C01: status update

Masahito Yamazaki
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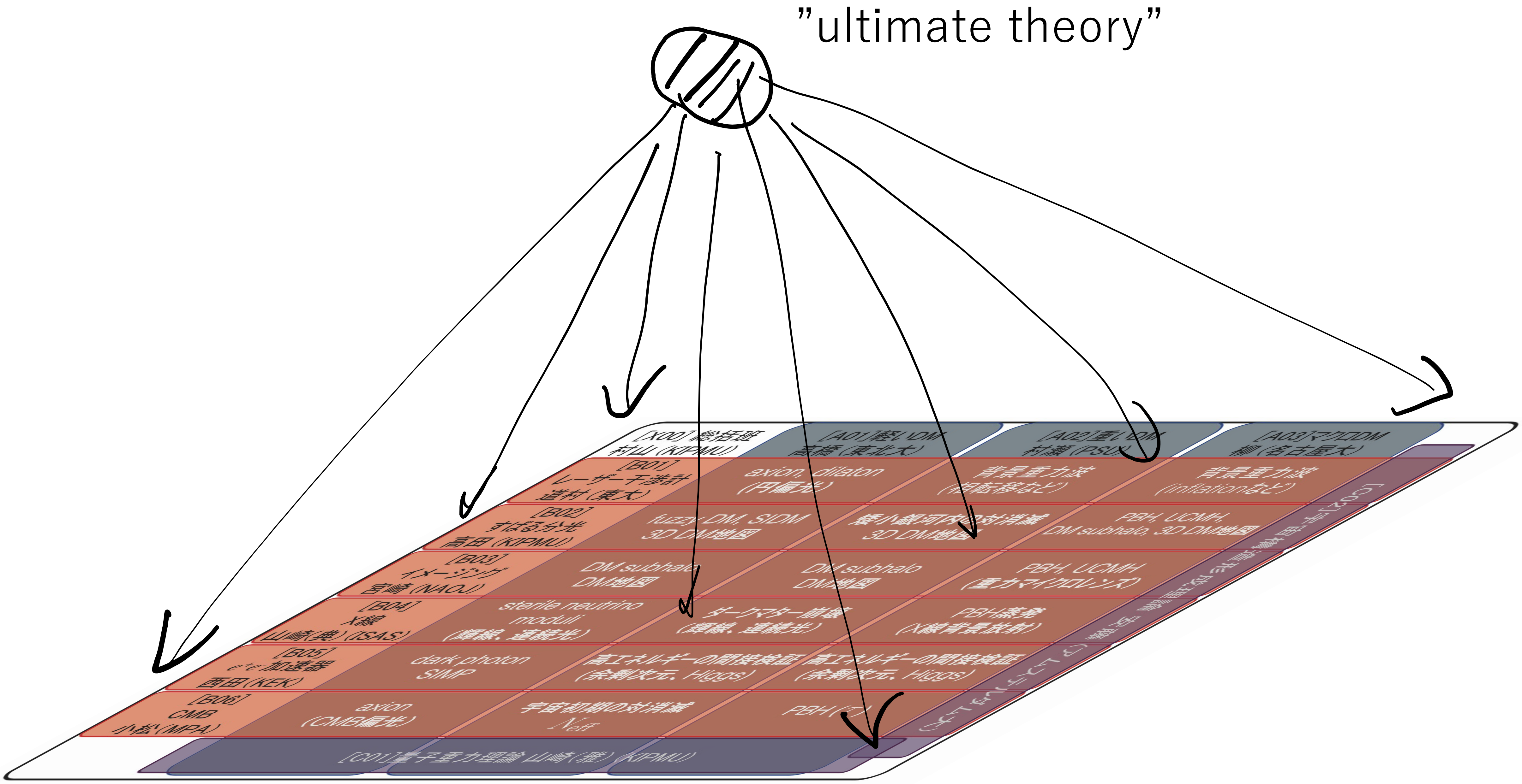
March 30, 2022

[X00] 総括班 村山（KIPMU）	[A01]軽いDM 高橋（東北大）	[A02]重いDM 村瀬（PSU）	[A03]マクロDM 柳（名古屋大）
[B01] レーザー干渉計 道村（東大）	axion, dilaton （円偏光）	背景重力波 （相転移など）	背景重力波 （inflationなど）
[B02] すばる分光 高田（KIPMU）	fuzzy DM, SIDM 3D DM地図	矮小銀河内の対消滅 3D DM地図	PBH, UCMH, DM subhalo, 3D DM地図
[B03] イメージング 宮崎（NAOJ）	DM subhalo DM地図	DM subhalo DM地図	PBH, UCMH （重力マイクロレンズ）
[B04] X線 山崎(典)（ISAS）	sterile neutrino moduli （輝線、連続光）	ダークマター崩壊 （輝線、連続光）	PBH蒸発 （X線背景放射）
[B05] e^+e^-加速器 西田（KEK）	dark photon SIMP	高エネルギーの間接検証 （余剰次元、Higgs）	高エネルギーの間接検証 （余剰次元、Higgs）
[B06] CMB 小松（MPA）	axion （CMB偏光）	宇宙初期の対消滅 N_{eff}	PBH (τ)

[C02]宇宙構造形成理論 安藤（アムステルダム大）

[C01]量子重力理論 山崎（雅）（KIPMU）

quantum gravity??



"ultimate theory"
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axion, dilaton (円偏光)
背景重力波 (相転移など)
背景重力波 (inflationなど)
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axion (CMB偏光)
宇宙初期の対消滅 $N_{\rm eff}$
[C01]量子重力理論 山崎(雅)(KIPMU)
[C02]

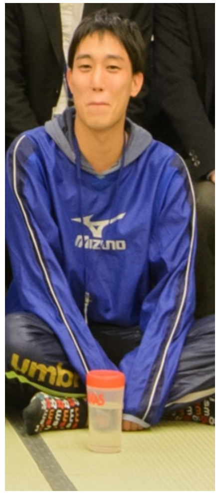

Comfort Zone
Challenge

The Team

Yasunori Nomura
(Berkeley)

Ryo Saito
(Yamaguchi)

Satoshi Shirai
(IPMU)



Syuhei Iguro
(IPMU -> Karlruhe)

Activity of Hired PD

Syuhei Iguro (2021/Apr – 2021/Sep, move to Karlsruhe)

Expert of flavor and collider physics:

Precision calculation of flavor observables: arXiv:2109.10811

- “Revisiting rescattering contributions to $B_{(s)} \to D^{(*)}_{(s)} M$ decays,”

Idea of detection of monopole cosmic ray: arXiv:2111.12091

- “Monopoles From an Atmospheric Collider”

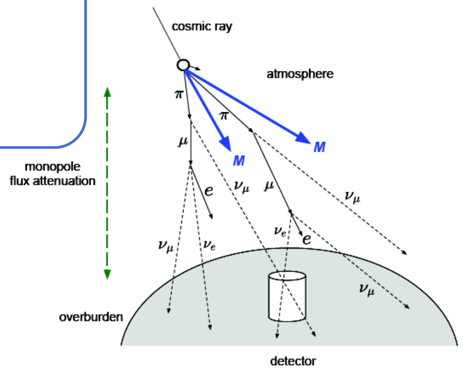
2111

2109

2111

High energy collider test of flavor anomalies: arXiv:2111.04748

- “Non-resonant new physics search at the LHC for the $b \to c \tau \nu$ anomalies,”



Unified approach to secondary CMB B-mode polarization

T. Namikawa, A. Naruko, **RS**, A. Taruya, and D. Yamauchi:
JCAP 10 (2021) 029

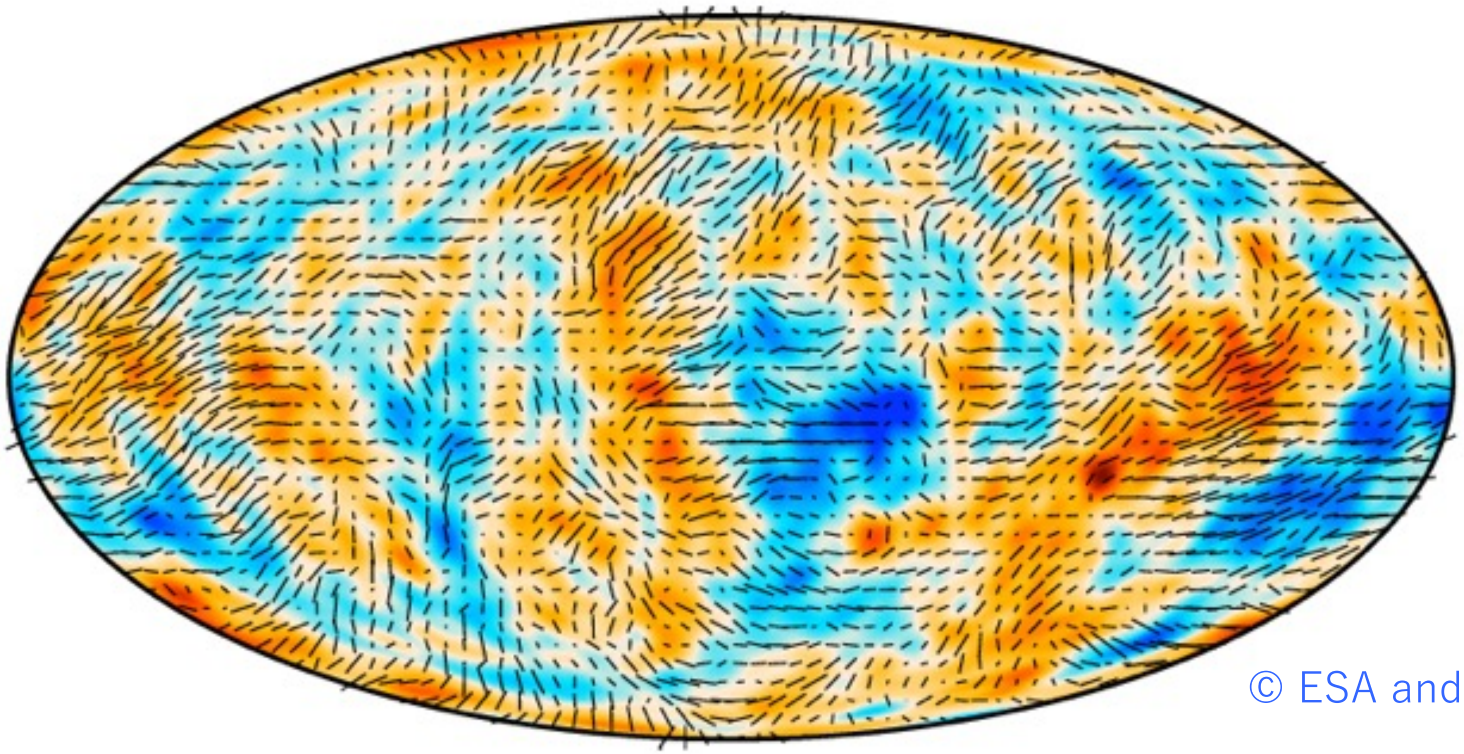
[B06]

[A02]

[C01]

[C02]

Cosmic Microwave Background (CMB) anisotropies



- Anisotropies of order 10^{-5} : a source of rich information on the early universe, calculable by cosmological perturbation theory
- Recent precise measurements → Small, nonlinear effects

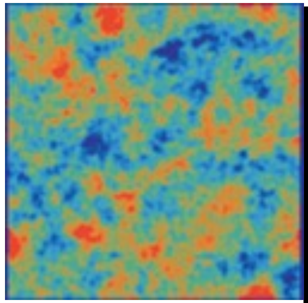
Curve-of-Sight (CoS) approach :

A new approach to compute all secondary (non-primordial) nonlinear effects to CMB anisotropies in a single framework.

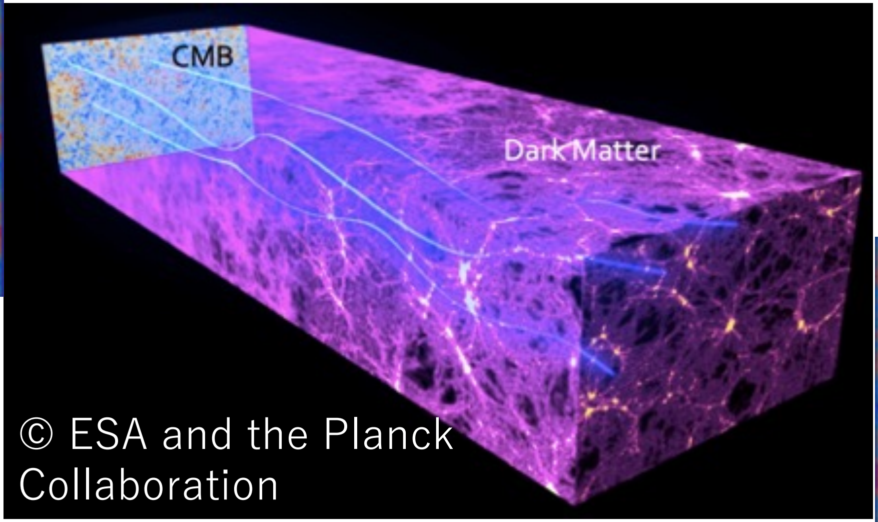
- A solution to the Boltzmann equation of CMB photons *at nonlinear orders*

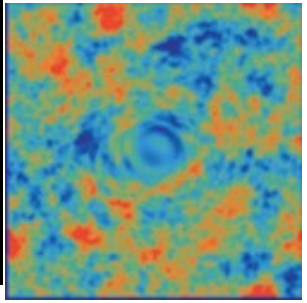
(An extension of the Line-of-Sight approach [Seljak & Zaldarriaga 96] at the linear order.)

- Weak gravitational lensing can be integrated to the Boltzmann equation.



Unlensed



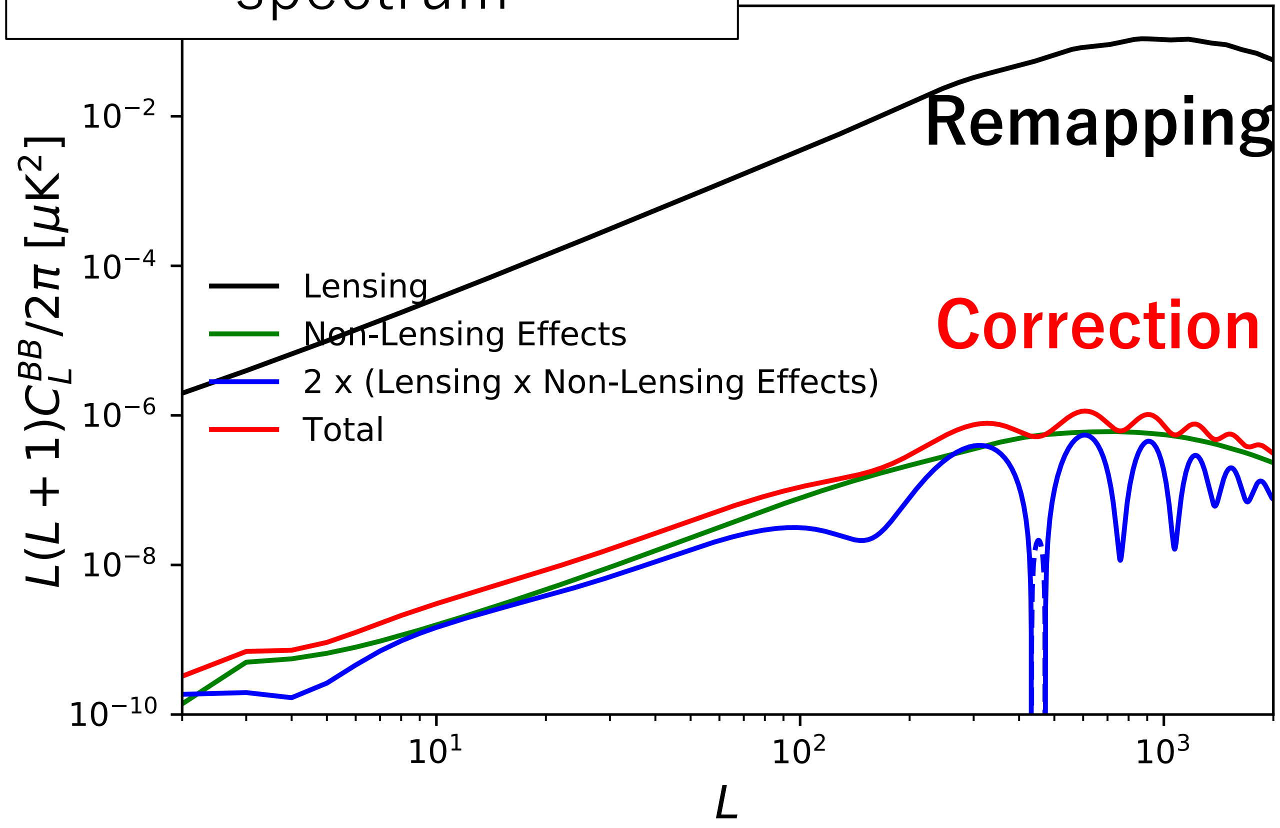


Lensed

Application : an accuracy test of the remapping approach

The standard remapping approach is reliable to subtract the lensing B mode to detect the primordial GWs in upcoming CMB experiments.

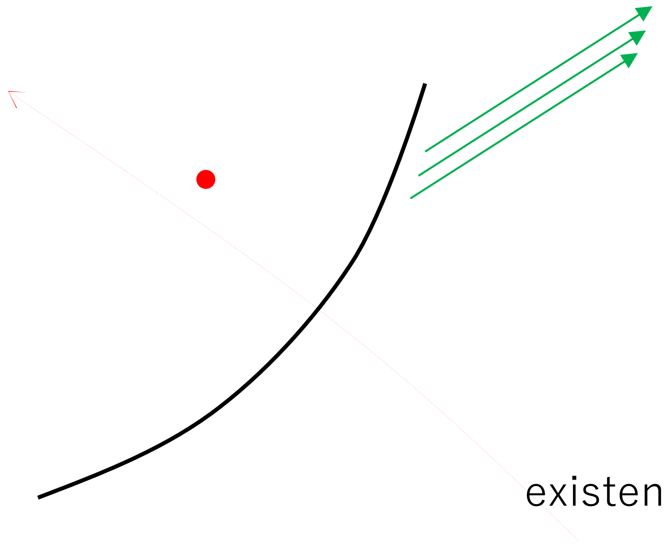
B-mode power spectrum



- **Estimation of all nonlinear effects not in the remapping approach.**
  Redshift, time delay,…
- **The correction is *O(0.01)* %**
  ~ **Inflationary B mode** with the tensor-to-scalar ratio $r = O(10^{-5})$

Yasunori Nomura

What ensures the stability of dark matter?



existence of the **interior** of an **evaporating** black hole

→ Any linearly realized global symmetry must be **explicitly** broken
with O(1) strength at the string scale (the cutoff scale of low energy field theory).

Y.N., Phys. Rev. **D101** (2020) 066024

⋯ suggests specific candidates for dark matter

- string axion
- particle whose stability is ensured by an accidental symmetry

⋯ occurs naturally for composite dark matter

Yasunori Nomura

Chiral Dark Sector

A very **simple**, perhaps the simplest, model of composite dark matter with the properties **consistent with the black hole physics**.

	$SU(N)$	$U(1)_D$
Ψ_1	$\Box$	1
Ψ_2	$\Box$	-1
$\bar{\Psi}_1$	$\bar{\Box}$	$-a$
$\bar{\Psi}_2$	$\bar{\Box}$	a

$(0 \leq a < 1)$

the **most general** Lagrangian consistent with **gauge** symmetry

→ stable dark matter with the correct abundance (dark pion, dark nucleon)

K. Harigaya and Y.N., Phys. Rev. **D94** (2016) 035013

R. T. Co, K. Harigaya and Y.N., *Phys. Rev. Lett.* **118** (2017) 101801

⋯ rich phenomenology

possibility of two-component dark matter (dark pion and nucleon), dark radiation for $a = 0$, ⋯

Plan

- detailed study of the model
  ⋯ latest constraints, prospect for future observations, ⋯
- analysis of general features of the class of similar models
  ⋯ effect of U(1) gauge symmetry on the confining phase transition in the early universe, ⋯

with Shirai et al.

Examples of MY’s Recent Research

Holography for ensemble averages of CFTs

(as suggested by “wormholes” in 2d gravity / black hole information paradox)

M. Ashwinkumar, M. Dodelson, A. Kidambi, J. Leedom, MY (JHEP ’21., and to appear)

Revisiting Θ-angles/axions in Yang-Mills

R. Kitano, R. Matsudo, N. Yamada + MY (‘21) and in progress
Implications? Cf. Y. Nomura + T. Watari + MY (‘17), M. Ibe + T.T. Yanagida + MY (‘18) [e.g. A01?]

Refining/quantifying some swampland constraints?

Ongoing discussions with J. Leedom, T. Rudelius and others

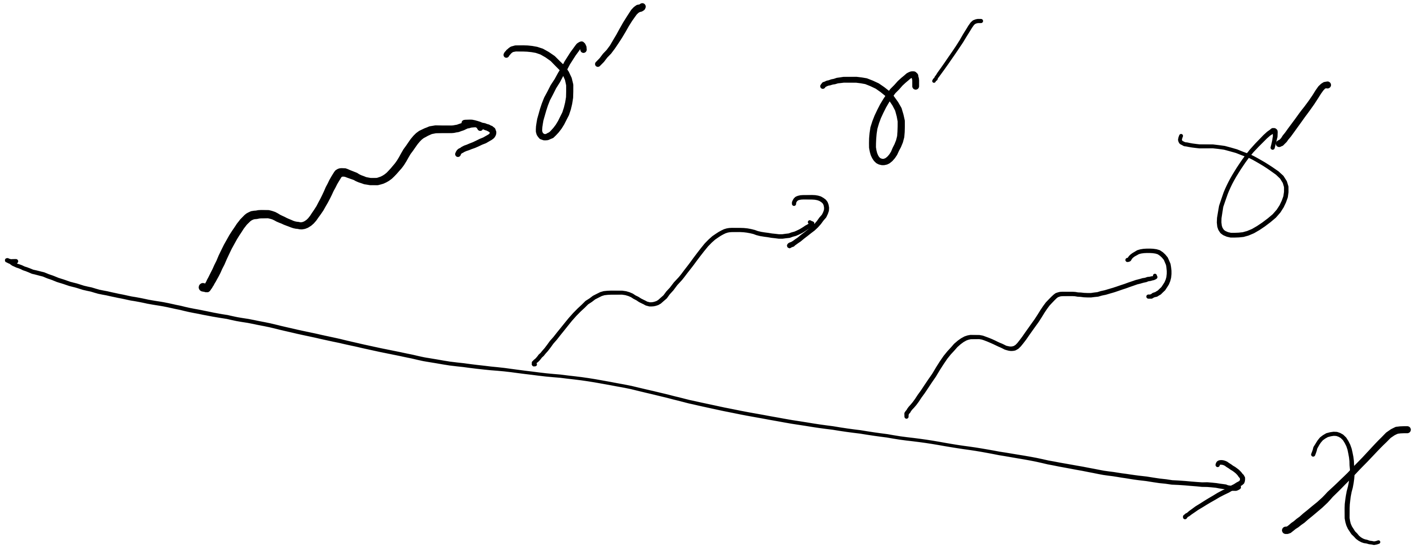
More constraints from UV completion / positivity, causality, unitarity …

Discussion with T. Noumi (part of this scheme), K. Aoki, J. Tokuda and C01 group

Dark Sector Jets

DM + dark photon U(1)_D γ'

+ dark fermion charged under U(1)_D χ



dark photon: mediator for SIDM

better for large-scale structure?

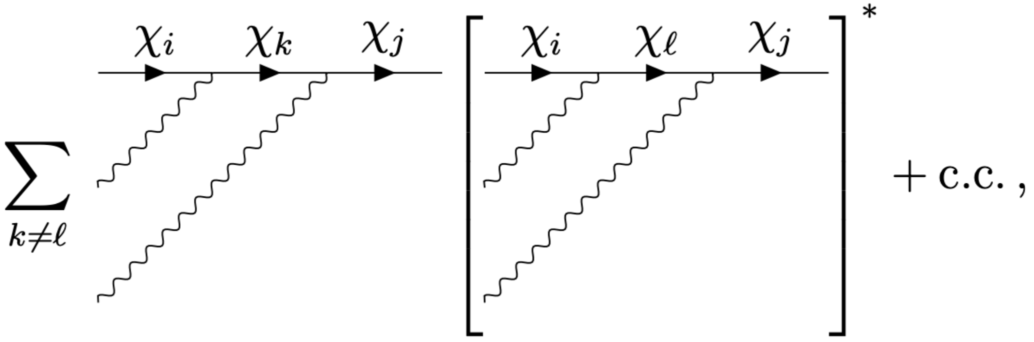
explain positron excess?
@ PAMELA/FERMI-LAT/AMS-02 ?

UHECR??

quantum dark sector shower, leading to characteristic signal
(e.g. lepton jets with 4, 6, 8, $\cdots$ μ's) [Many papers recently; cf. Tanaka-san's talk]

Classical Monte Carlo:
insufficient because of quantum interference effects

(only approximate, e.g. large Nc limit, small off-diagonal flavor coupling,⋯)



Important quantum interference effects between different flavors

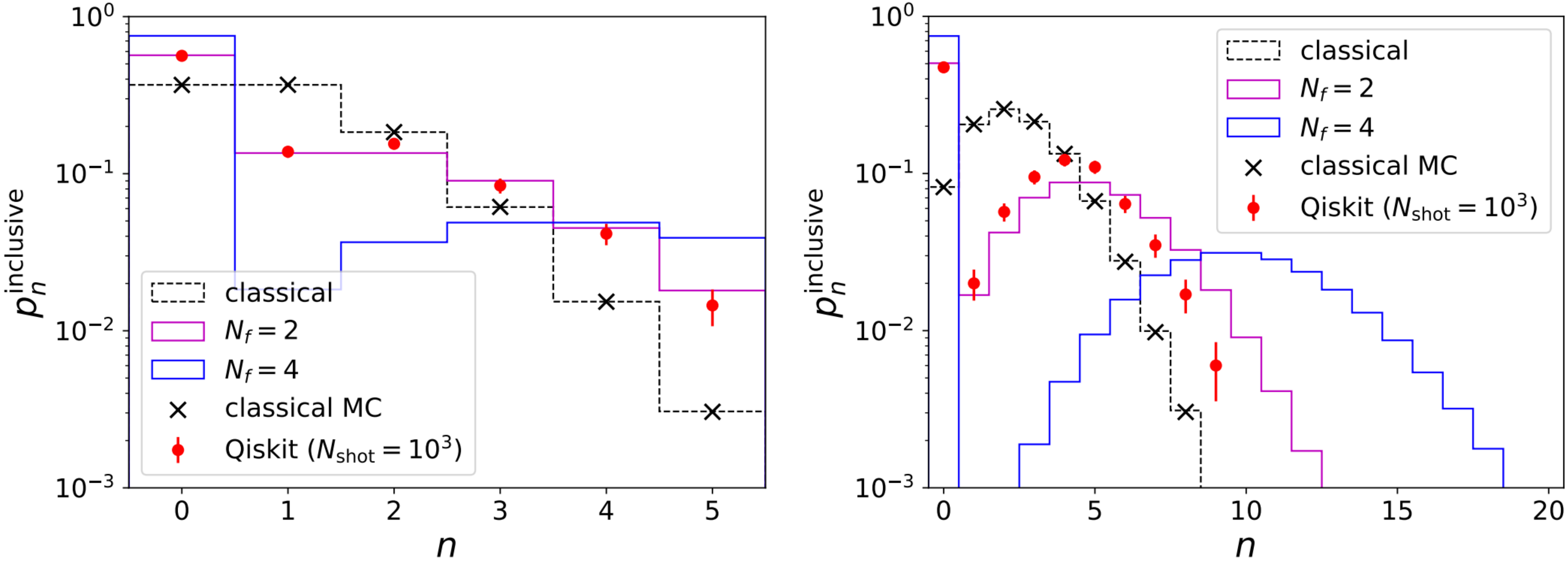
Quantum processes are better simulated by quantum computers!

cf. [Bauer, de Jong, Nachman, Provasol ('19)]
as a toy model for QCD

So Chigusa
(UC Berkeley)

MY

From [Chigusa-MY], to appear



Sometimes dramatic enhancement for n-dark-photon events for large n (e.g. 2n μ events); implications for DM collider search @ e.g. FASER?

[cf. Otono-san's talk]

Dark Matter + Quantum Computers? Quantum Sensors?

new ideas / questions / collaborations welcome!

MOONSHOT RESEARCH & DEVELOPMENT PROGRAM

2022 ~ MY as member
(課題推進者)

ibm_Kawasaki @ Utokyo
27 qubit machine