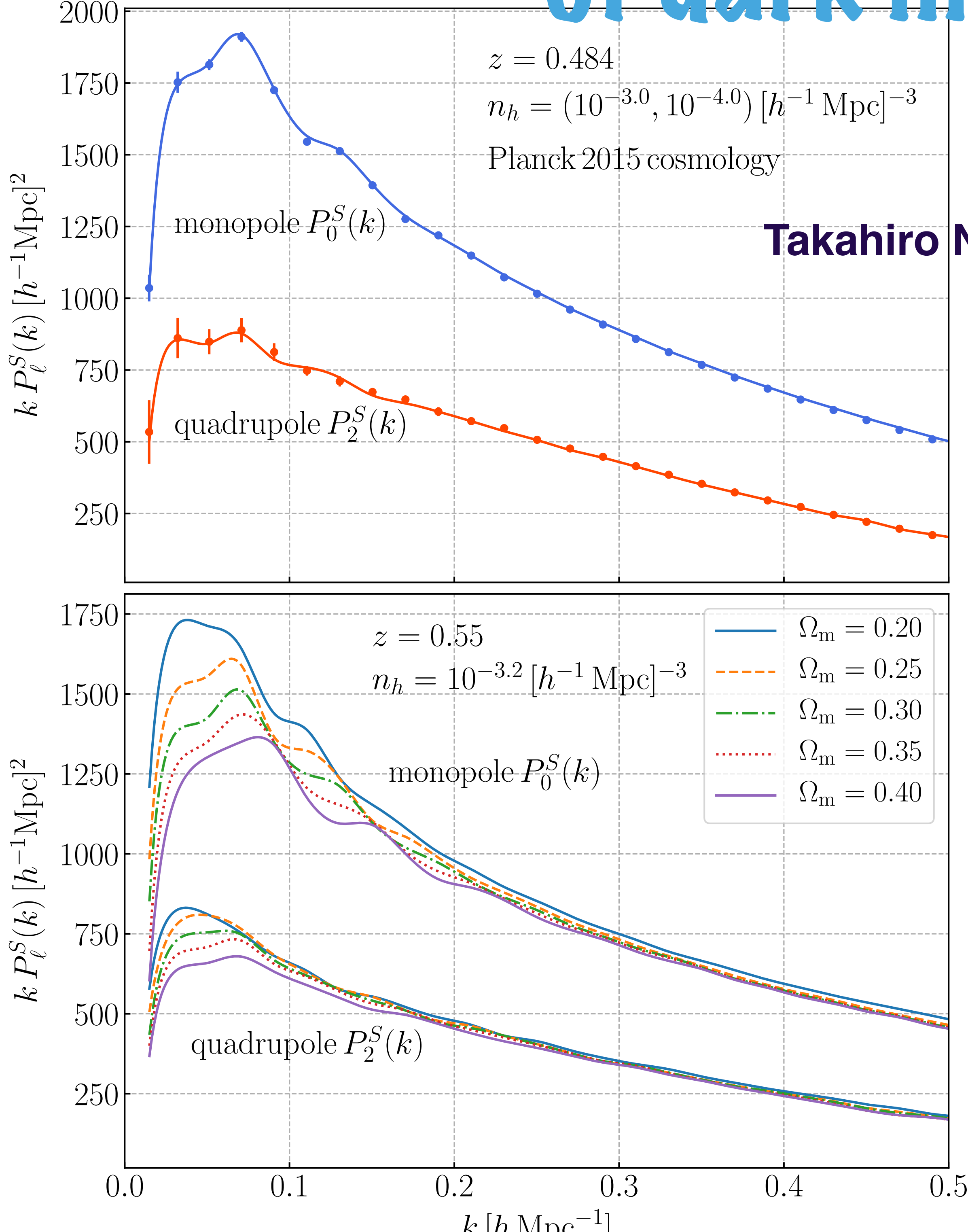




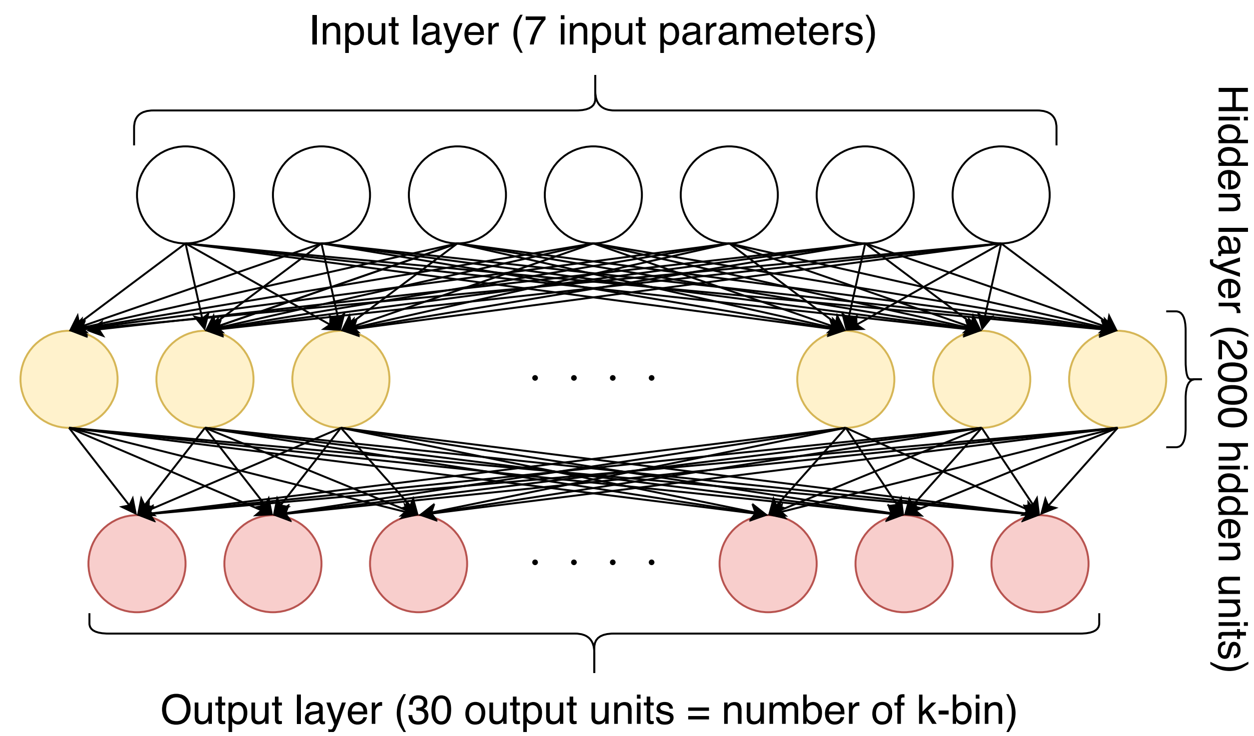
<u>New production mechanism of dark photon dark matter</u>

Development of the accurate emulator for the redshift-space power spectrum of dark matter halos

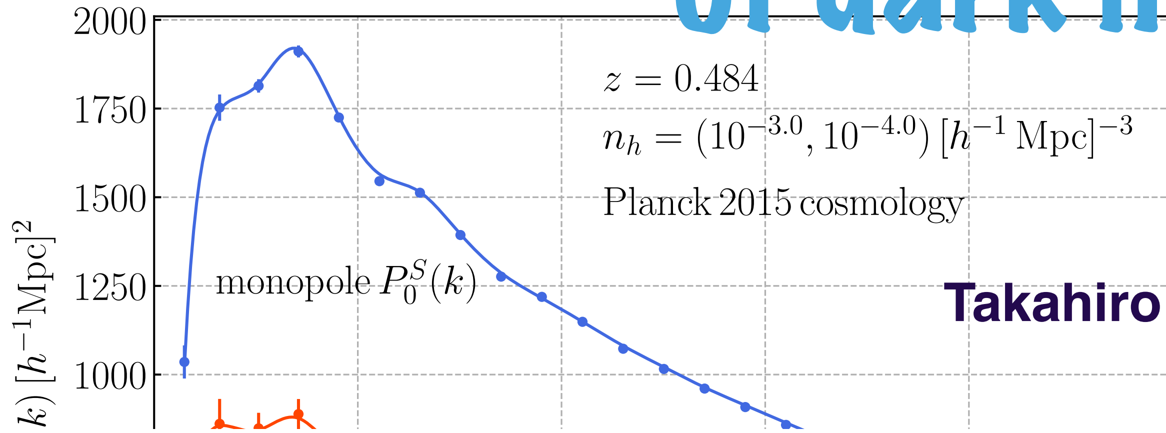
Yosuke Kobayashi (Kavli IPMU)
in collaboration with
Takahiro Nishimichi (YITP) & Masahiro Takada (Kavli IPMU)



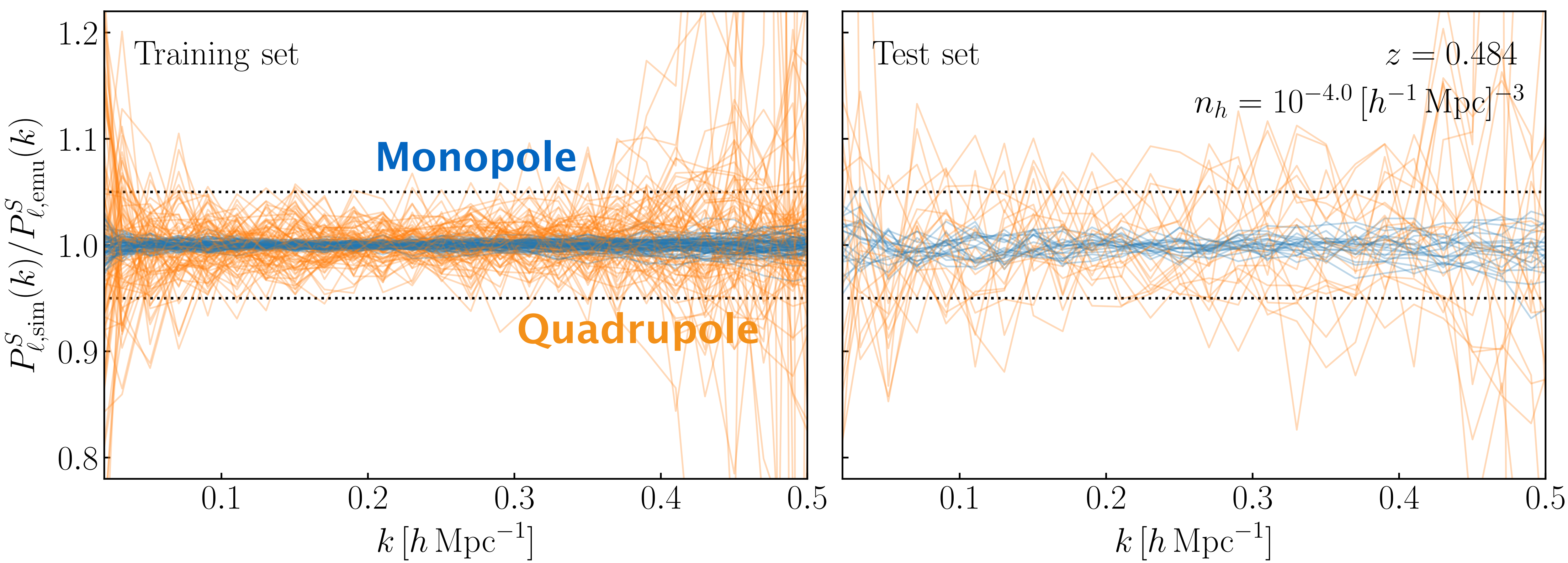
$$P_\ell^S(k) = \frac{2\ell + 1}{2} \int_{-1}^{1} \mathrm{d}\mu P^S(k,\mu) \mathscr{L}_\ell(\mu)$$

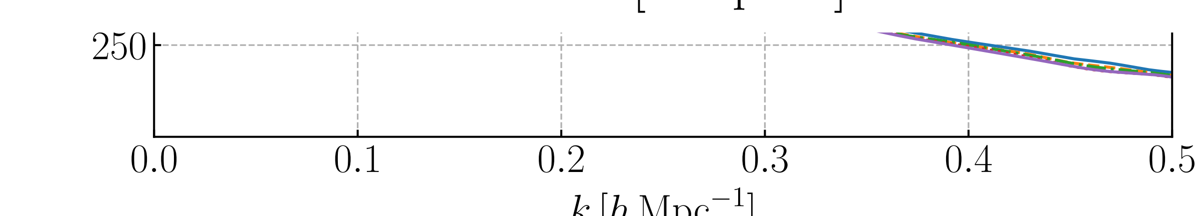


Development of the accurate emulator for the redshift-space power spectrum of dark matter halos



Yosuke Kobayashi (Kavli IPMU)
in collaboration with
Takahiro Nishimichi (YITP) & Masahiro Takada (Kavli IPMU)





Output layer (30 output units = number of k-bin)

Approach to Angular dependent Primordial Non-Gaussianity with Intrinsic Galaxy Alignments

#9 Kazuhiro Kogai (Nagoya U.)
*1 Takahiko Matsubara (KEK), Atsushi J. Nishizawa (Nagoya U.), Yuko Urakawa (Bielefeld U.)
*2 Kazuyuki Akitsu (Kavli IPMU), Fabian Schmidt (MPA), Yuko Urakawa (Bielefeld U.)

Exploring high energy particles by Cosmological Observation

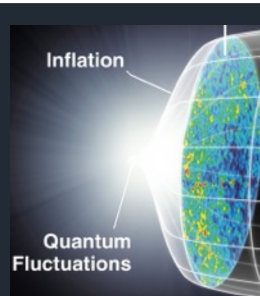
Generate
High energy particles

PNGs →

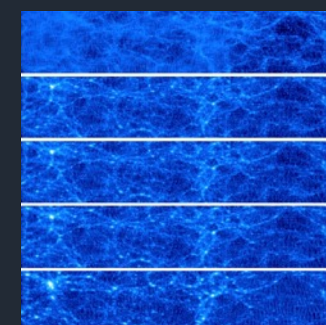
Imprint of new particles

$H < 10^{14}$ GeV

Planck 2018



Initial perturbation



Focus on squeezed Bispectra from massive higher spin particles

- Angular dependence based on spin-s
- Scale dependence based on spin-s and mass

Approach to Angular dependent Primordial Non-Gaussianity with Intrinsic Galaxy Alignments

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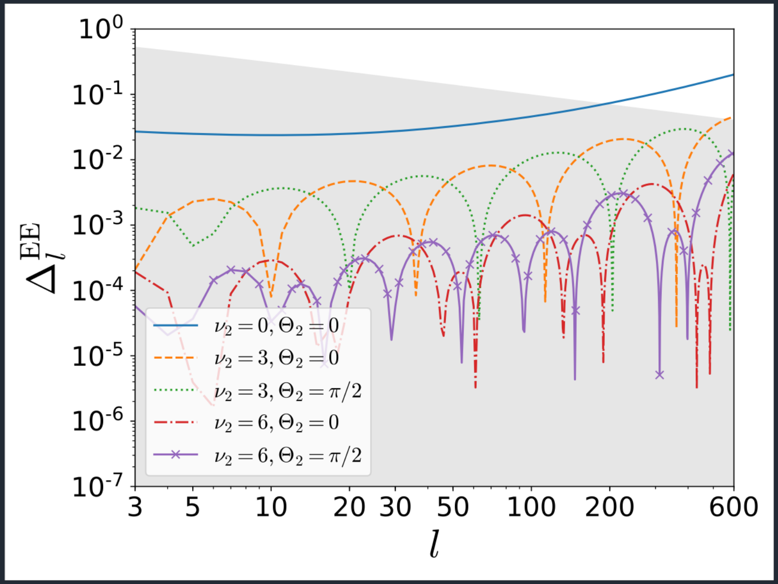
Intrinsic Alignment for elliptical galaxies

2nd moment

$$g_{ij} = b\left[\partial_i \partial_j \Phi\right]^{\mathrm{TL}}$$

Sensitive to PNGs from spin-2 particles



Extend

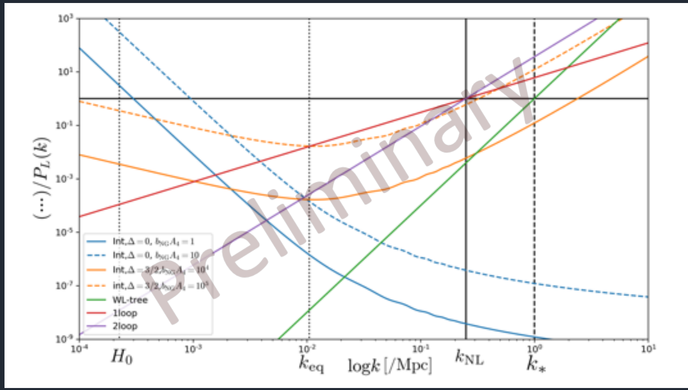
4th moment

$$g_{ijkl}$$

Sensitive to PNGs from spin-4 particles

We examined scale dependence.

Find the Imprint on the large scale

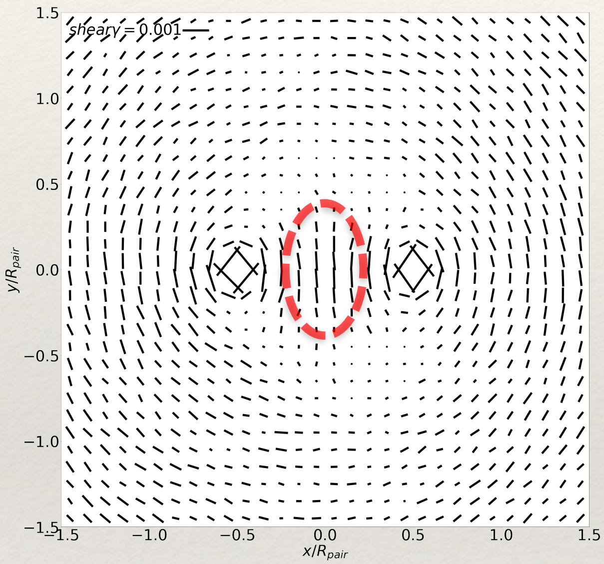


poster number 10

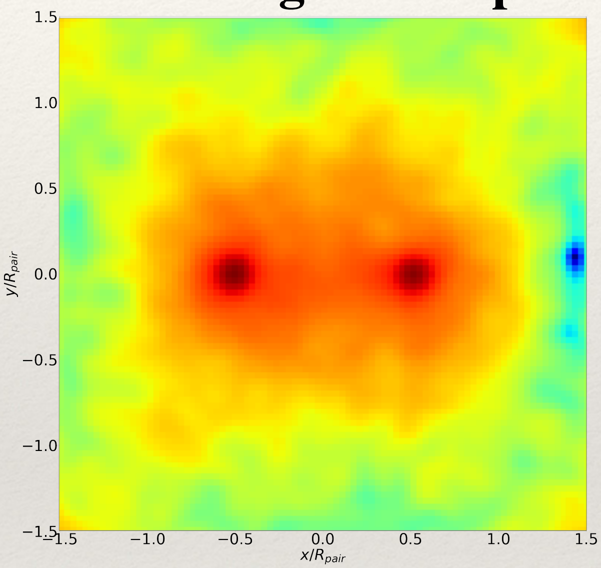
Weak lensing measurement of filamentary structure between BOSS galaxies with the Subaru HSC data.

Hiroto Kondo (Nagoya University), Hironao Miyatake (Nagoya University),
and the HSC SSP collaboration

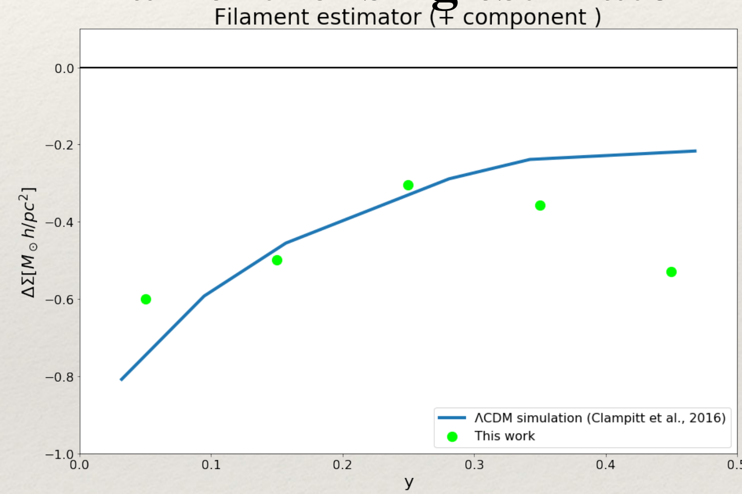
Shear map



Convergence map



"Halo-free" filament lensing estimator



- We have measured dark matter filamentary structure between CMASS galaxies using the HSC first year data.
- We have obtained the "diffuse" and "thick" filamentary structure which is consistent with the previous measurement of LRG pairs.

Constraints on the stochastic gravitational wave background with HSC weak lensing survey

Toshiki Kurita, Kazuyuki Akitsu, Masahiro Takada, Chiaki Hikage, Masamune Oguri (Kavli IPMU)

Thu 07/03

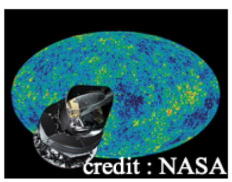
14:00

Constraining the stochastic gravitational wave background using the cosmic shear B-mode	*Kazuyuki Akitsu*
Yukawa Institute for Theoretical Physics, Kyoto University	13:50 - 14:10

The Stochastic Gavitational Wave Background

- cosmological origin
  - inflation, phase transition, cosmic string,…
- astrophysical origin
  - unresolved compact binary(BH,NS,…)

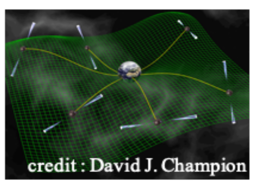
Upper limits of $\Omega_{\rm GW}$ by various observations



CMB measurements

$k \sim \mathrm{Gpc}^{-1}$

$\Omega_{\rm GW} \lesssim 10^{-13}$



Pulsar Timing Array

$k \sim \mathrm{pc}^{-1}$

$\Omega_{\rm GW} \lesssim 10^{-9}$

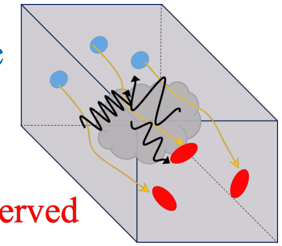
Laser Interferometer experiments

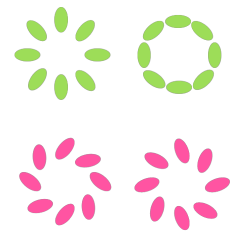
$k \sim \mathrm{km}^{-1}$

$\Omega_{\rm GW} \lesssim 10^{-6}$

In addition to these observations, we constrain the SGWB by using the weak lensing survey.

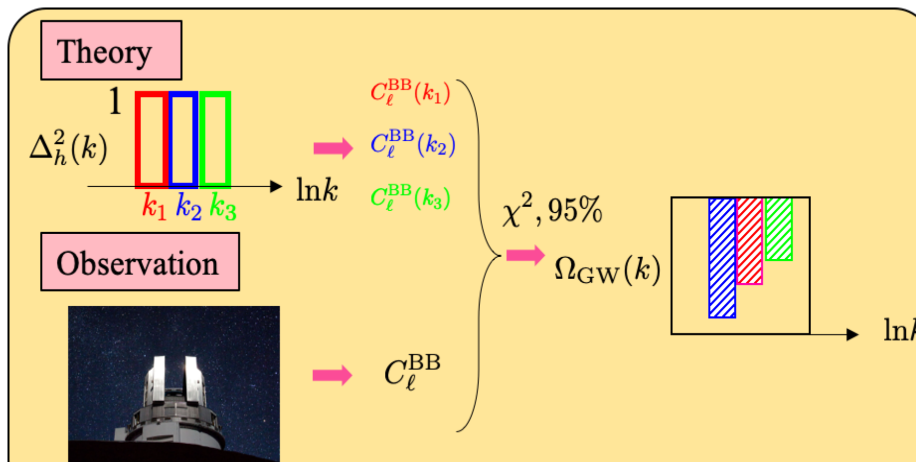
GWs produce the weak lensing signal



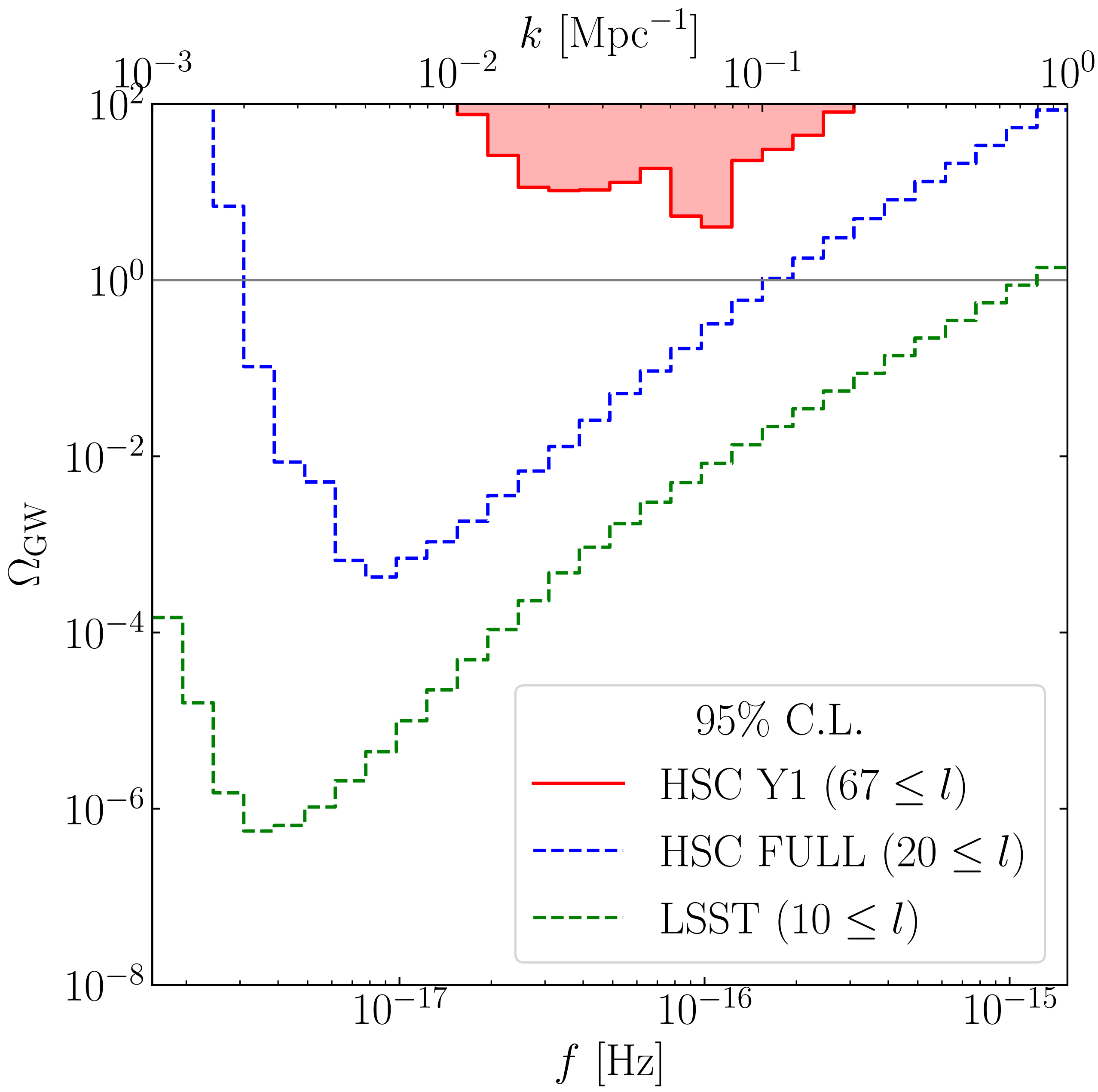


GWs create EE & BB
- scalar only EE

➡ ***We can constrain the SGWB at leading order by using the data of the BB power spectrum of cosmic shear.***



flow-chart



k [Mpc^{-1}]
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{2}
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
$\Omega_{\rm GW}$
95% C.L.
HSC Y1 ($67 \leq l$)
HSC FULL ($20 \leq l$)
LSST ($10 \leq l$)
10^{-17}
10^{-16}
10^{-15}
f [Hz]

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

TEPPEI MINODA (Nagoya-U, Japan)

Magnetic fields exist with many galaxies.

QUESTION: What is the origin?

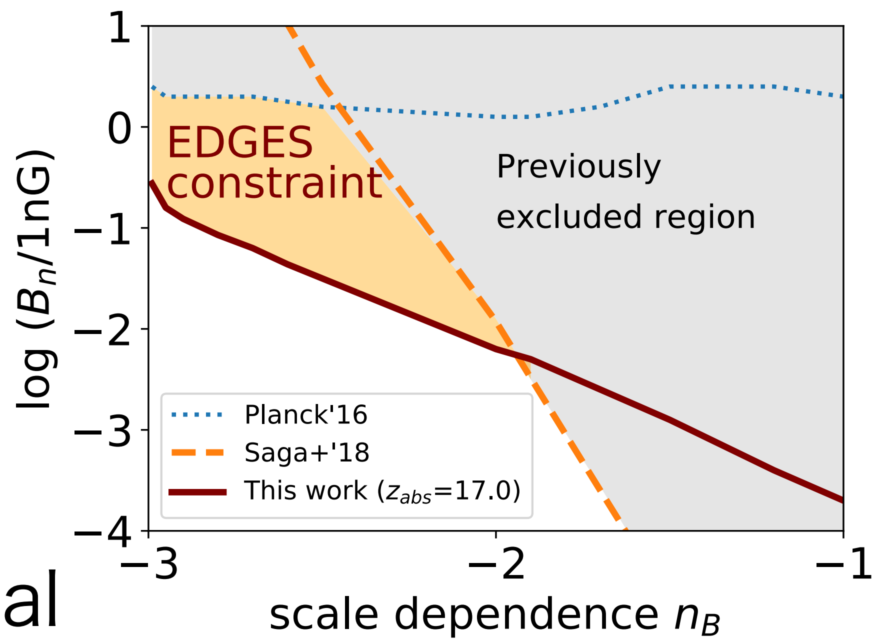
=> **Primordial Magnetic Fields (PMFs)**

↓ MHD dissipation

Heating IGM baryon gas

↓ If the gas temperature is compatible with the CMB one,

Vanishing 21-cm global signal



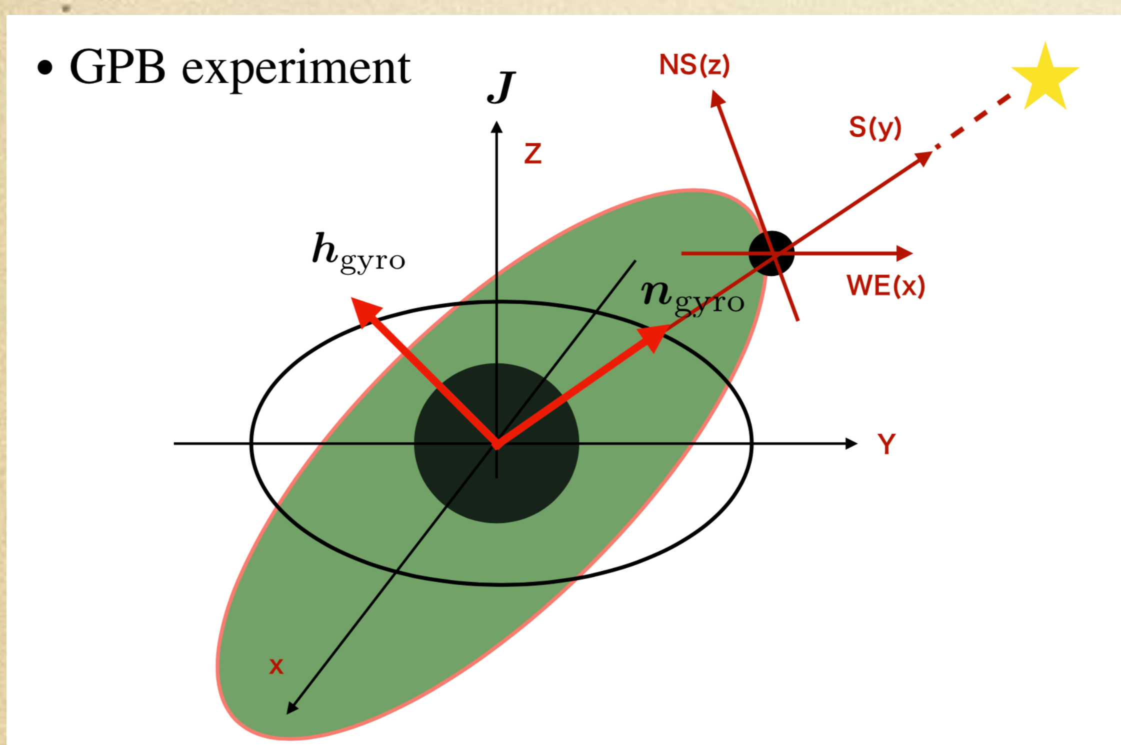
21-cm line detection can constrain the PMFs tightly!

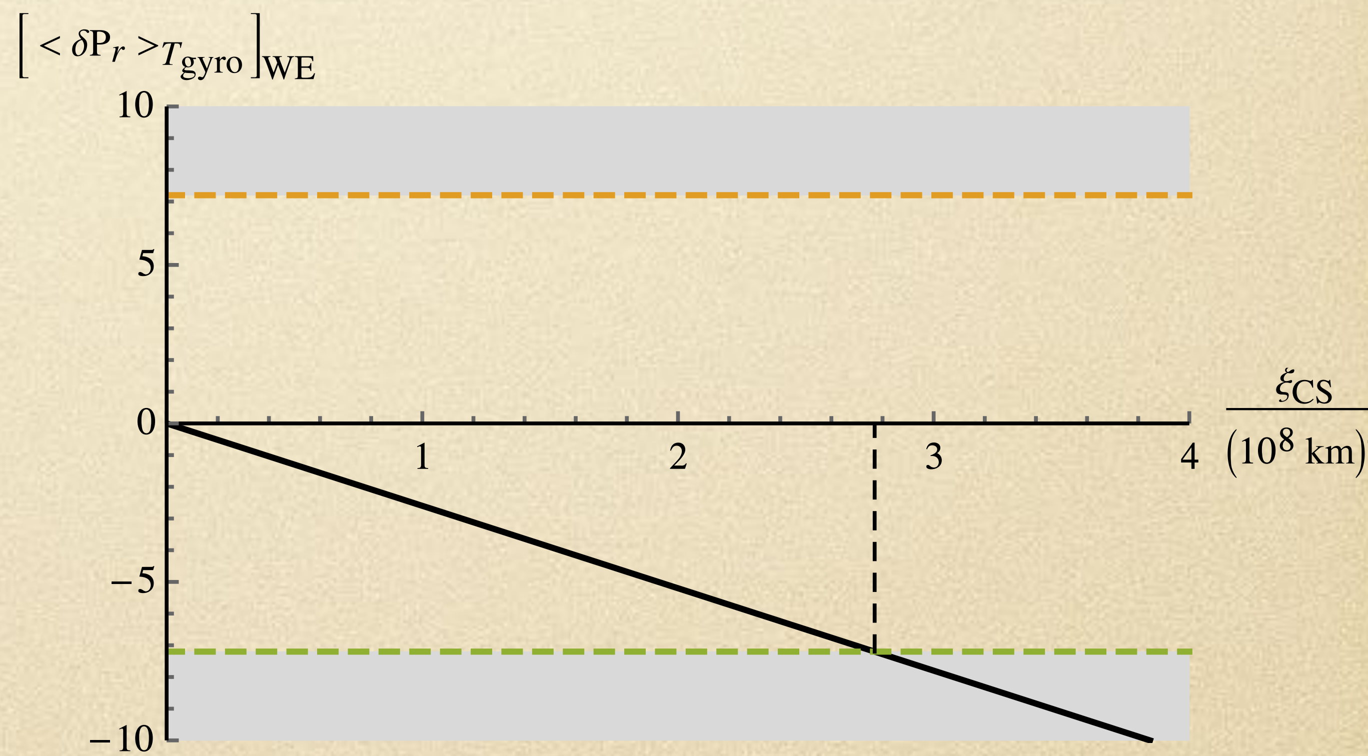
Poster No. 14 Kyoto Mar. 4 - 8, 2019

HIROSAKI UNIVERSITY

Weakly self-gravitating objects in Chern-Simons modified gravity

Yuya nakamura
Hirosaki University, Japan
with Daiki Kikuchi (Hirosaki), Kei. Yamada (Kyoto),
Hideki Asada (Hirosaki), N. Yunes (Montana)



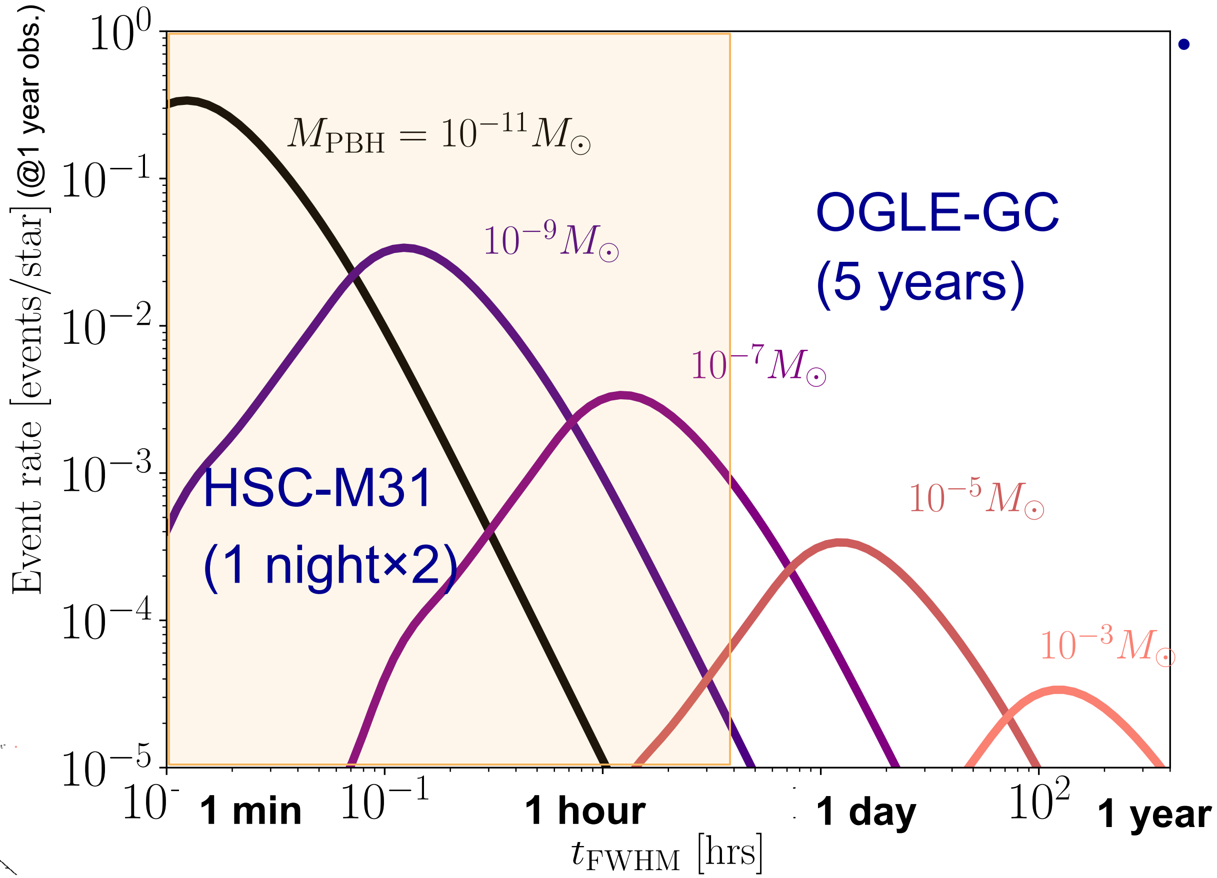


No. 15

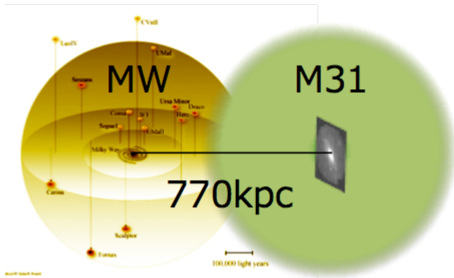
Constraining primordial black holes with gravitational microlensing effect

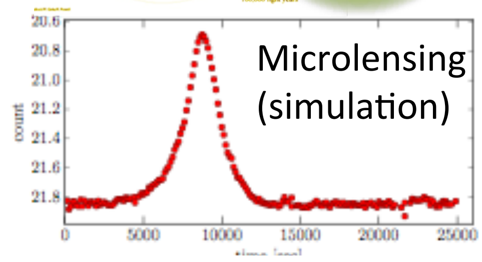
Hiroko Niikura (UTokyo/KIPMU)

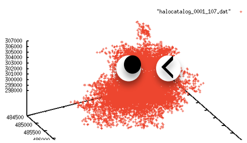
- Microlensing event rate by PBHs for a single star (in M31)



- Target: microlensing effect by PBH, a candidate of dark matter (or put constraint on the abundance of PBH.)





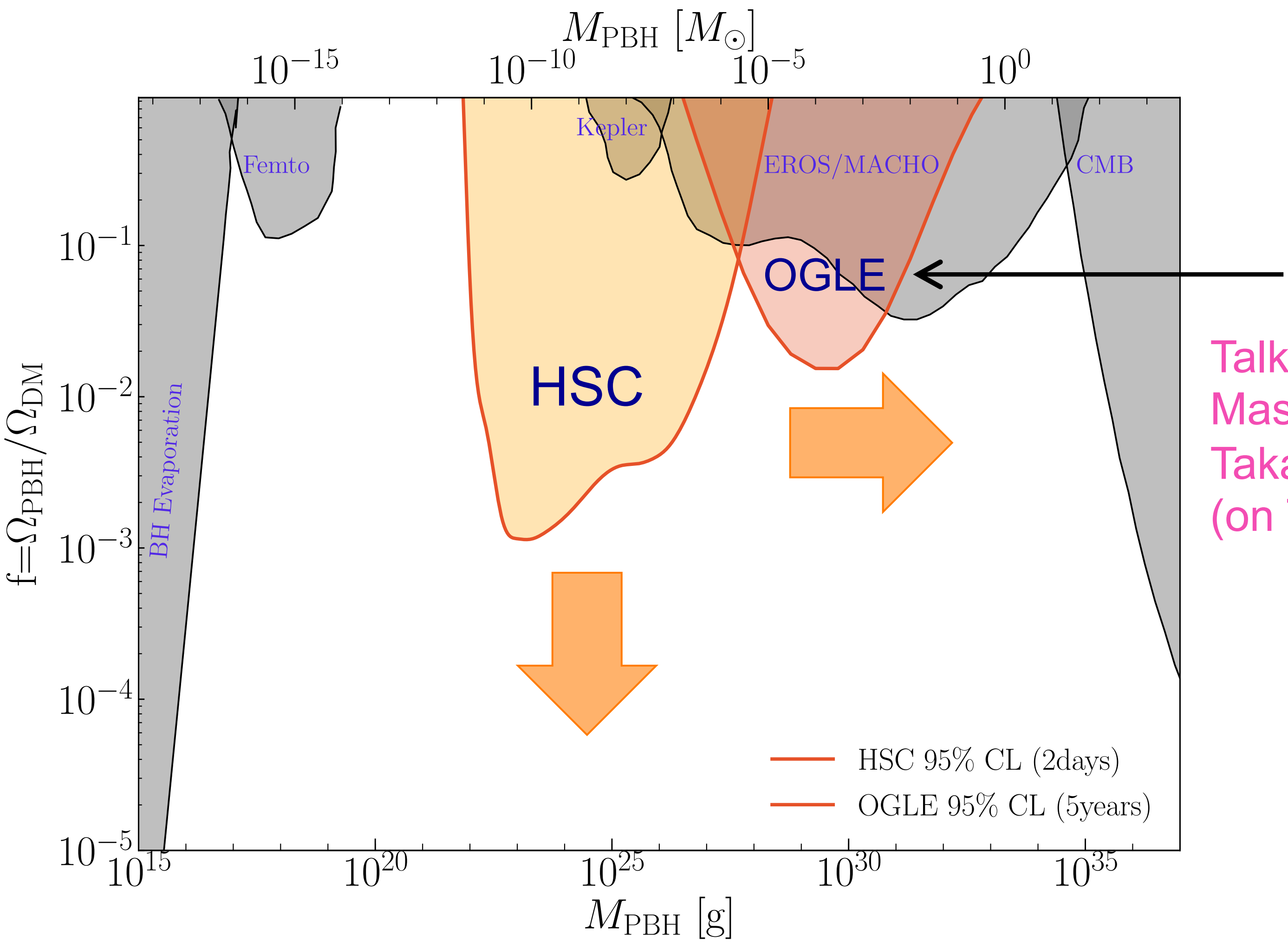


No. 15

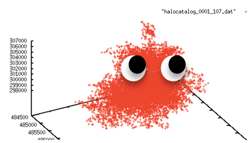
Constraining primordial black holes with gravitational microlensing effect

Hiroko Niikura (UTokyo/KIPMU)

A mass fraction of PBHs to DM

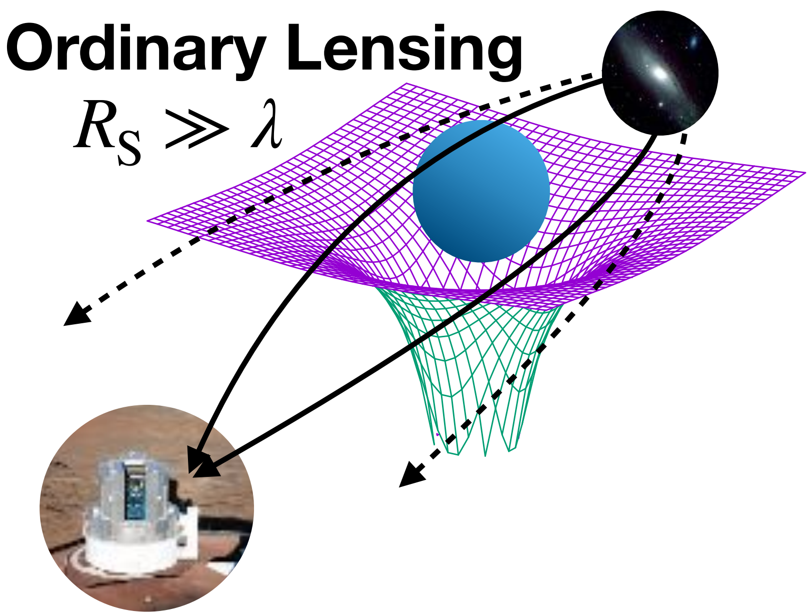


Talk by Masahiro Takada (on Thursday)

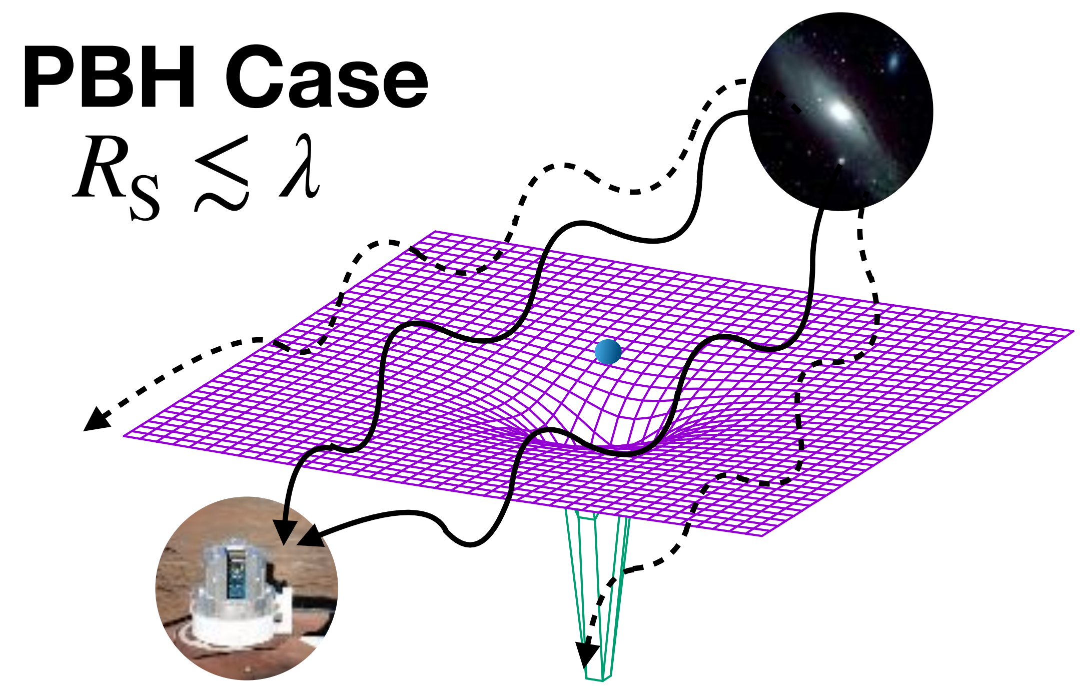


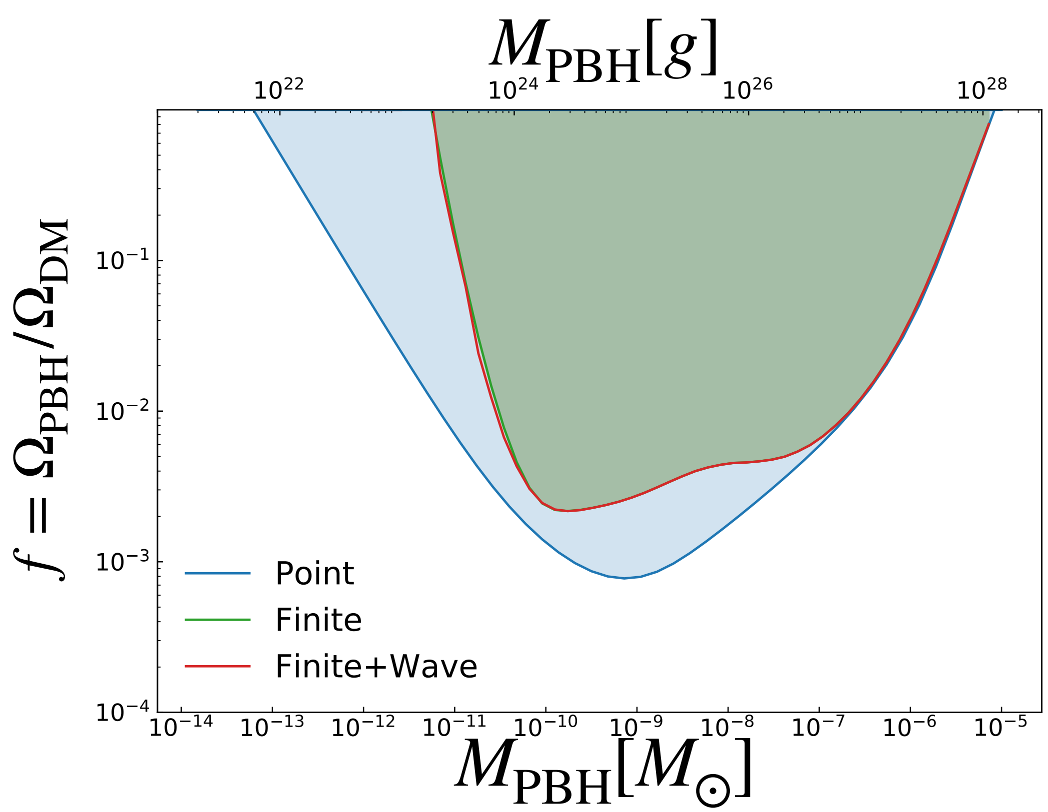
Presenter : Sunao Sugiyama
Collaborator : T. Kurita, M. Takada, H. Niikura

Wave Effect on PBH Micro-lensing



But





Calc

Light PBH
→Small Schwarzschild radius $\sim \lambda$
→Weaken interference & magnification
→Less lensing event rate
→Weaken PBH abundance constraint

Carefully calculated
wave effect on PBH micro-lensing.

Relativistic stars in a cubic Galileon Universe

Poster 16

Collaborators: Tsutomu Kobayashi, Kazuya Koyama

Cubic Galileon (Shift-symmetric Horndeski theory)

$$S = \int d^4x\sqrt{-g}[\zeta(R-2\Lambda) - \eta(\partial\phi)^2 + \gamma\Box\phi(\partial\phi)^2]$$

$$\phi = \phi(r)$$

No-hair theorem holds for Black hole and star

There are some loopholes…

$$\phi = qt + \Psi(r)$$ **:time dependence**

Many black hole solutions are found

We have studied Relativistic star solutions, the exterior spacetime is de-Sitter like

$$S = \int d^4x\sqrt{-g}[\zeta(R-2\Lambda) - \eta(\partial\phi)^2 + \gamma\Box\phi(\partial\phi)^2 + \mathcal{L}_{\rm m}]$$

minimally coupled

spherical symmetric

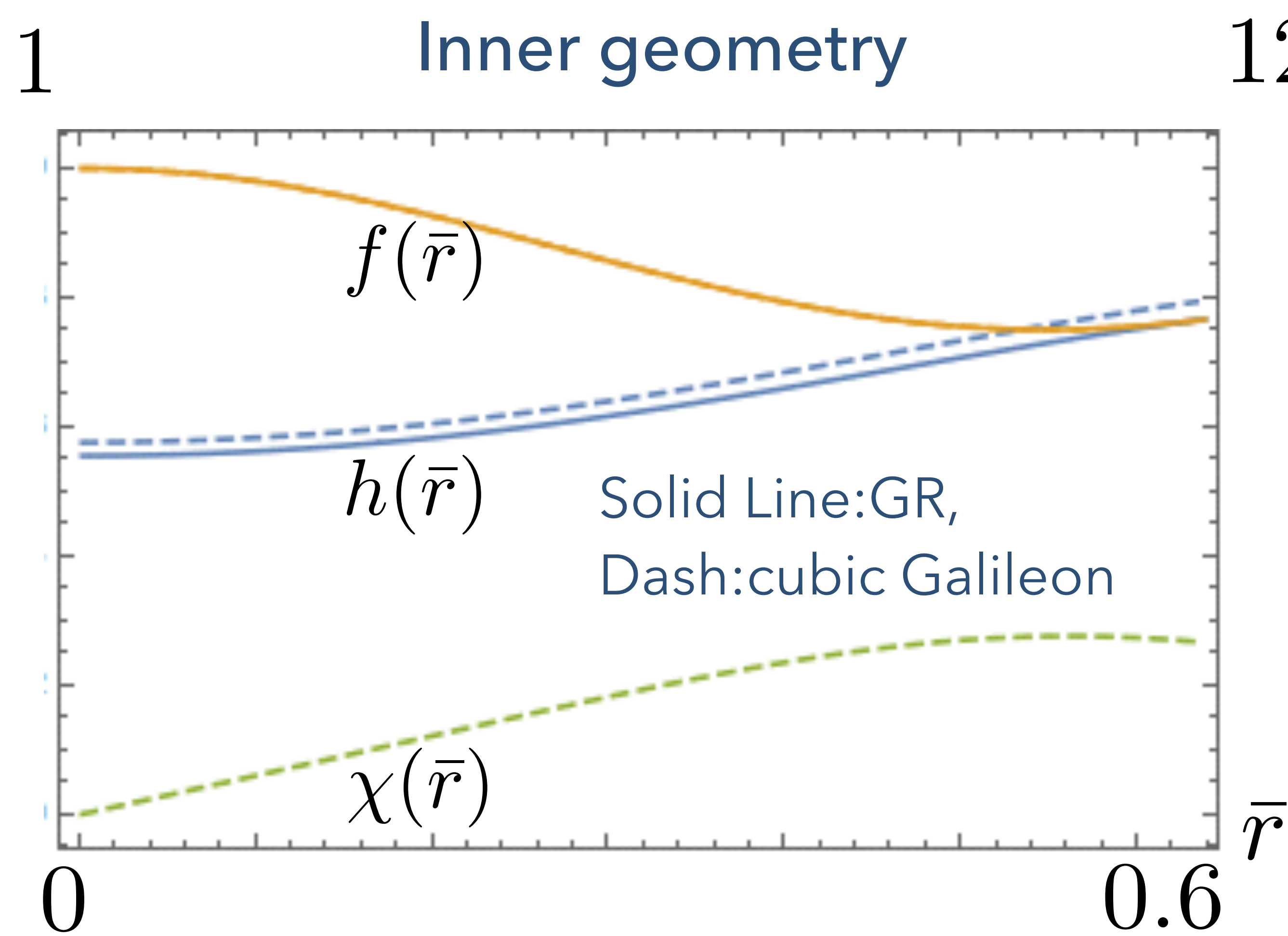
$$ds^2 = -h(r)dt^2 + \frac{dr^2}{f(r)} + r^2 d\Omega^2$$

lineally time-dependent scalar field

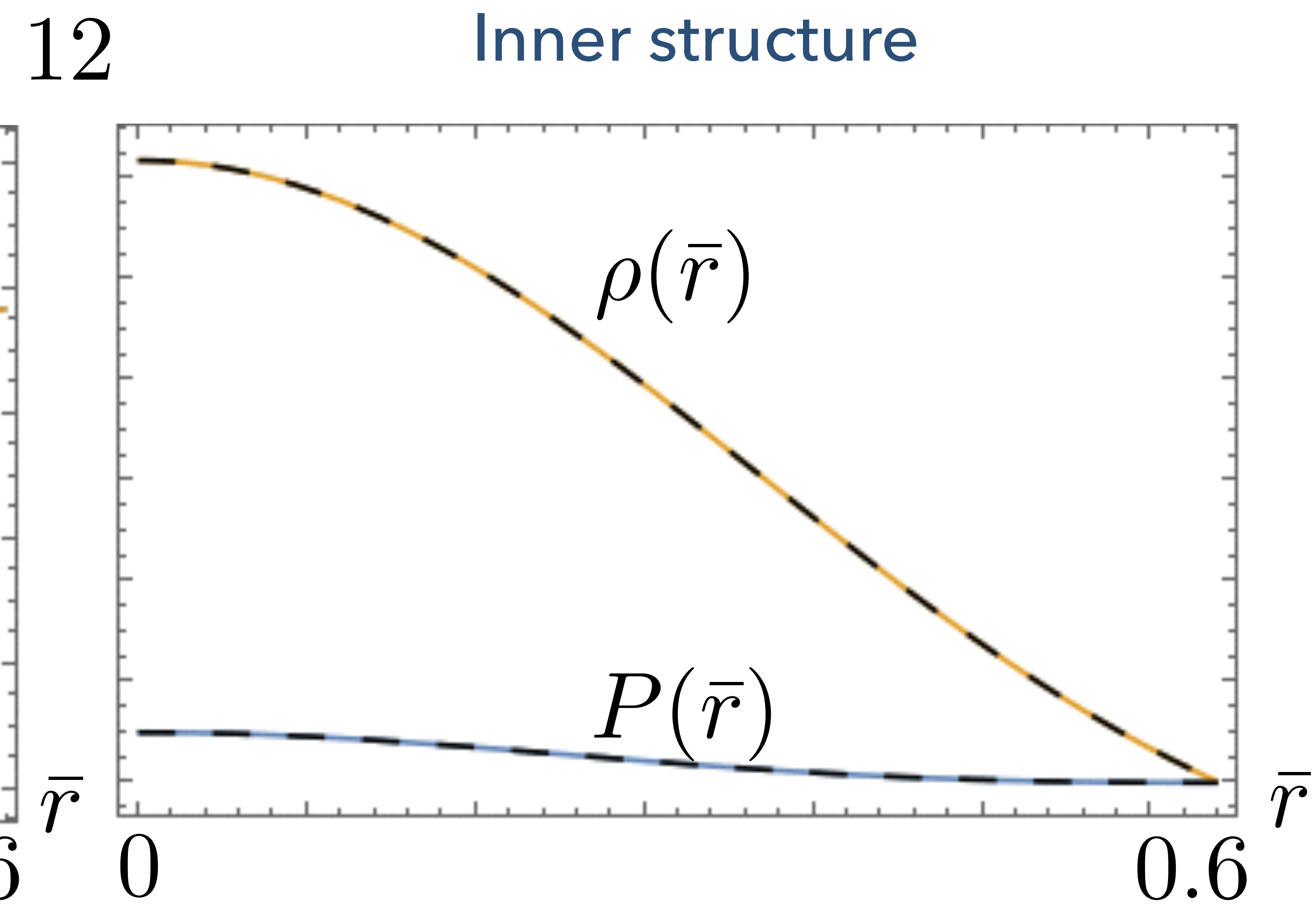
$$\phi(r,t) = qt + \int dr \frac{\chi(r)}{h(r)}$$

perfect fluid

Inner geometry



Inner structure



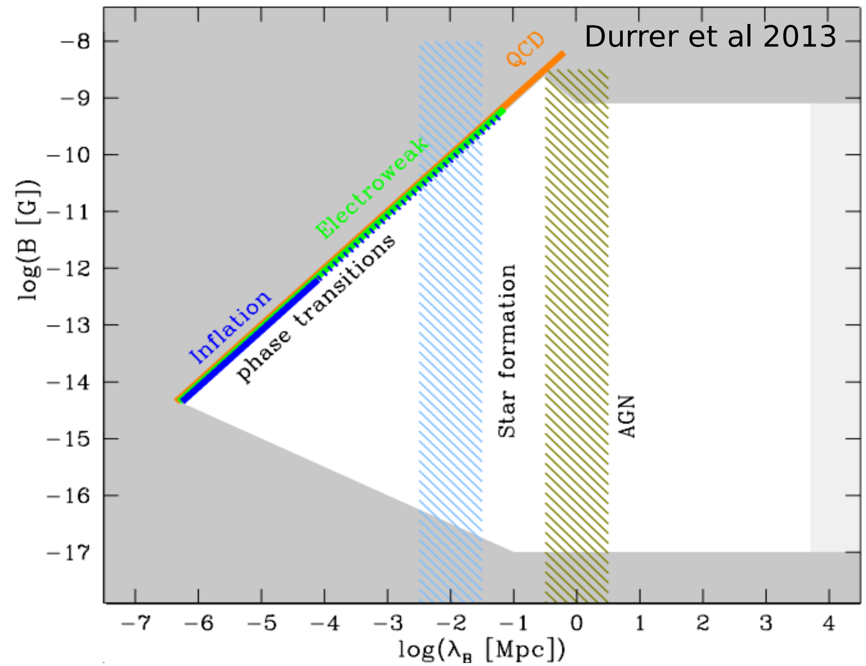
no difference, Vainshtein screening works

TEERTHAL PATEL
Cosmology Research Group, Nagoya University

Resonant magnetogenesis from axions

in collaboration with Tatsuo Kobayashi[2] ,Hiroyuki Tashiro[1], Yuko Urakawa [1]

What is the origin of cosmic magnetic fields?



Can oscillating axions generate strong enough magnetic fields?

$$S[\phi, \mathcal{A}_\mu] = \int \sqrt{-g}[\mathcal{L}_\phi(\phi) + \mathcal{L}_{\rm em}(\mathcal{A}) + \mathcal{L}_I(\phi, \mathcal{A}_\mu)]$$

Helical Coupling

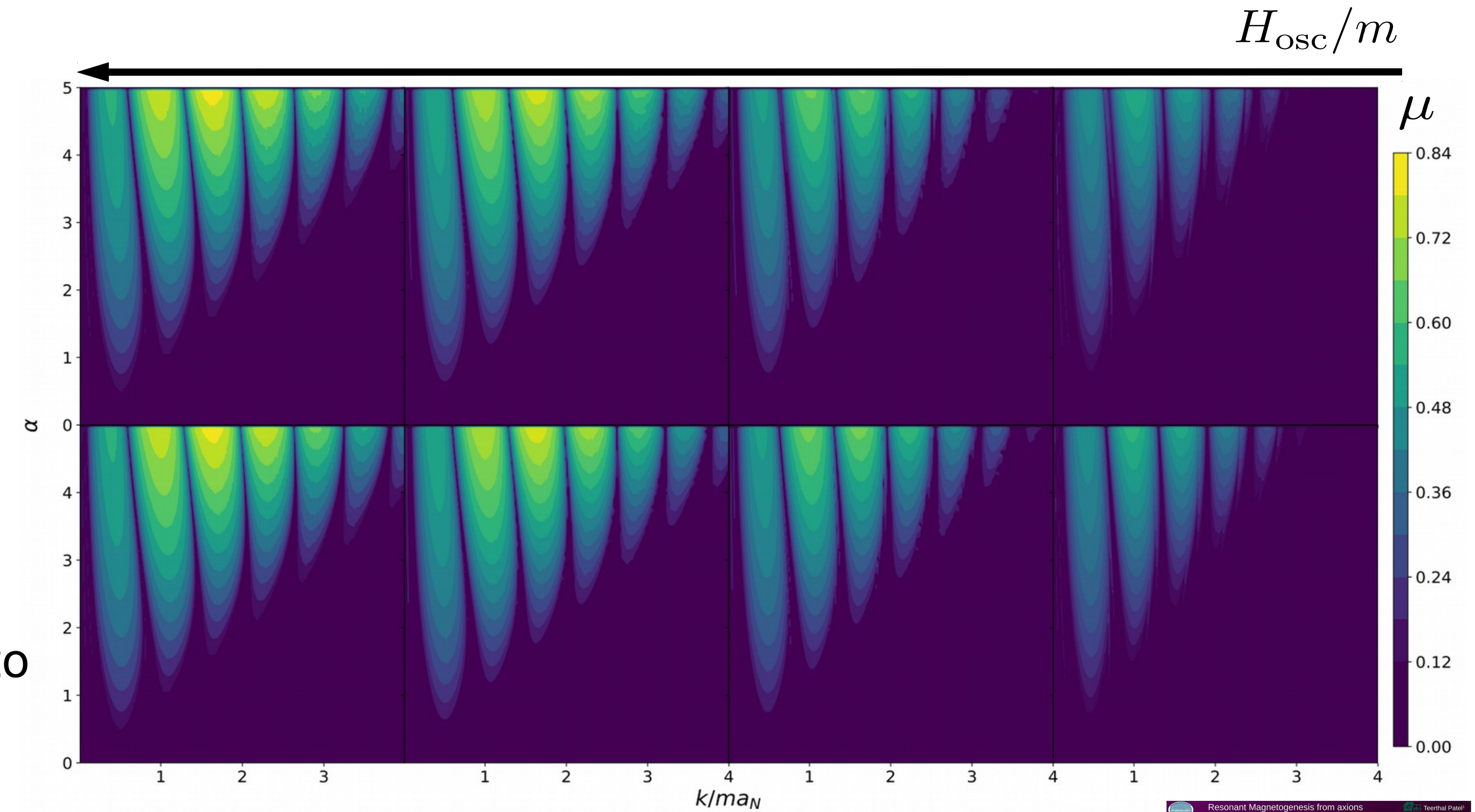
$$\mathcal{L}_I = -\frac{\alpha\phi}{4f} F_{\mu\nu}\tilde{F}^{\mu\nu}$$

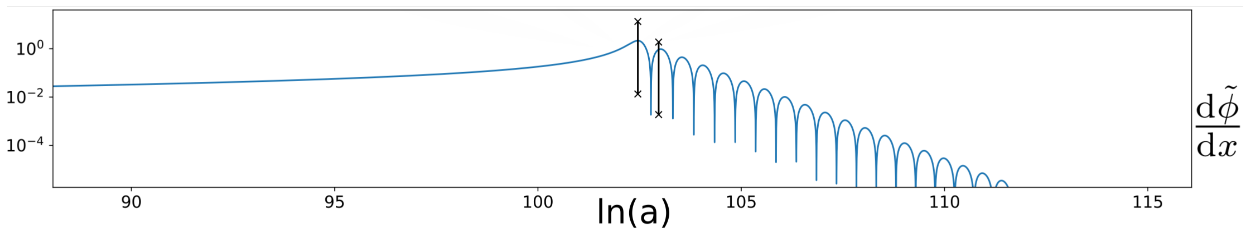
Spectator Axion undergoing coherent oscillation

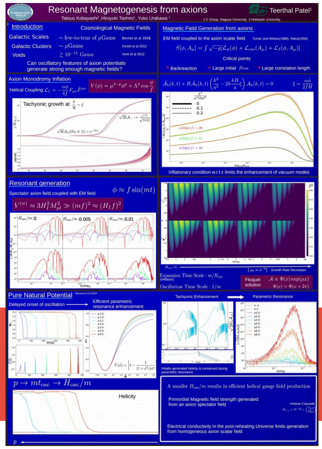
Parametric Resonance

→ The gauge modes can be rather efficiently amplified.

Tachyonic Phase prior to oscillation generates a helical spectrum







Accelerating Universe in the Dark, Kyoto, Feb 2019.

#17

#18 Quintessence Saves Higgs Instability

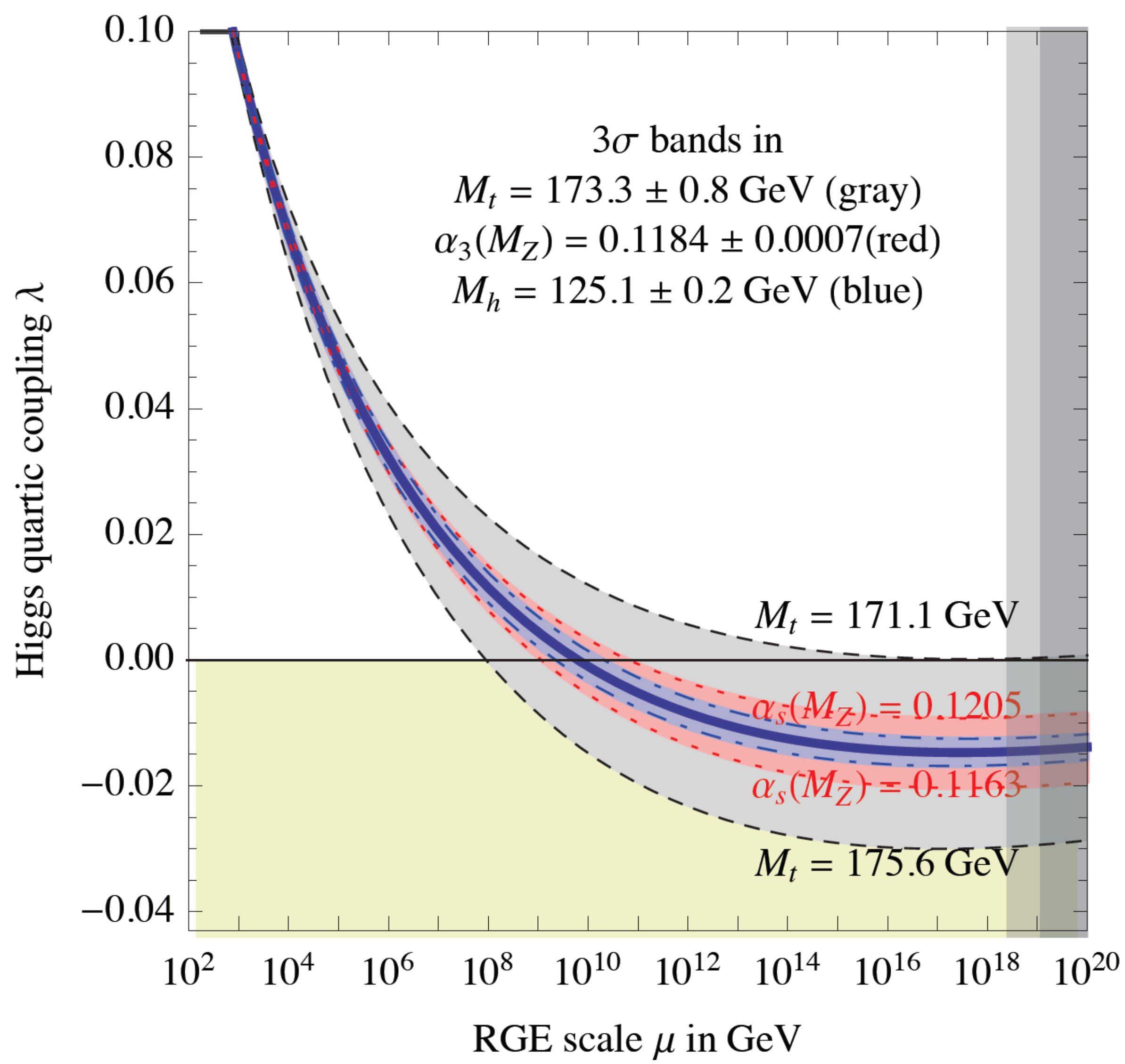
Shi Pi, Kavli IPMU, University of Tokyo

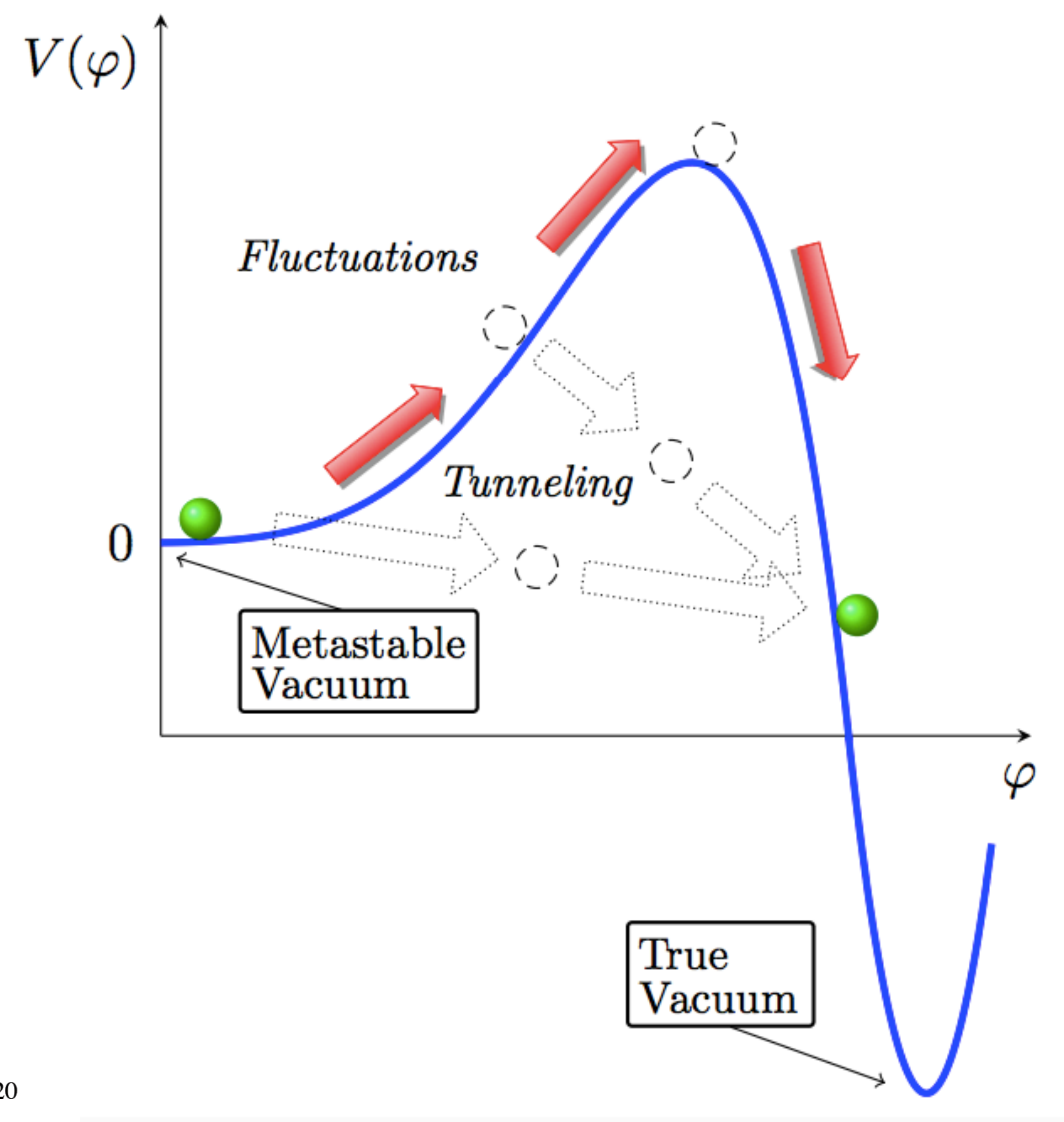
Based on arXiv:1809.05507, Chengcheng Han, SP, and Misao Sasaki

$$V = \lambda(\mathcal{H}^\dagger\mathcal{H} - v^2)^2$$

$\lambda \sim 0.13$

$v \sim 174$ GeV

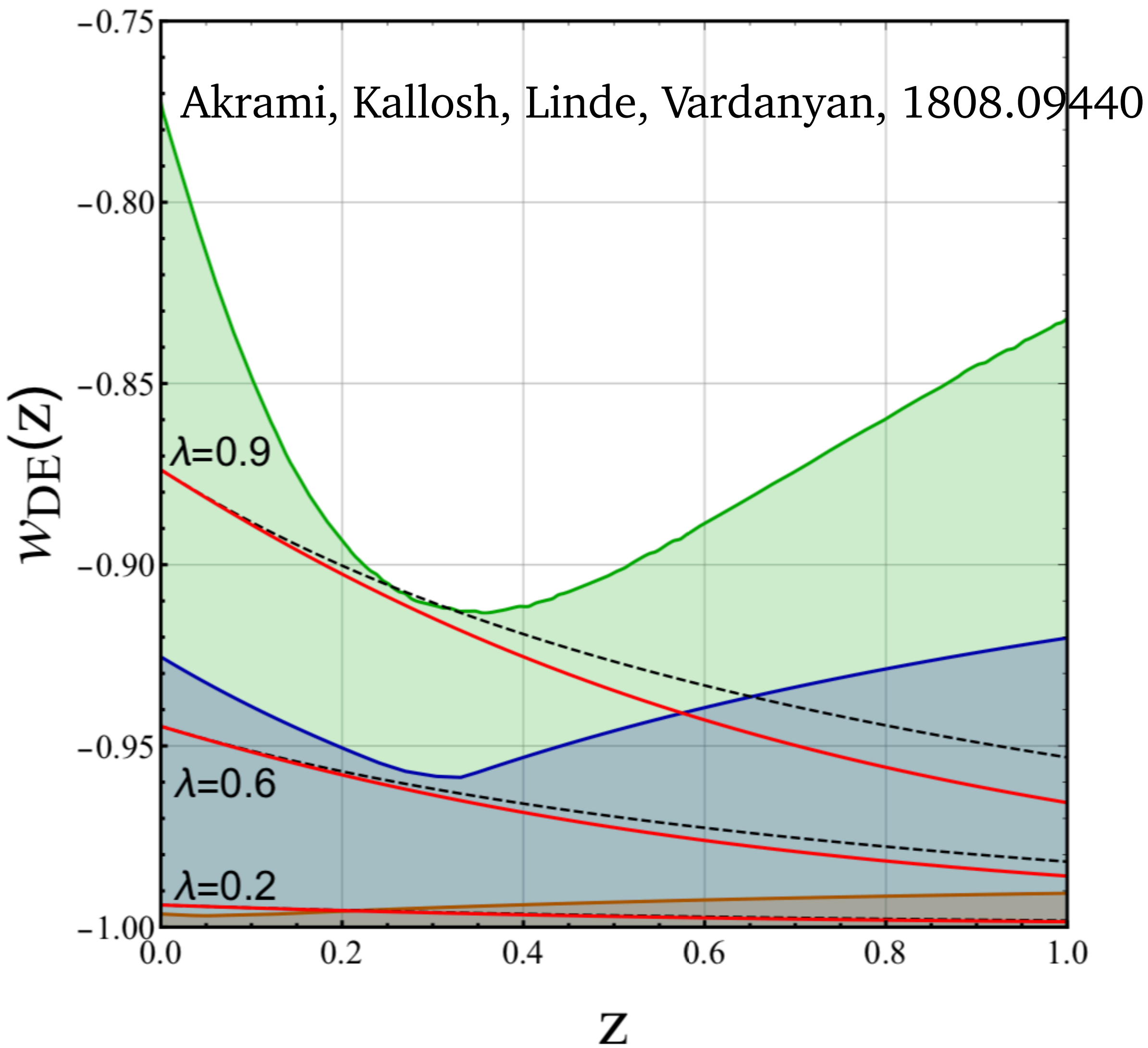


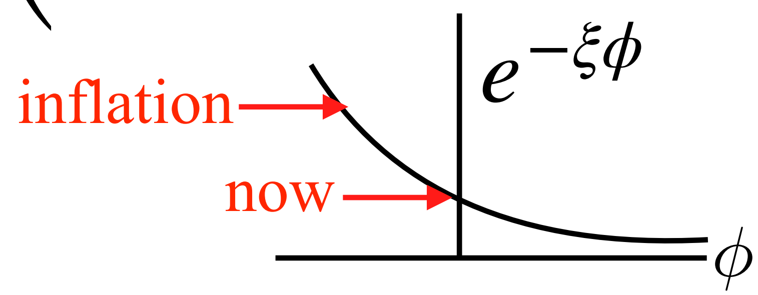


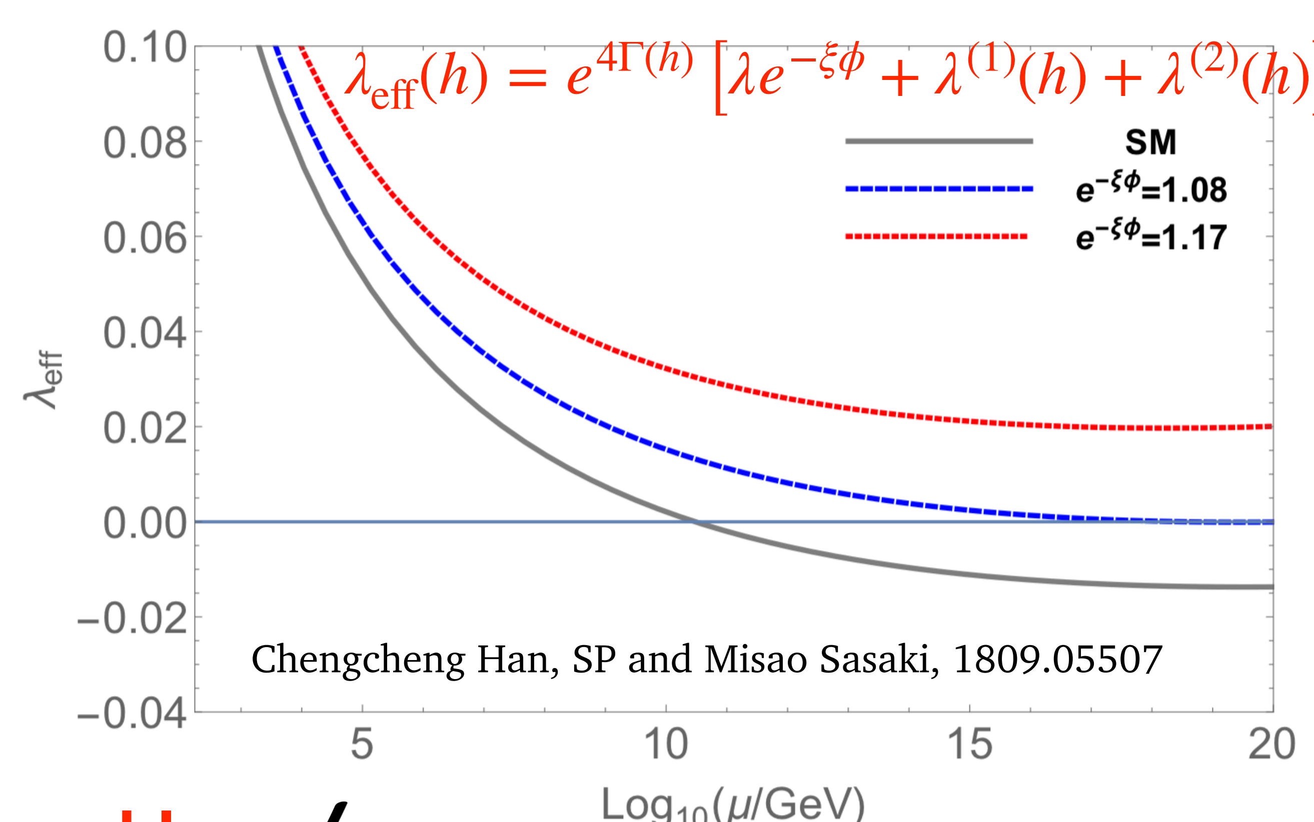
#18 Quintessence Saves Higgs Instability

- Denef, Hebecker, Wrase, 1807.06581.

$$V(\phi, \mathscr{H}) = e^{-\xi\phi}\left(\lambda\left(|\mathscr{H}|^2 - v^2\right)^2 + \Lambda\right)$$







Higgs instability problem ✓

Observational detectability ✓

Swampland Conjecture ✓

A fitting formula of non-linear matter bispectrum for weak lensing surveys

Ryuichi Takahashi

with T Nishimichi, A Taruya, Y Kobayashi, …

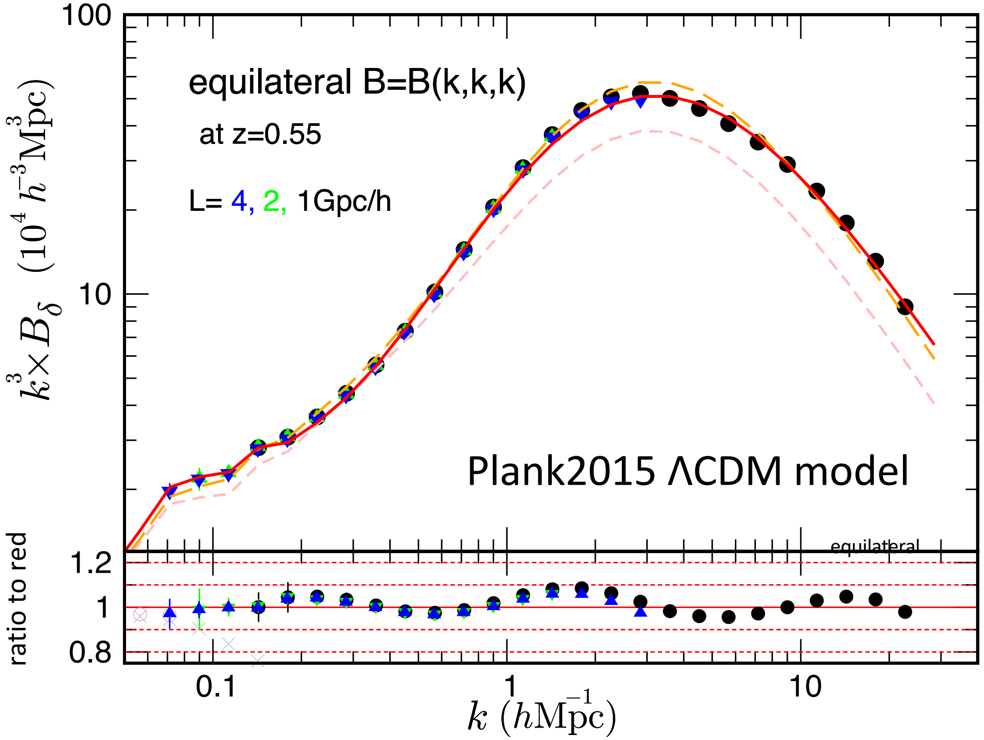
We are constructing an accurate fitting formula of matter bispectrum based on the halo model and halo fit

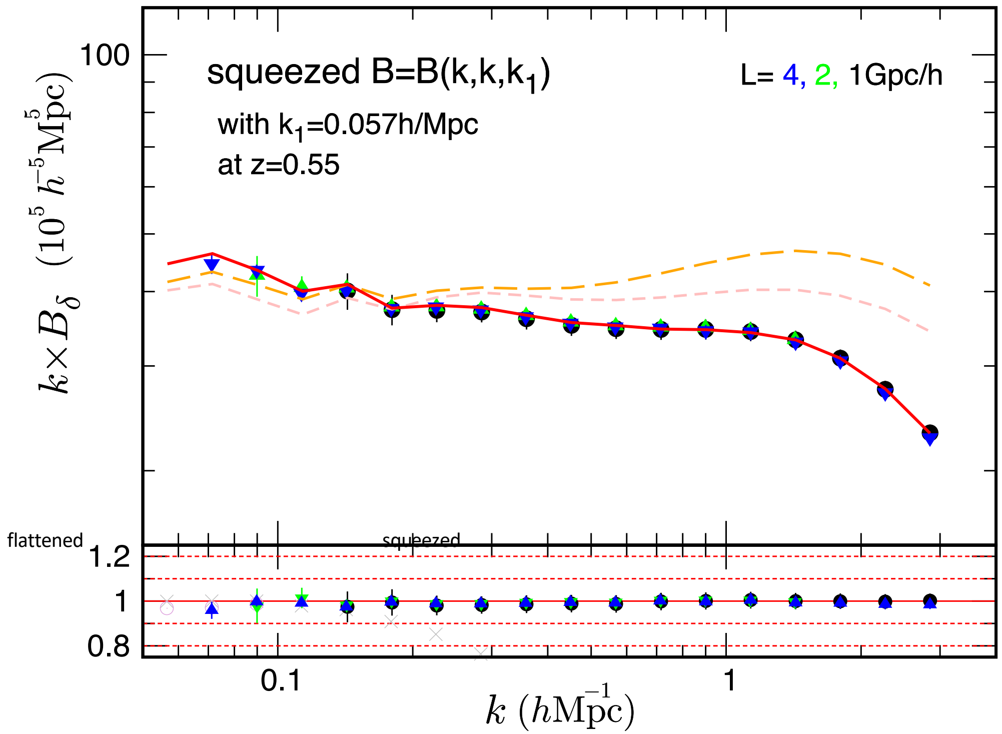
$$B(k_1, k_2, k_3) \sim \langle \tilde{\delta}(\vec{k}_1)\tilde{\delta}(\vec{k}_2)\tilde{\delta}(\vec{k}_3)\rangle \quad \text{with} \quad \vec{k}_1 + \vec{k}_2 + \vec{k}_3 = 0$$

the Dark Emulator N-body suite （Nishimichi+ 2018）

- dark matter only simulations
- 41 cosmological models（default : Planck2015 best fit）
- redshift range z=0-10
- wavenumber up to k=30h/Mpc

equilateral △ squeezed





solid red : our fitting formula

dashed orange : Gil-Marin+（2012）

dotted pink : Scoccimarro & Couchman（2001）

Our model agrees with the simulations within 10% up to k=10h/Mpc

Possible violation of **positivity bounds** for local/non-local theories

D2 Junsei Tokuda (Kyoto Univ.) Ref.) JT arXiv:1902.10039

- As a phenomenological quest for the fundamental theory

  ・・・ Effective field theories (EFT)

$$e^{iS_{\mathrm{EFT}}[\phi]} = \int \mathfrak{D}\mathrm{Heavy}\ e^{iS_{UV}[\phi,\,\mathrm{Heavy}]}$$

e.g.) : Modified Gravity models

- Info. of UV completion is *secretly* encoded in EFT data.

Assuming UV completion is

① Unitary
② Lorentz invariant
③ Analytic (↔ Causal)
④ Local

(※ Introducing mass terms as IR regulators)

→

"Positivity bounds"

Infinite number of constraints on *low energy* scattering amplitude.

e.g.) $\mathcal{L}_{\mathrm{EFT}} = -\frac{1}{2}(\partial\phi)^2 + \frac{c_1}{\Lambda^4}(\partial\phi)^4 + \cdots$

$c_1 > 0$

A. Adams *et al*. ('06)
C. de Rham *et al*. ('17,…)

Is it impossible to derive these bounds only from ①-③ ?

Assuming UV completion is

① Unitary ③ Analytic (↔ Causal)
② Lorentz invariant ~~④ Local~~ ➡ ?

Method

- We consider scattering of massive scalar in non-local QFT.

$$\rho(-k^2) \sim (-k^2)^N \exp\left[\sigma(-k^2)^\alpha\right]$$

Lehmann-Källén spectral density

$0 \le \alpha < \frac{1}{2}$: strictly local

$\alpha \ge \frac{1}{2}$: non-local A. M. Jaffe (1967)…

e.g.) Little string theories : $\alpha = \frac{1}{2}$ A. Kapustin (‘01)

Galileon theories : $\alpha > \frac{1}{2}$ A. J. Tolley *et al*. (‘15)

Result

- We derive positivity bounds only from ①-③. (as long as $\alpha < 1$)
- We open the new possibility to falsify analytic, unitary, and Lorentz inv. UV completion via the violation of positivity bounds, even if EFT is apparently Lorentz inv.

No-Go theorems for inflation and ekpyrosis from string theory

(No.21) (JHEP 1806 (2018) 041)

Kunihito Uzawa (Kwansei Gakuin University)

❑ Contents :

(1) No-Go theorems of ekpyrosis and inflation in type II string theory.

(2) The 4-dimensional effective potential of two scalar fields has been constructed by gravity, orientifold planes, and D-branes.

(3) Since the fast (slow)-roll parameter is not small during the ekpyrotic (inflationary) phase, the dynamics has made it impossible to realize the ekpyrotic (inflationary) scenario.