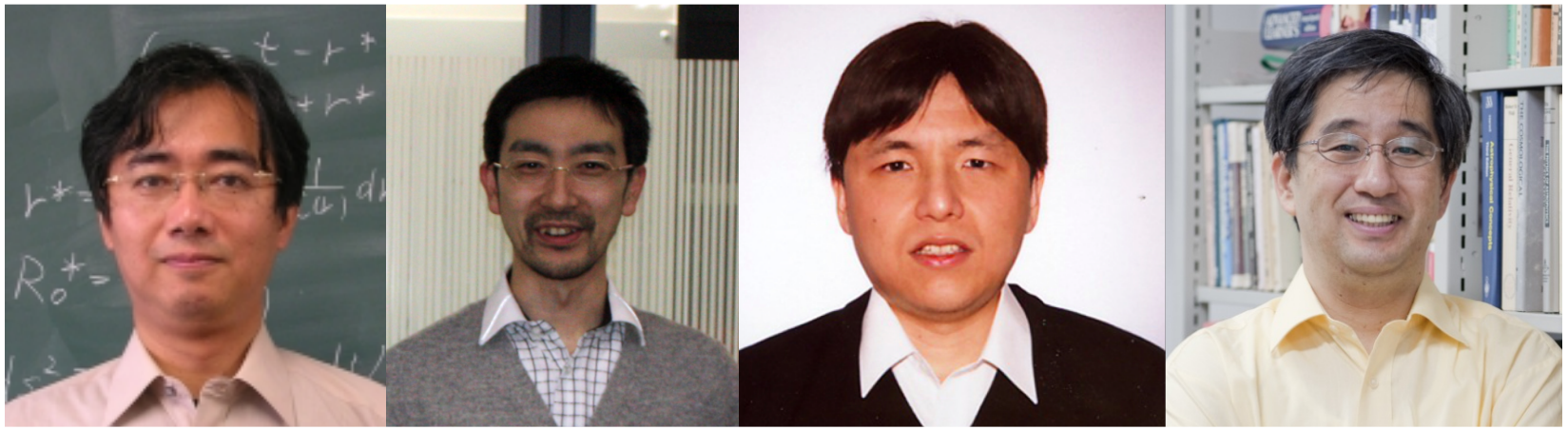
A03 update

Naoshi SUGIYAMA

Members of A03

Naoshi SGUIYAMA, Shinichi NOJIRI, Kiyotomo ICHIKI (Nagoy U)

Shinji TSUJIKAWA(Tokyo Univ. of Science)



S. Nojiri　　K. Ichiki　　S. Tsujikawa　　N. Sugiyama

Moving

Atsushi J. NISHIZAWA(Nagoya U) is included in A03

Jean-Baptiste Durrive（Nagoya U→IRAP, Toulouse, France）

A03 updates: 2018/3 – List of Publications（Coloured ones will be mentioned later)

1. **R. Ando, A. J. Nishizawa, K. Hasegawa, I. Shimizu and K. Nagamine, Redshift space distortion of 21 cm line at 1 < z < 5 with cosmological hydrodynamic simulations,** MNRAS 484 (Apr., 2019) 5389–5399, [1808.01116].
2. N. Frusciante, R. Kase, K. Koyama, S. Tsujikawa and D. Vernieri, Tracker and scaling solutions in DHOST theories, Physics Letters B 790 (Mar., 2019) 167–175.
3. S. Yoshiura, K. Ichiki, B. Pindor, K. Takahashi, H. Tashiro and C. M. Trott, Study of systematics effects on the cross power spectrum of 21 cm line and cosmic microwave background using Murchison Widefield Array data, MNRAS 483 (Feb., 2019) 2697–2711, [1803.00756].
4. Y. Matsuoka, M. Onoue, N. Kashikawa, M. A. Strauss, K. Iwasawa, C.-H. Lee et al., Discovery of the First Low-luminosity Quasar at z7, ApJ 872 (Feb., 2019) L2, [1901.10487].
5. L. Heisenberg, H. Ramírez and S. Tsujikawa, Inflation with mixed helicities and its observational imprint on CMB, Phys. Rev. D 99 (Jan., 2019) 023505, [1812.03340].
6. E. Elizalde, M. Khurshudyan and S. Nojiri, Cosmological singularities in interacting dark energy models with an ω(q) parametrization, International Journal of Modern Physics D 28 (2019) 1950019, [1809.01961].
7. N. Frusciante, R. Kase, N. J. Nunes and S. Tsujikawa, Most general cubic-order Horndeski Lagrangian allowing for scaling solutions and the application to dark energy, Phys. Rev. D 98 (Dec., 2018) 123517, [1810.07957].

A03 updates: 2018/3 – List of Publications（Coloured ones will be mentioned later)

8. L. Heisenberg, R. Kase and S. Tsujikawa, Gauge-ready formulation of cosmological perturbations in scalar-vector-tensor theories, Phys. Rev. D 98 (Dec., 2018) 123504, [1807.07202].
9. T. Minoda, K. Hasegawa, H. Tashiro, K. Ichiki and N. Sugiyama, Thermal Sunyaev-Zel'dovich Effect in the IGM due to Primordial Magnetic Fields, Galaxies 6 (Dec., 2018) 143, [1812.09813].
10. Y. Matsuoka, M. A. Strauss, N. Kashikawa, M. Onoue, K. Iwasawa, J.-J. Tang et al., Subaru High-z Exploration of Low-luminosity Quasars (SHELLQs). V. Quasar Luminosity Function and Contribution to Cosmic Reionization at z = 6, ApJ 869 (Dec., 2018) 150, [1811.01963].
11. **[11] J. Ooba, B. Ratra and N. Sugiyama, Planck 2015 Constraints on the Non-flat XCDM Inflation Model**, ApJ 869 (Dec., 2018) 34, [1710.03271].
12. R. Kase and S. Tsujikawa, Dark energy in scalar-vector-tensor theories, J. Cosmology Astropart. Phys. 11 (Nov., 2018) 024, [1805.11919].
13. T. Tanaka, K. Hasegawa, H. Yajima, M. I. N. Kobayashi and N. Sugiyama, Stellar mass dependence of the 21-cm signal around the first star and its impact on the global signal, MNRAS 480 (Oct., 2018) 1925–1937, [1805.07947].
14. **J. Ooba, B. Ratra and N. Sugiyama, Planck 2015 Constraints on the Nonflat ϕCDM Inflation Model**, ApJ 866 (Oct., 2018) 68, [1712.08617].
15. I. S. Albuquerque, N. Frusciante, N. J. Nunes and S. Tsujikawa, New scaling solutions in cubic Horndeski theories, PRD 98 (Sept., 2018) 064038, [1807.09800].

A03 updates: 2018/3 – List of Publications（Coloured ones will be mentioned later)

16. M. R. Gangopadhyay, G. J. Mathews, K. Ichiki and T. Kajino, Explaining low ℓ anomalies in the CMB power spectrum with resonant superstring excitations during inflation, European Physical Journal C 78 (Sept., 2018) 733, [1701.00577].
17. **J. Ooba, B. Ratra and N. Sugiyama, Planck 2015 Constraints on the Non-flat CDM Inflation Model**, ApJ 864 (Sept., 2018) 80, [1707.03452].
18. **T. Endo, A. J. Nishizawa and K. Ichiki, Effect of dark energy perturbation on cosmic voids formation**, MNRAS 478 (Aug., 2018) 5230–5239, [1805.03837].
19. K. Kogai, T. Matsubara, A. J. Nishizawa and Y. Urakawa, Intrinsic galaxy alignment from angular dependent primordial non-Gaussianity, J. Cosmology Astropart. Phys. 8 (Aug., 2018) 014, [1804.06284].
20. L. Heisenberg, R. Kase and S. Tsujikawa, Cosmology in scalar-vector-tensor theories, Phys. Rev. D 98 (July, 2018) 024038, [1805.01066].
21. S. Nojiri, S. D. Odintsov and V. Faraoni, Effects of modified gravity on the turnaround radius in cosmology, Phys. Rev. D 98 (July, 2018) 024005, [1806.01966].
22. K. Bamba, S. Nojiri and S. D. Odintsov, Propagation of gravitational waves in strong magnetic fields, Phys. Rev. D 98 (July, 2018) 024002, [1804.02275].
23. R. Kase, M. Minamitsuji and S. Tsujikawa, Black holes in quartic-order beyond-generalized Proca theories, Physics Letters B 782 (July, 2018) 541–550, [1803.06335].

A03 updates: 2018/3 – List of Publications（Coloured ones will be mentioned later)

24. Y. Matsuoka, K. Iwasawa, M. Onoue, N. Kashikawa, M. A. Strauss, C.-H. Lee et al., Subaru High-z Exploration of Low-luminosity Quasars (SHELLQs). IV. Discovery of 41 Quasars and Luminous Galaxies at 5.7z6.9, ApJS 237 (July, 2018) 5, [1803.01861].
25. L. Heisenberg, R. Kase and S. Tsujikawa, Odd-parity stability of hairy black holes in U (1) gauge-invariant scalar-vector-tensor theories, Phys. Rev. D 97 (June, 2018) 124043, [1804.00535].
26. M. Shirasaki, O. Macias, S. Horiuchi, N. Yoshida, C.-H. Lee and A. J. Nishizawa, Correlation of extragalactic γ rays with cosmic matter density distributions from weak gravitational lensing, Phys. Rev. D 97 (June, 2018) 123015, [1802.10257].
27. S. Capozziello, S. Nojiri and S. D. Odintsov, The role of energy conditions in f(R) cosmology, Physics Letters B 781 (June, 2018) 99–106, [1803.08815].
28. R. Kase and S. Tsujikawa, Dark energy scenario consistent with GW170817 in theories beyond Horndeski gravity, Phys. Rev. D 97 (May, 2018) 103501, [1802.02728].
29. L. Heisenberg and S. Tsujikawa, Hairy black hole solutions in U(1) gauge-invariant scalar-vector-tensor theories, Physics Letters B 780 (May, 2018) 638–646, [1802.07035].
30. R. Kase, M. Minamitsuji and S. Tsujikawa, Relativistic stars in vector-tensor theories, Phys. Rev. D 97 (Apr., 2018) 084009, [1711.08713].

A03 updates: 2018/3 – List of Publications（Coloured ones will be mentioned later)

31. S. Nojiri and S. D. Odintsov, Cosmological bound from the neutron star merger GW170817 in scalar-tensor and F(R) gravity theories, Physics Letters B 779 (Apr., 2018) 425–429, [1711.00492].
32. E. Medezinski, M. Oguri, A. J. Nishizawa, J. S. Speagle, H. Miyatake, K. Umetsu et al., Source selection for cluster weak lensing measurements in the Hyper Suprime-Cam survey, PASJ 70 (Mar., 2018) 30, [1706.00427].
33. M. Tokutake, K. Ichiki and C.-M. Yoo, Observational constraint on spherical inhomogeneity with CMB and local Hubble parameter, J. Cosmology Astropart. Phys. 3 (Mar., 2018) 033, [1712.04229].

International Meeting（1）
Midified Gravity 2018

Organized by Nojiri and Ichiki, Kobyashi Maskawa Ins, Nagoya

August 8-10, 60 participants (10 from overseas)

KMI International Conference

International Conference on Modified Gravity 2018
MOGRA 2018

8 – 10 August 2018

Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University

Nagoya, Japan

Web page: http://www.kmi.nagoya-u.ac.jp/workshop/mogra2018/

Invited Speakers

Salvatore Capozziello [Universita di Napoli]
Tsutomu Kobayashi [Rikkyo University]
Atsushi Nishizawa [KMI/Nagoya]
Sergei D. Odintsov [ICE|CSIC)/ICREA]
Massimo Porrati [New York University/YITP]
Taotao Qiu [Central China Normal University]
Andrew J. Tolley [Imperial College London]

Organizing Committee

Timetable

programme(pdf)

August 8th (Wed.)

09:30 - 10:40 Registration

<Morning Session 1> Chair: Shin'ichi Nojiri

10:40 - 10:50 Opening Remarks

10:50 - 11:30 Progress in Massive Gravity
Andrew J. Tolley (Imperial College London)

11:30 - 11:50 Extended mimetic gravity: Hamiltonian analysis and gradient instabiliti
Kazufumi Takahashi (Rikkyo University)

11:50 - 12:10 Inflation from modified gravity in higher dimensions
Hiroshi Nakada (Tokyo Metropolitan University)

11:10 - 12:30 Scalar-tensor theories in metric-affine formalism
Katsuki Aoki (Waseda University)

12:30 - 14:00 Lunch

<Afternoon Session 1> Chair: Hiroaki Kanno

14:00 - 14:40 Two applications of the infrared factorization of IR dynamics
Massimo Porrati (New York University, YITP)

14:40 - 15:00 S-matrix Unitarity and Renormalizability in Higher Derivative Theories
Tomotaka Kitamura (Waseda University)

15:00 - 15:20 Generalization of massive spin-two theory in arbitrary curved spacetime
Satoshi Akagi (Nagoya University)

15:20 - 15:40 Renormalization and running some gravitational coupling constants
Taisaku Mori (Nagoya University)

15:40 - 16:00 Coffee Break

<Afternoon Session 2> Chair: Kiyotomo Ichiki, Yuichiro Tada

16:00 - 16:40 Test of gravity with gravitational wave observations
Atsushi Nishizawa (KMI, Nagoya)

16:40 - 17:00 Six Polarizations of GW and detector network with KAGRA
Hideki Asada (Hirosaki University)

17:00 - 17:20 Superradiance of the Alfven wave in force-free region
Takuma Tsukamoto (Nagoya University)

17:20 - 17:40 Validity of chameleon mechanism in inhomogeneous density profile
Tomohiro Nakamura (Nagoya University)

August 9th (Thu.)

<Morning Session 1> Chair: Tetsuya Shiromizu

09:30 - 09:50 On Uniqueness of Static Asymptotic AdS Space-time
Xiaoning Wu (Institute of Mathematics, AMSS)

09:50 - 10:10 On Some Estimates of Hawking Mass for CMC Surfaces
Naqing Xie (Fudan University)

10:10 - 10:30 Quasi-local energy and universal horizon thermodynamics
Fei-hung Ho (Jimei University)

10:30 - 10:50 Coffee Break

<Morning Session 2> Chair: Andrew J. Tolley

10:50 - 11:30 Scalar-tensor theories after GW170817 and relativistic stars in DHOST
Tsutomu Kobayashi (Rikkyo University)

11:30 - 11:50 Phantom crossing dark energy in Horndeski's theory
Jiro Matsumoto (National Taiwan University)

11:50 - 12:10 Cosmological implication of DHOST theory
Shin'ichi Hirano (Rikkyo University)

12:10 - 12:30 Extended Cuscuton : Formulation and Cosmology
Aya Iyonaga (Rikkyo University)

<Afternoon Session 1> Chair: Atsushi Nishizawa

14:00 - 14:40 Gravitational waves in modified teleparallel theories of gravity
Salvatore Capozziello (Universita di Napoli)

14:40 - 15:00 Relativistic Stars in dRGT massive gravity
Masashi Yamazaki (Nagoya University)

15:00 - 15:20 A slowly rotating object in the post-Newtonian approximation of the dynamical Charn-Simons m
Yuya Nakamura (Hirosaki University)

15:20 - 15:40 Anti-Screening of the Galileon force around a disk center hole
Hiromu Ogawa (Rikkyo University)

15:40 - 16:00 Coffee Break

<Afternoon Session 2> Chair: Chulmoon Yoo

16:00 - 16:40 Modified gravity cosmology: the works by Prof S. Nojiri
Sergei D. Odintsov (ICREA, ICE)

16:40 - 17:00 Chameleonic Dark Matter and F(R) Gravity
Taishi Katsuragawa (Central China Normal University)

17:00 - 17:20 Scalaron DM in logarithmic F(R) gravity
Yamato Matsuo (Hiroshima University)

17:20 - 17:40 Gravitational Wave in Modified Gravity
Shin'ichi Nojiri (KMI, Nagoya University)

18:00 - 20:00 Banquet

August 10th (Fri.)

<Morning Session 1> Chair: Tsutomu Kobayashi

09:30 - 10:10 Towards a Complete Scenario of the Early Universe
Taotao Qiu (Central China Normal University)

10:10 - 10:30 Probing the Starobinsky R^2 inflation model with CMB precision cosmology
Yuki Watanabe (NIT, Gunma College)

10:30 - 10:50: Coffee Break

<Morning Session 2> Chair: Yasusada Nambu

10:50 - 11:10 Stochastic inflation in a general field space
Yuichiro Tada (Nagoya University)

11:10 - 11:30 Generic analysis of kinetically driven inflation
Rio Saitou (LeCosPA, National Taiwan University)

11:30 - 11:50 Inflationary universe in unimodular F(T) gravity
Kazuharu Bamba (Fukushima University)

11:50 - 12:00 Closing Remarks

International Meeting (2)

5th Korea-Japan Workshop on Dark Energy

Organized by Tsujikawa, series one we hosted in Nagoya as A03 activity in last year

70 participants, 15 from Japan

5th Korea-Japan Workshop on Dark Energy: Starobinsky's Universe

Celebrating Alexei A. Starobinsky's 70th birthday

Time and Venue

- August 6(Mon) - 10(Fri) 2018
- Korea Astronomy and Space Science Institute, Daejeon, South Korea
- Lee Won Chul Hall 1st floor Seminar Room (#102)

Overview

- This will be the fifth Korea-Japan joint workshop on Dark Energy, celebrating Prof. Alexei Starobinsky' 70th birthday. Dark Energy is one of the biggest puzzles of modern cosmology and theoretical physics. We will discuss the most recent advancements in the field, focusing on both theoretical and observational aspects. We will not restrict the topics of the workshop to dark energy only, but we also welcome talks on quantum gravity, modified gravity, inflation, gravitational waves, cosmic microwave background, large-scale structures, and dark matter.

Poster

Invited Speakers

Stephen Appleby (KIAS)
Inyong Cho (Seoul Tech)
Fabio Finelli (INAF)
Ho Seong Hwang (KIAS)
Kenji Kadota (IBS)
Seoktae Koh (Jeju)
Eric Linder (LBNL)
Shinji Mukohyama (YITP)
Dmitry Pogosyan (CITA)
Varun Sahni (IUCAA)
Alexei Starobinsky (Landau)
Shinji Tsujikawa (TUS)
Yuting Wang (NAOC)
Ying-li Zhang (TUS)

Gianluca Calcagni (IEM-CSIC)
Ki-Young Choi (SKKU)
Jan Hamann (UNSW)
Jaichan Hwang (Kyunpook)
Alexander Kamenshchik (Bologna)
Sachiko Kuroyanagi (Nagoya)
Kei-ichi Maeda (Waseda)
Teppei Okumura (ASIAA)
David Polarski (Montpellier)
Misao Sasaki (IPMU)
Takahiro Tanaka (Kyoto)
Keiichi Umetsu (ASIAA)
Yvonne Wong (UNSW)
Yi Zheng (KIAS)

Takeshi Chiba (Nihon)
Antonio De Felice (YITP)
Lavinia Heisenberg (ETH)
M. James Jee (Yonsei)
Ryan Edward Keeley (KASI)
Seokcheon Lee (Gyeongsang)
Hayato Motohashi (YITP)
Changbom Park (KIAS)
Cris Sabiu (Yonsei)
Jiro Soda (Kobe)
Atsushi Taruya (YITP)
Maurice Van Putten (Sejong)
Jun'ichi Yokoyama (Tokyo)

Selections of Individual Research

Works done by Students!

Effect of dark energy perturbation on cosmic voids formation

“Effect of dark energy perturbation on cosmic voids formation”,
T. Endo, A.J. Nishizawa and K. Ichiki, MNRAS 478, 4, p5230, 2018

Prove Dark Energy by observables of VOIDs such as Sizes and Numbers

- Effect of Dark Energy on Large Structure
  - Evolution of Density Perturbations
- Previous work
  - Influence of DE on clustering of clusters of galaxies （Besse et al., 2010）
- In this work, focus on Voids
  - Large Structure:
    - Can be a probe of expansion history of the universe
    - Free from messy small scale physics, such as non-linear evolution and hadron physics
  - Automatically observed by galaxy surveys

Using Spherical collapse model, we study the effect of fluid dark energy (w and c_s^2) on Voids formation

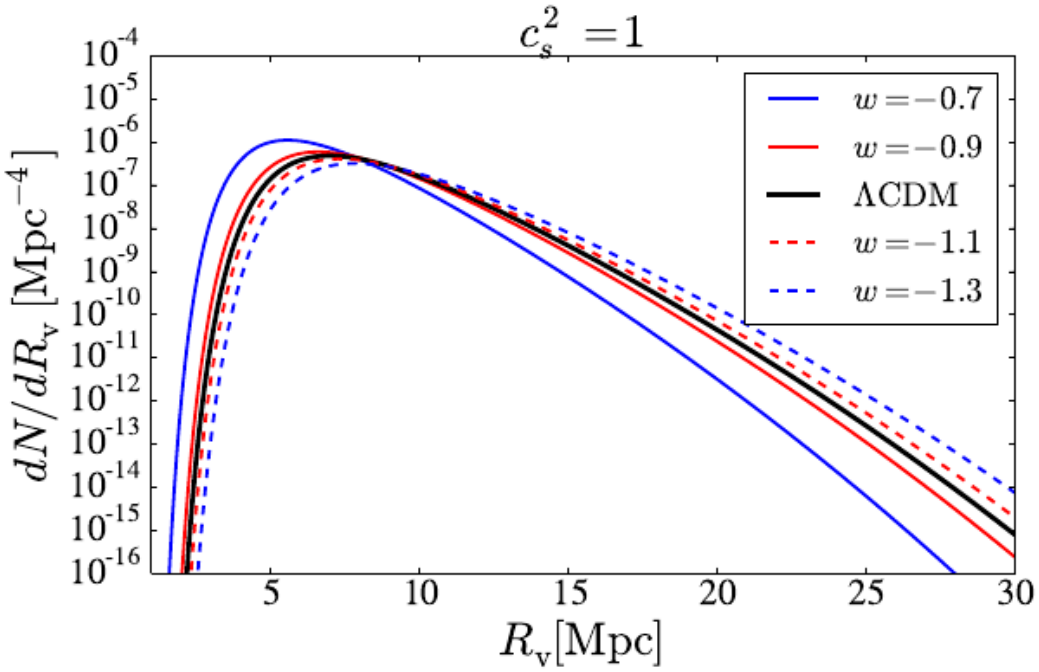
Results: size-abundance

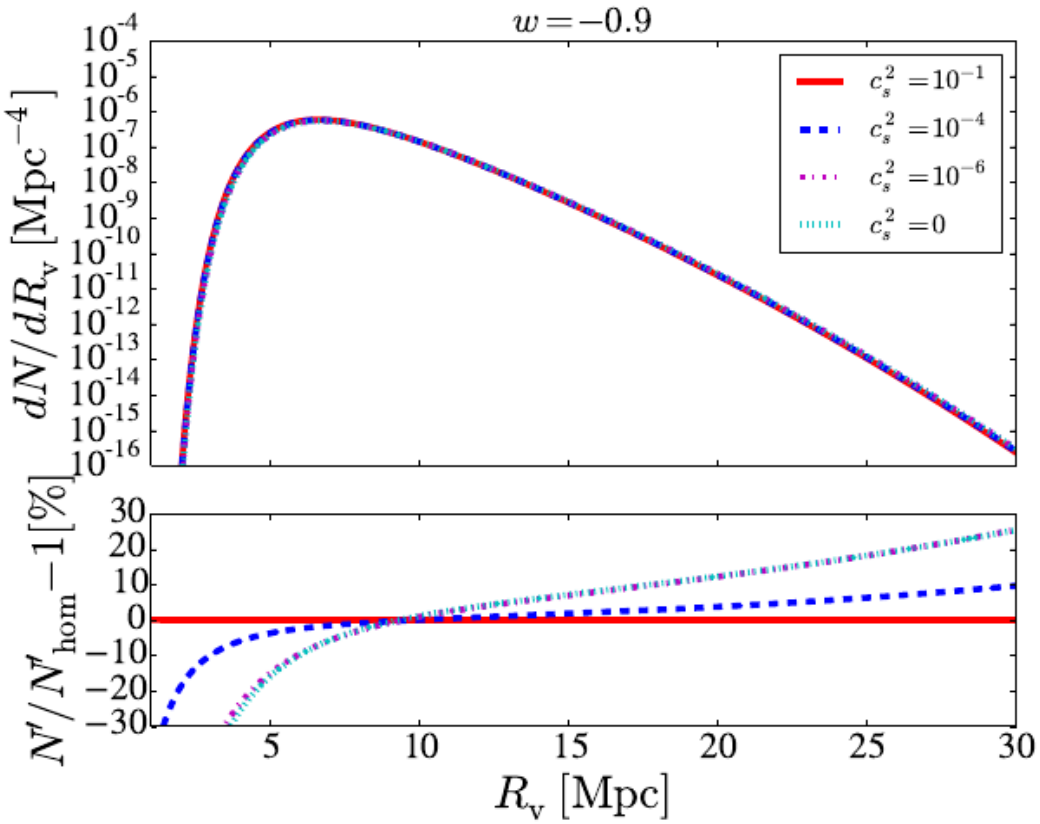
w dependence

- w<-1: size is smaller
- w>-1: size is larger
- Modify the abundance order of magnitude

c_s^2 dependence

- Modify the abundance in case of w>-1
- 10 to 20% effect





Ia型超新星を用いた宇宙論パラメータ推定への重力レンズ効果による影響

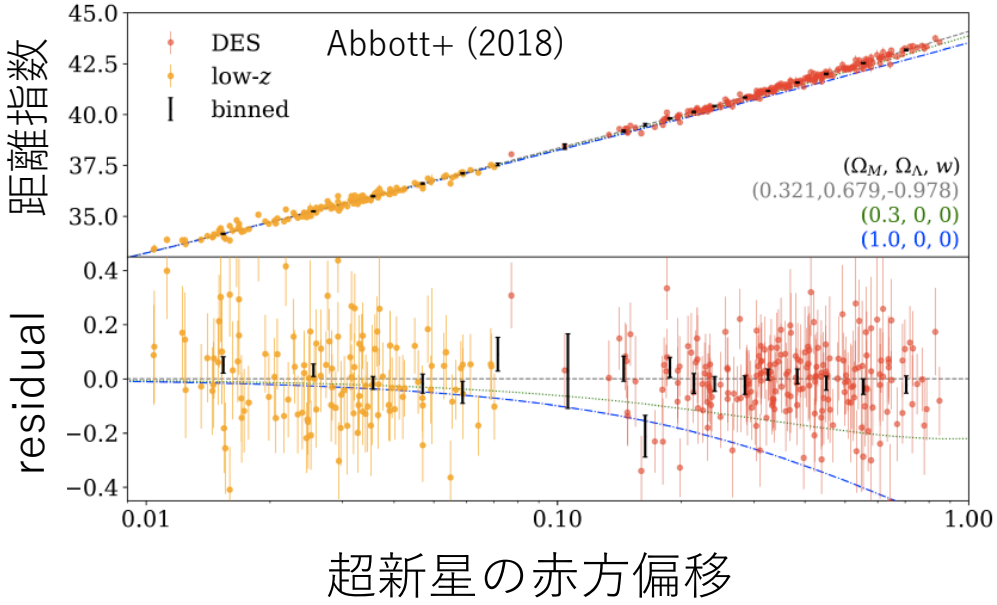
“Effect of lensing magnification on type Ia supernova cosmology”, H. Sakakibara, A.J. Nishizawa, M. Oguri, M. Tanaka, B-C. Hsieh, K. C. Wong, arxiv:1901.10129

Ia型超新星の距離指数の分散

宇宙論パラメータ推定に用いられる
距離指数(明るさの指標)の観測値

…理論曲線周りにばらついて分布

分散の要因の一つ：
重力レンズ効果による
フラックスの増減光

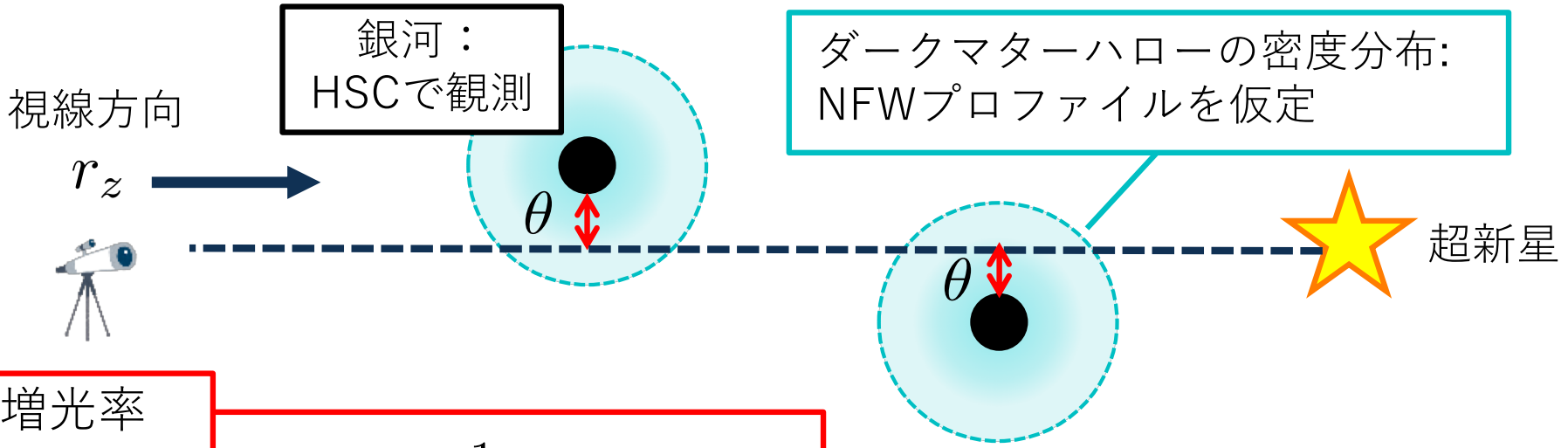


先行研究では、宇宙論パラメータを推定する際に
個々の超新星に対して増光率を補正していない

- 推定値へのバイアスや誤差の過大評価の可能性あり

パラメータ推定への重力レンズ効果の影響を調査

銀河の質量分布からの増光率の推定



増光率

$$\mu_{\rm lens} = \frac{1}{(1-\kappa)^2 - |\gamma|^2}$$

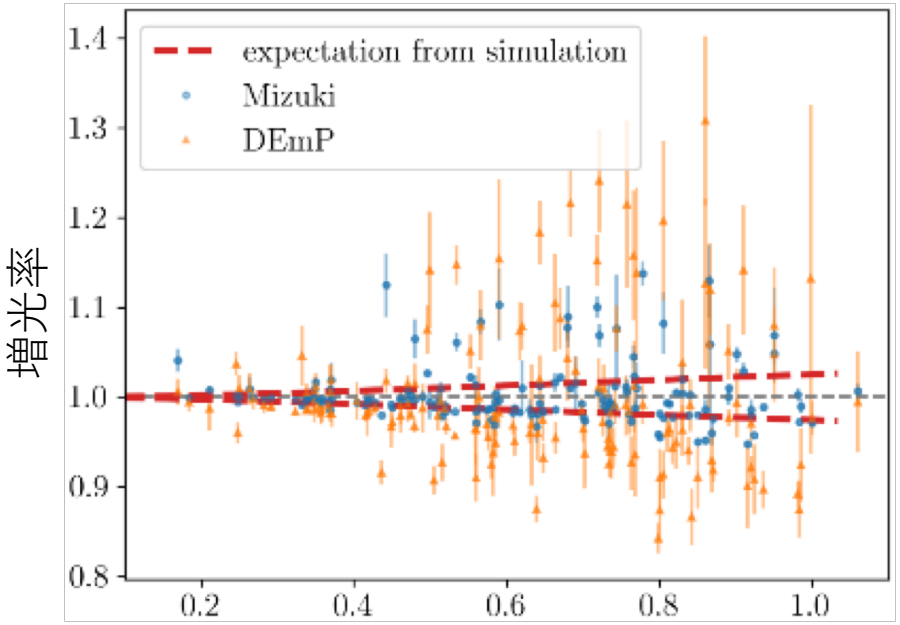
$$\kappa(\theta) = \Sigma_{\rm cr}^{-1} \int \rho\left(\sqrt{r_z^2 + (D_l\theta)^2}\right) dr_z$$

$$\gamma(\theta) = \frac{1}{\pi} \int \mathcal{D}(\theta - \theta')\kappa(\theta') d^2\theta'$$

Kaiser & Squires (1993)

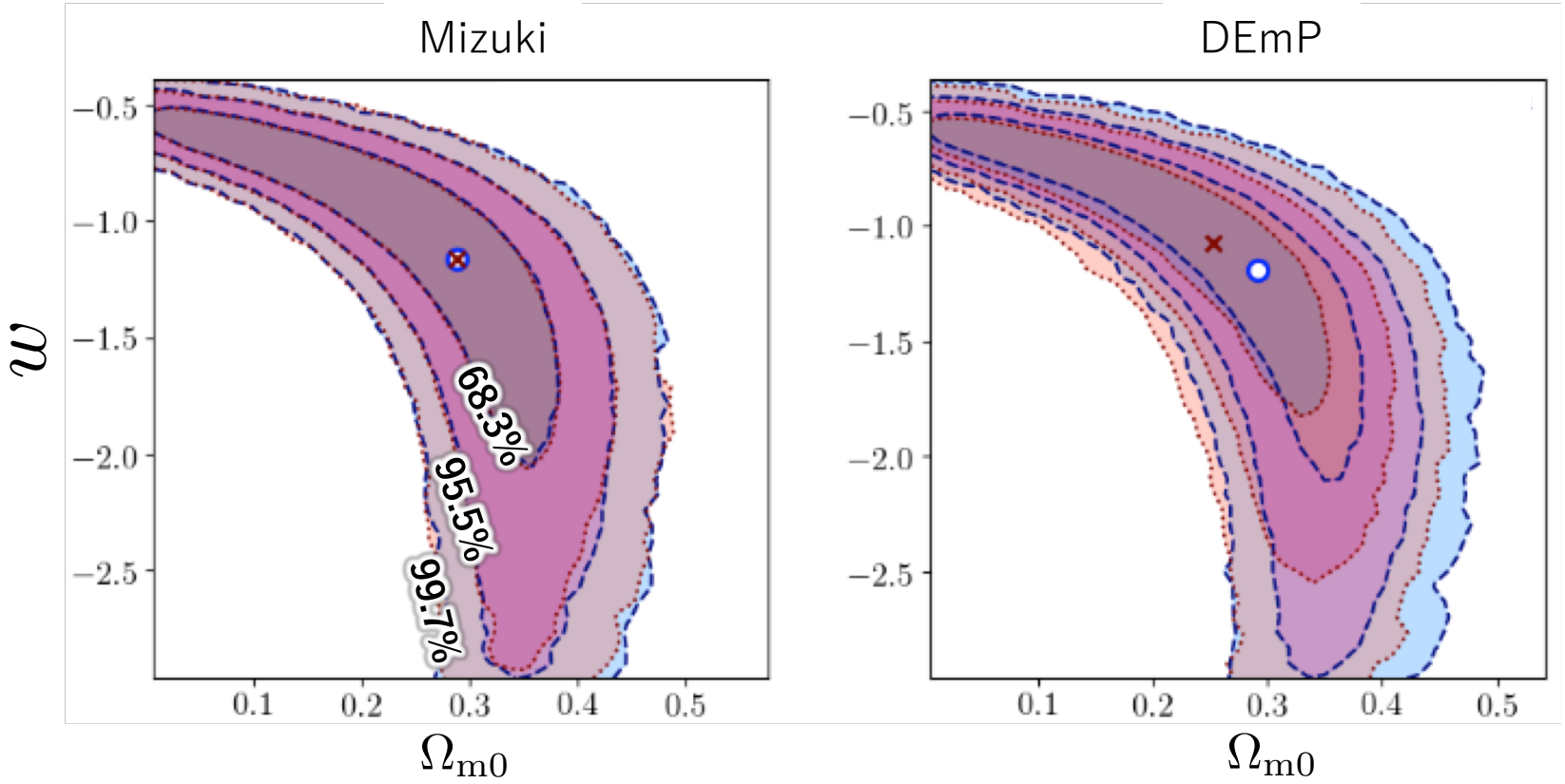
使用したHSC測光的赤方偏移カタログ

- Mizuki：テンプレートフィッティング
  Tanaka (2015)
- DEmP：機械学習
  Hsieh & Yee (2014)



超新星の赤方偏移

増光率を補正したパラメータ推定



補正なし

補正あり

使用した赤方偏移カタログにかかわらず、
どちらのパラメータも68%の信頼度で補正前の値と一致

パラメータ推定への重力レンズ効果の影響は十分小さい

宇宙論の観測を用いた暗黒エネルギーモデルと重力理論への制限

“Cosmological constraints on scalar-tensor gravity and the variation of the gravitational constant”
J. Ooba, K. Ichiki, T. Chiba and N. Sugiyama, PTEP, 2017

“Planck 2015 Constraints on the Non-flat ΛCDM Inflation Model”
J. Ooba, B. Ratra and N. Sugiyama, ApJ869, 2018

“Planck 2015 Constraints on the Nonflat φCDM Inflation Model”
J. Ooba, B. Ratra and N. Sugiyama, ApJ866, 2018

“Planck 2015 Constraints on the Non-flat XCDM Inflation Model”
J. Ooba, B. Ratra and N. Sugiyama, ApJ864, 2018

宇宙の曲率

- 計量

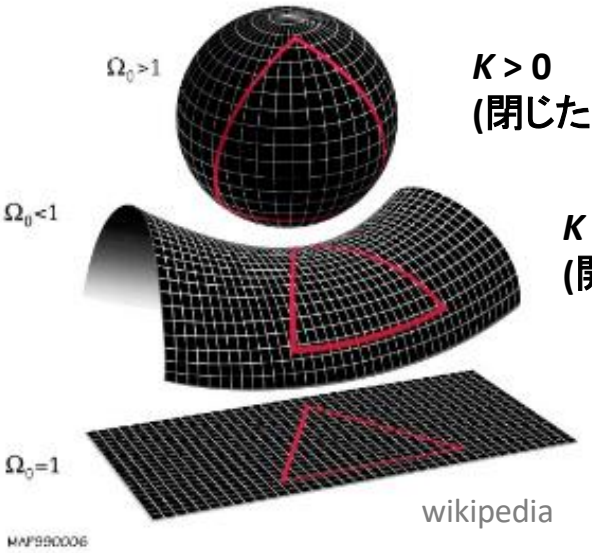
$$ds^2 = -dt^2 + a^2(t)\left[\frac{dr^2}{1-Kr^2} + r^2(d\theta^2 + \sin^2\theta d\phi^2)\right]$$

- フリードマン方程式と密度パラメータ

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{K}{a^2}$$

$$1 = \Omega_0 + \Omega_{K0}$$

- ここで、 $\Omega_{K0} = -\frac{K}{H_0^2}$



K **> 0**
(閉じた宇宙)

K **< 0**
(開いた宇宙)

K **= 0**
(平坦な宇宙)

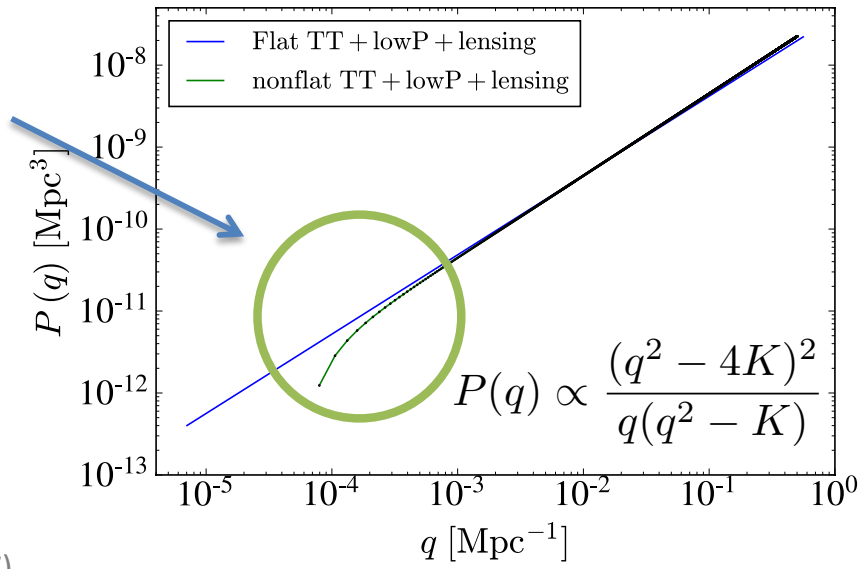
wikipedia

初期ゆらぎのパワースペクトル

- **大スケールにおいて特徴的な波数依存性を持つ(小スケールでは$n_s = 1$)**
  - **Best-fit (closed)ΛCDMモデルでは、flatモデルに比べて大スケールでパワーが減衰**

- **開いた宇宙 : *q*は0から∞まで**
- **閉じた宇宙 : *q*/sqrt(*K*) は 3, 4, 5, …**
  - **離散的な値をとる**

Ratra & Peebles (1995)



Ratra (2017)

$$q^2 = k^2 + K$$

パラメータ推定結果

※マルコフ連鎖モンテカルロ(MCMC)法

Planckのみ

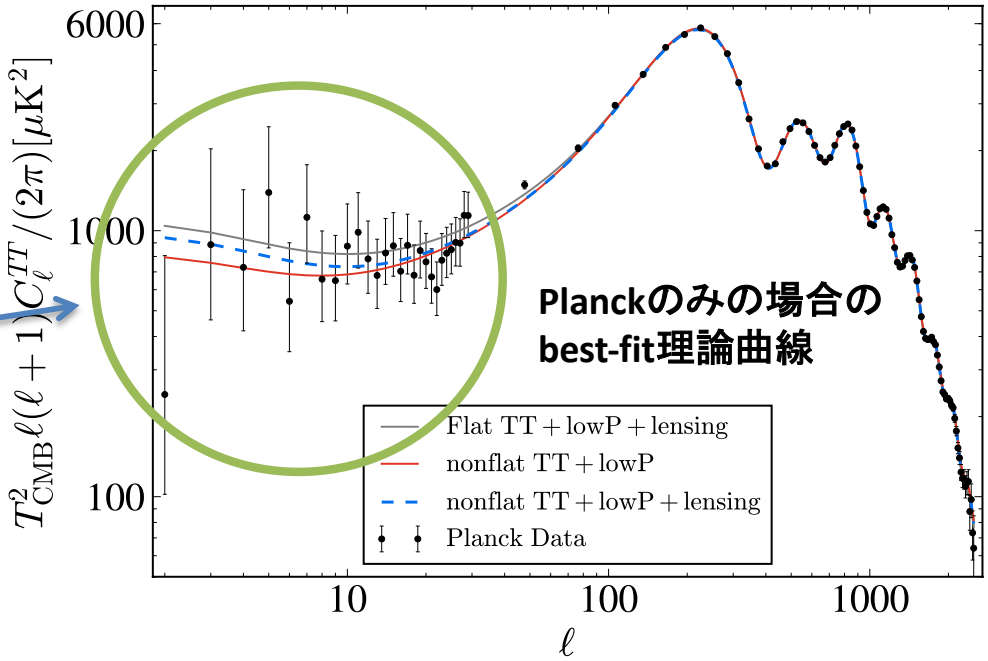
- Non-flat ΛCDMモデルのbest-fitは、より小さな温度ゆらぎを予言
  - Best-fitは閉じた宇宙
  - XCDM, ΦCDMでも同様

$$p_X = w_0 \rho_X$$

Turner & White (1997)

$$V(\phi) \propto \phi^{-\alpha}$$

Ratra & Peebles (1988)

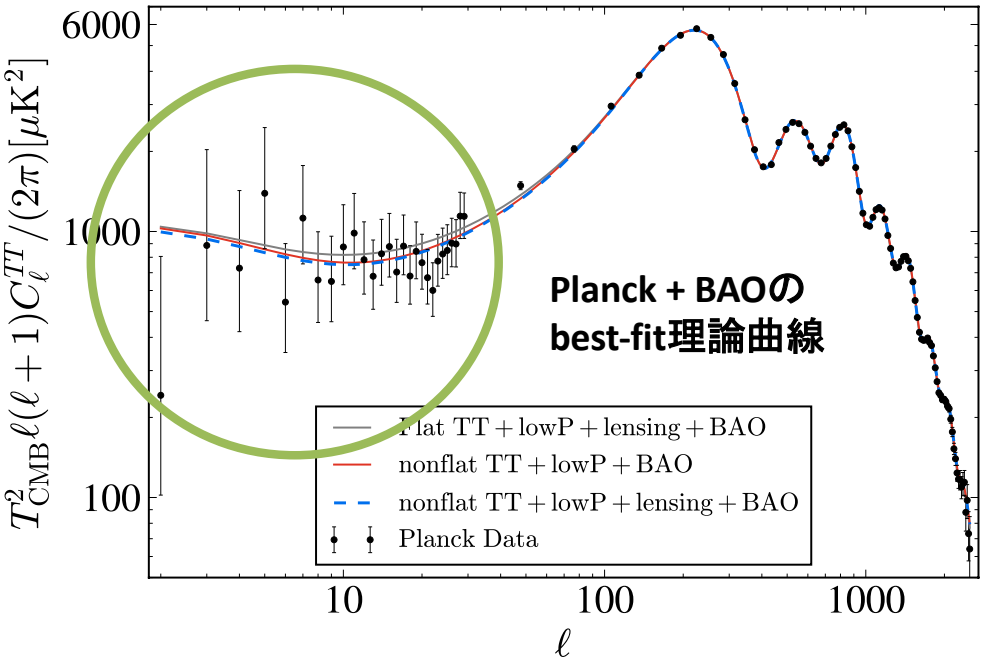


Planck + BAO

- BAOデータを加えるとパラメータの範囲が強く制限されるため、減衰の効果は小さくなる
- しかし、データは閉じた宇宙を好む
- 曲率パラメータへの制限(ΛCDM)

$$\Omega_{K0} = -0.008 \pm 0.004$$

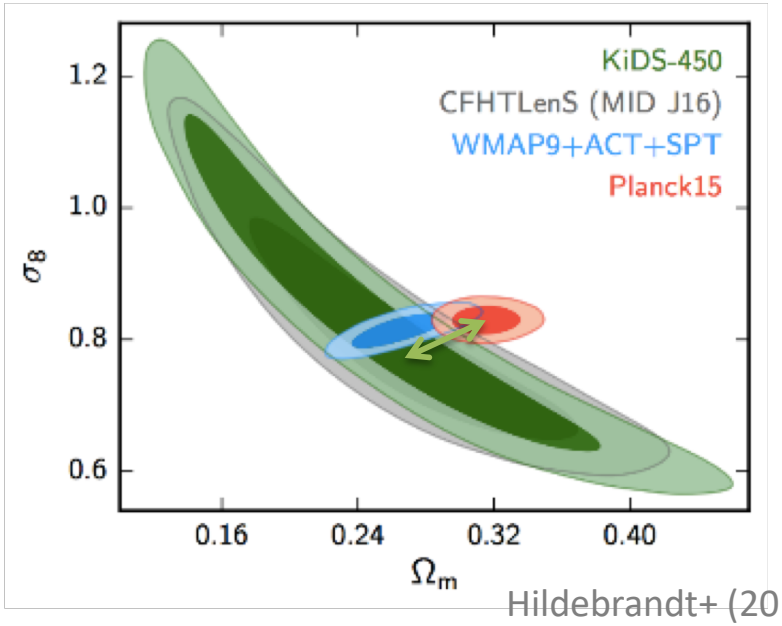
$$(95.45\%,\ \mathrm{TT} + \mathrm{lowP} + \mathrm{lensing} + \mathrm{BAO})$$



$\Omega_m - \sigma_8$

σ_8: 現在での密度ゆらぎの振幅を表す指標

- **Flat-ΛCDMモデルを仮定したPlanck CMB観測による推定値は、近傍宇宙の観測値に比べ、大きい Ω_m, σ_8 の値を予言 (下図)**

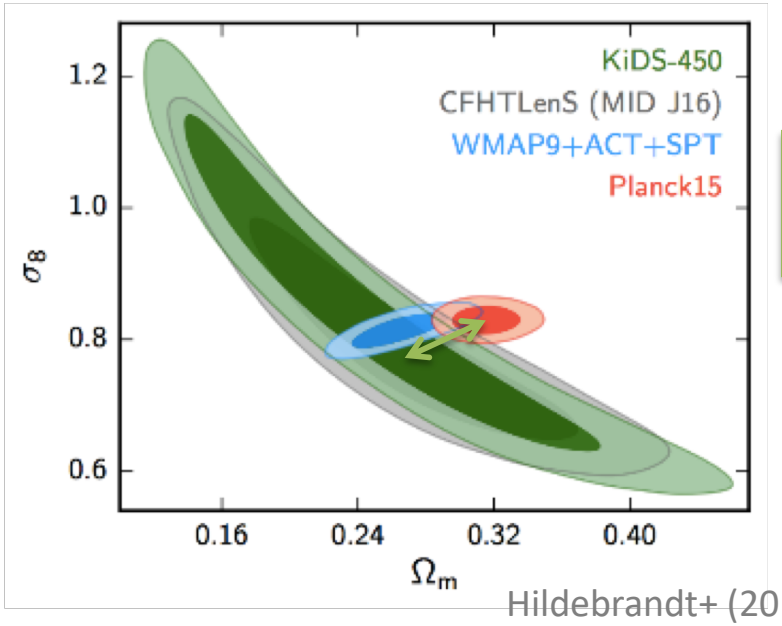


Hildebrandt+ (2016)

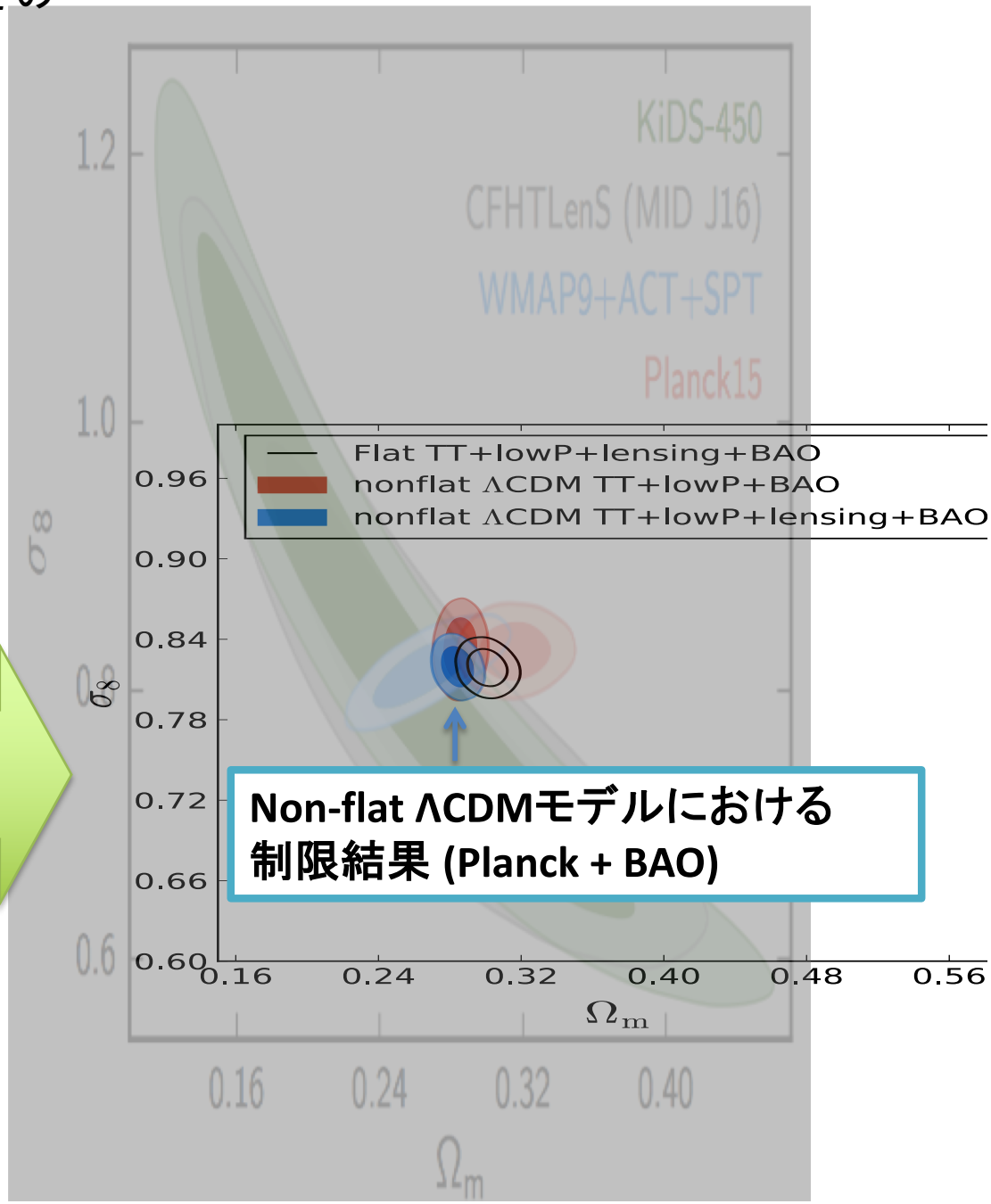
$\Omega_m - \sigma_8$

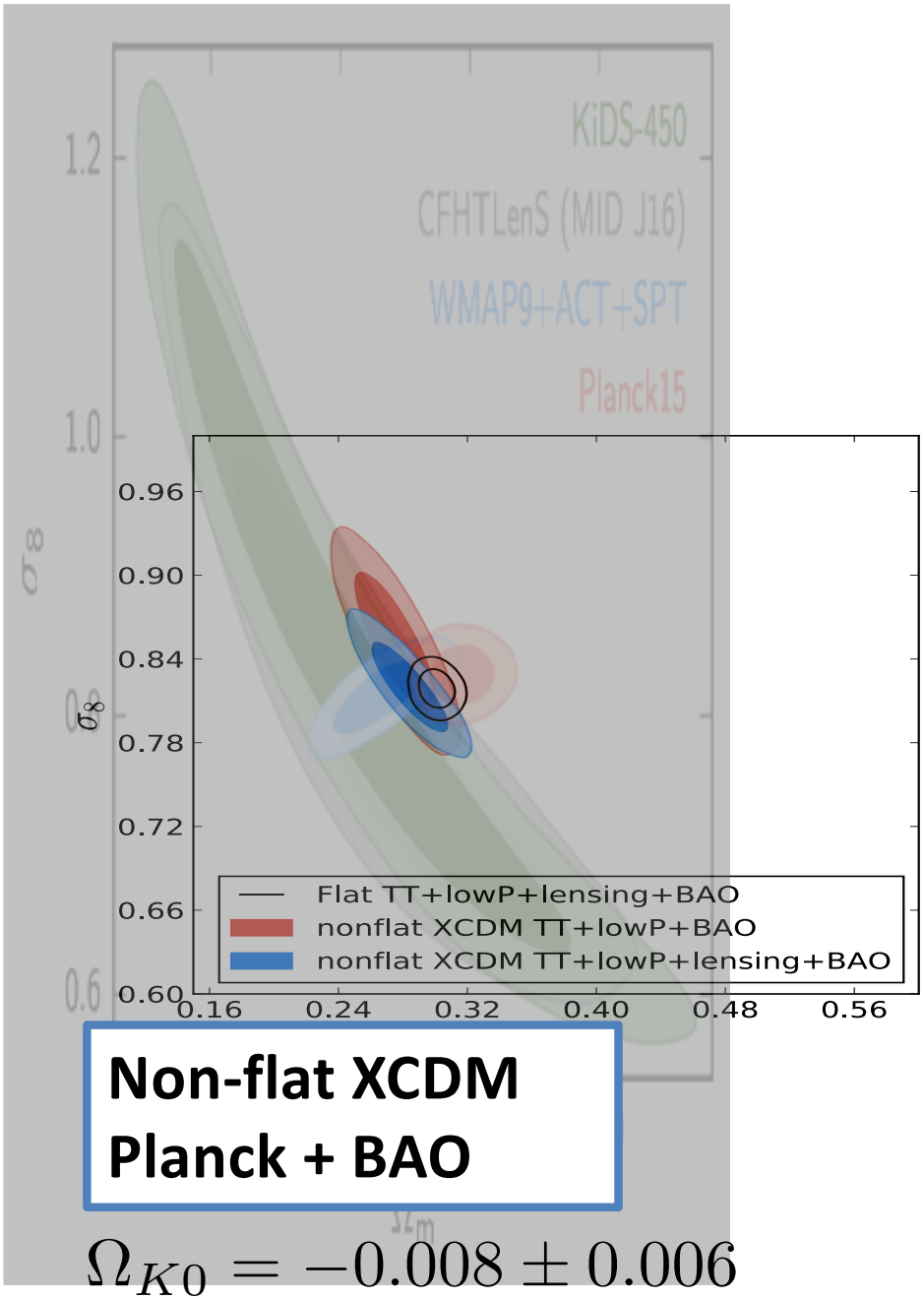
σ_8: 現在での密度ゆらぎの振幅を表す指標

- Flat-ΛCDMモデルを仮定したPlanck CMB観測による推定値は、近傍宇宙の観測値に比べ、大きい Ω_m, σ_8 の値を予言 (下図)
- Non-flatモデルでの制限結果は、近傍宇宙の観測とより整合的



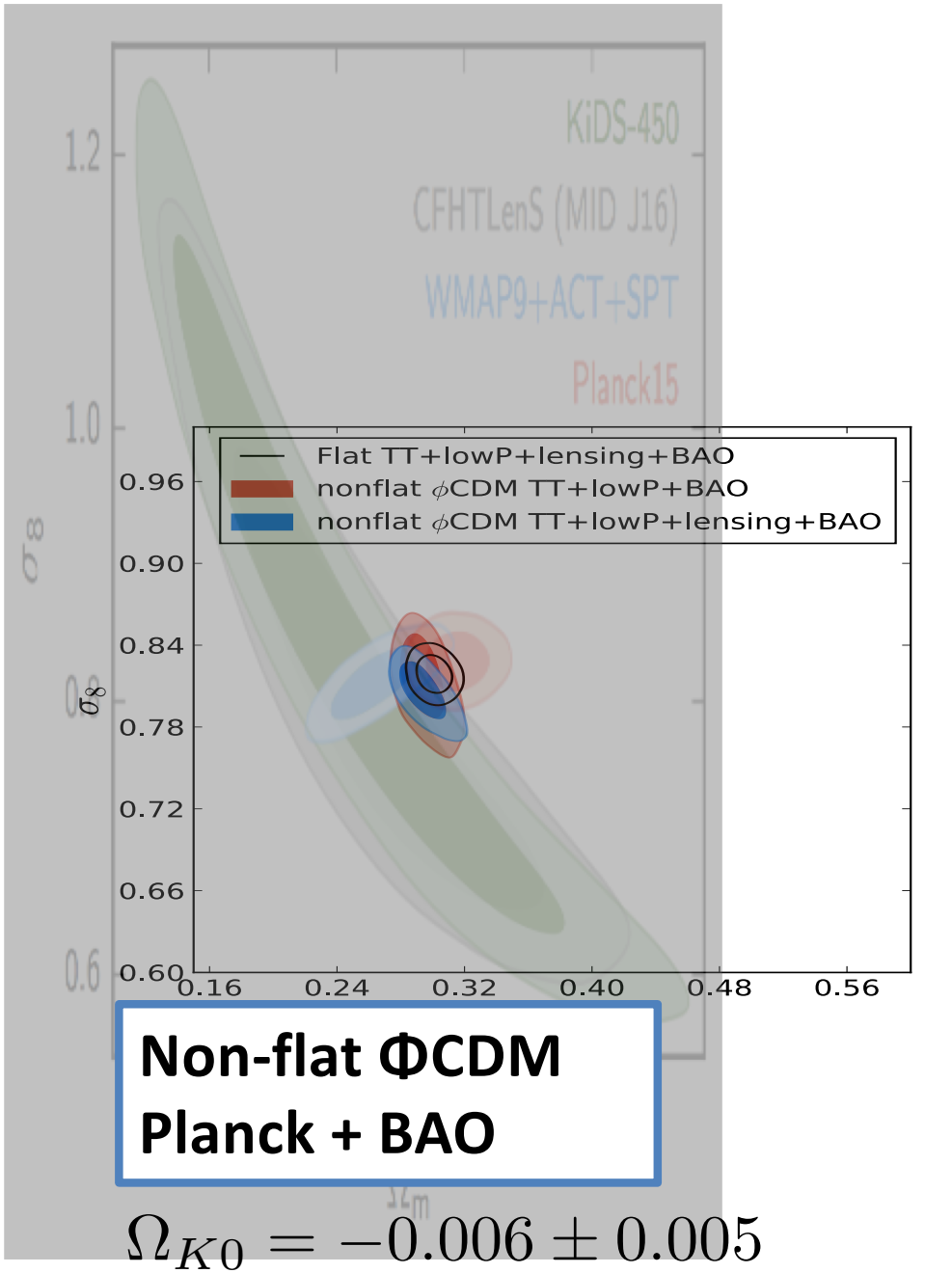
Hildebrandt+ (2016)





Non-flat XCDM
Planck + BAO

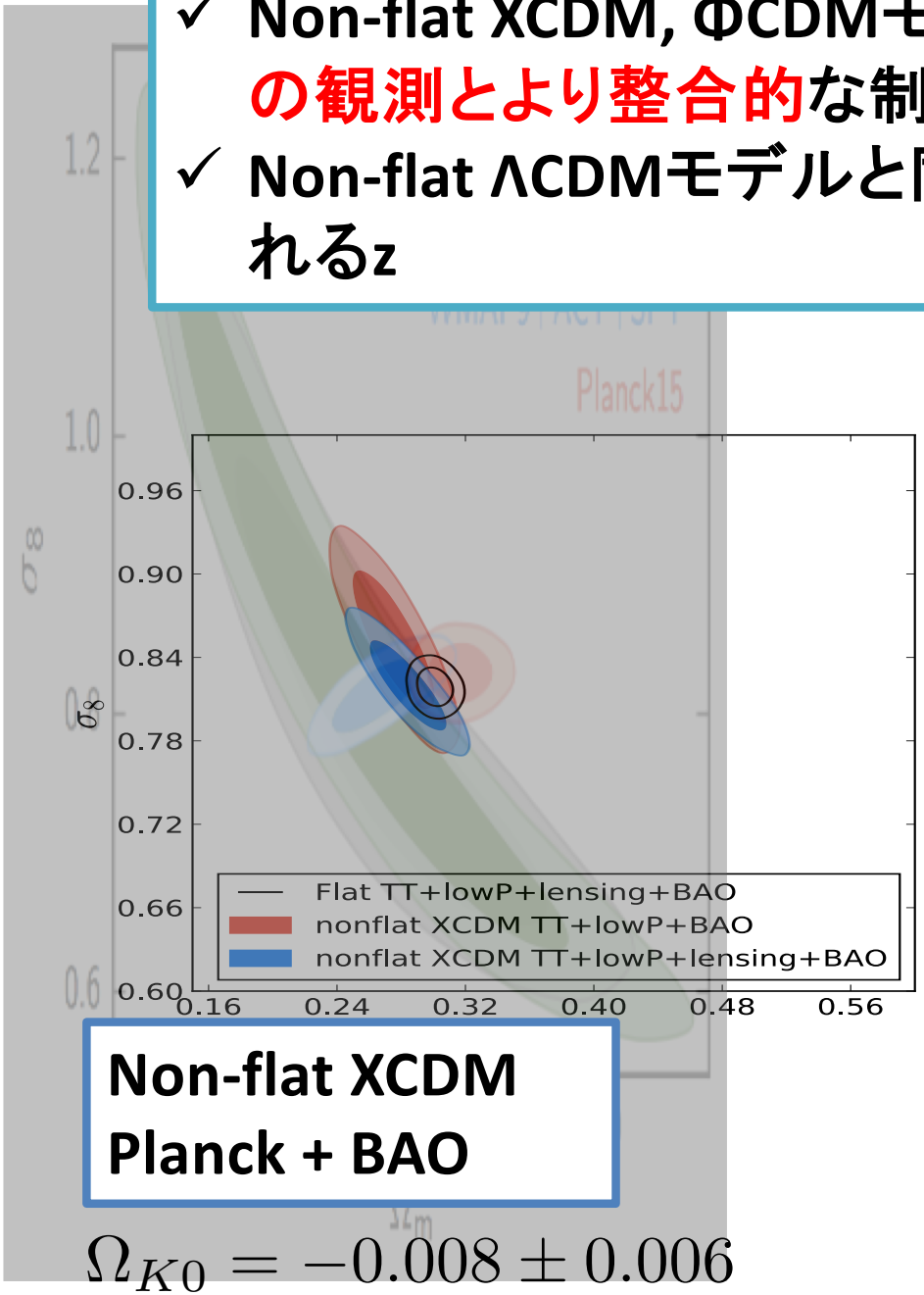
$$\Omega_{K0} = -0.008 \pm 0.006$$
(95.45%, TT + lowP + lensing + BAO)



Non-flat ΦCDM
Planck + BAO

$$\Omega_{K0} = -0.006 \pm 0.005$$
(95.45%, TT + lowP + lensing + BAO)

- ✓ Non-flat XCDM, ΦCDMモデルについても近傍宇宙の観測とより整合的な制限結果が得られた
- ✓ Non-flat ΛCDMモデルと同様に閉じた宇宙が好まれるz



Non-flat XCDM
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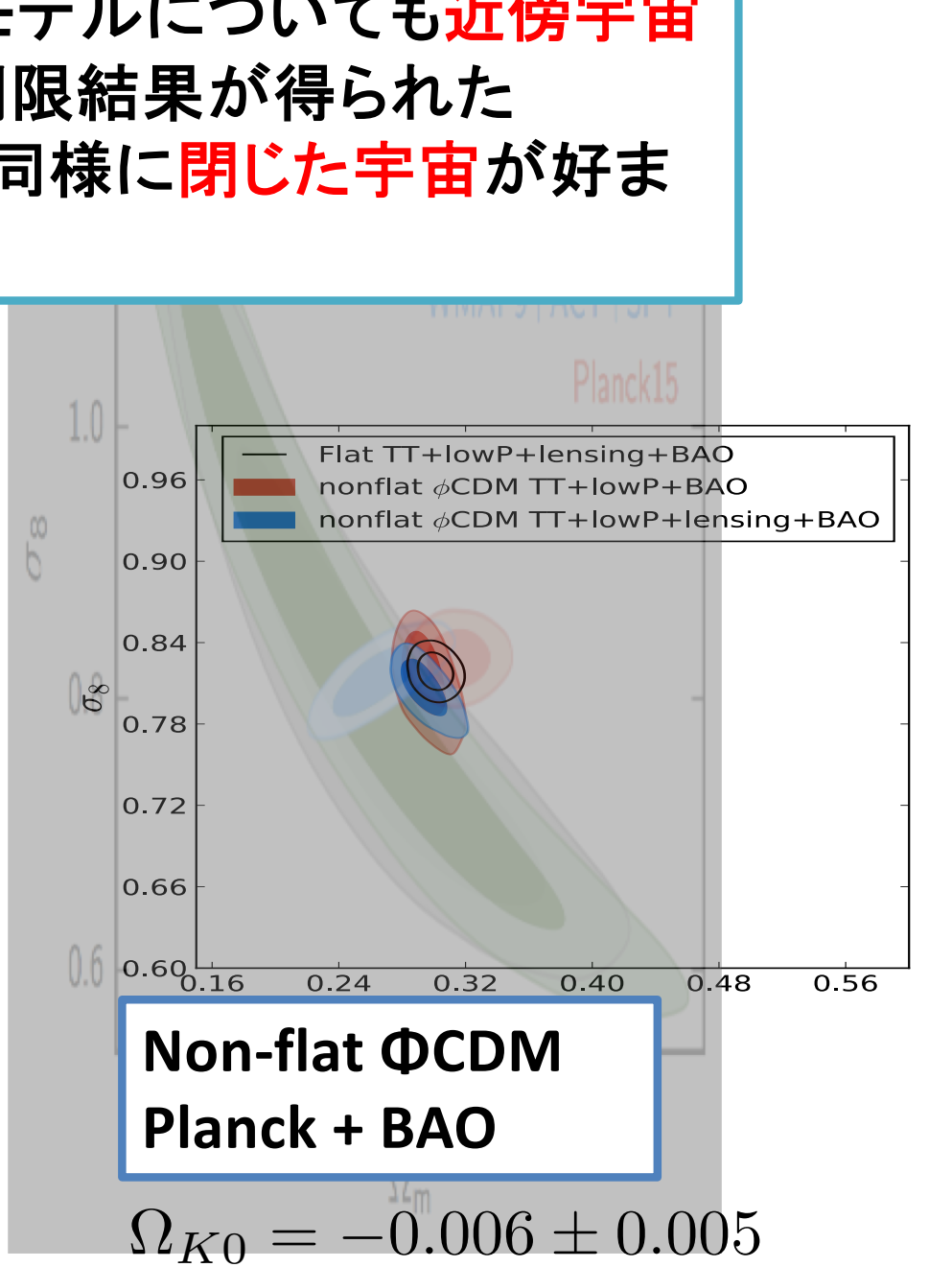


Non-flat ΦCDM
Planck + BAO

$$\Omega_{K0} = -0.006 \pm 0.005$$
$$(95.45\%,\ \mathrm{TT} + \mathrm{lowP} + \mathrm{lensing} + \mathrm{BAO})$$

HI intensity mapping によるBAO観測に向けて

“Redshift Space Distortion of 21cm line at $1 < z < 5$ with Cosmological Hydrodynamic Simulations”, Ando, Rika; Nishizawa, Atsushi J.; Hasegawa, Kenji; Shimizu, Ikkoh; Nagamine, Kentaro, MNRAS 484, p.5389-5399, 2019 (arXiv:1808.01116)

背景: HIの理論的枠組みの構築

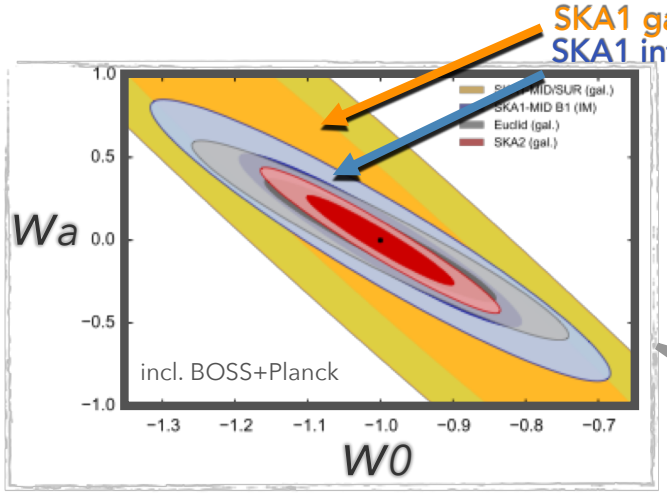
arXiv: 1808.01116

SKAの21cm線intensity mappingによる大規模構造の探査

- 広領域
- 高い周波数分解能
- 高赤方偏移

→ 探査の目的：宇宙論モデルへの制限

先行研究:線形モデルを用いた将来観測による制限予測



Bull et al. 2015

intensity mappingではdark energyのパラメータへの強い制限が期待

状態方程式 $p_{\rm de} = w\,\rho_{\rm de}$

$$w = w_0 + (1-a)w_a$$

目的: 精密なHIの理論的枠組みの構築

arXiv: 1808.01116

本研究の目的

中性水素を用いた宇宙論解析のための理論的枠組みの構築

HIの時間発展には
複雑な天体物理が寄与

研究手法

先行研究: N体 simulation + M_{halo}-M_{HI} model

- 仮定したモデルに強く依存

Sarkar et al. 2018

本研究: 宇宙論的流体シミュレーション

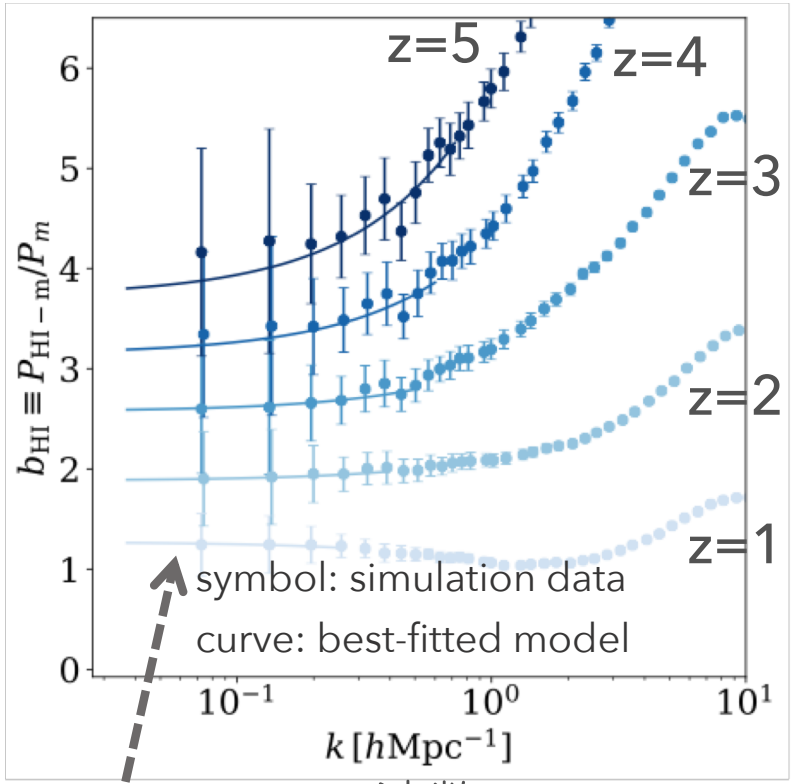
- ダークマターと中性水素の時間発展を計算
- より現実に即した精密な理論モデルの構築

結果: HIバイアスと赤方偏移空間歪み

arXiv: 1808.01116

HIバイアスを測定・モデル化

中性水素バイアス

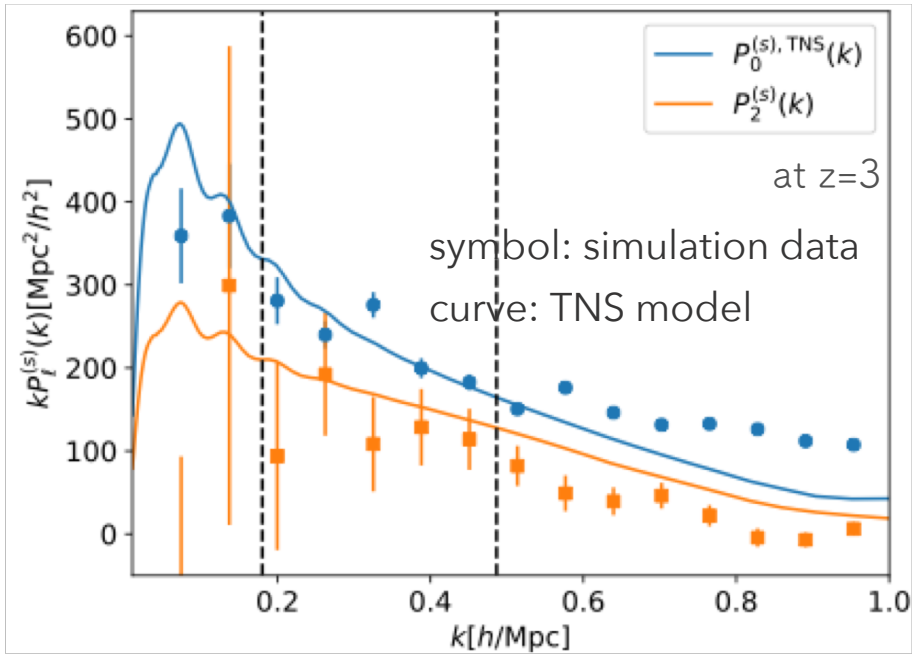


波数

$$b(k) = b_0 + b_1(k)$$

赤方偏移空間におけるHIの
パワースペクトルを測定

多重極パワースペクトル



波数

→ 銀河サーベイに用いられる
理論モデルでHIを記述可能

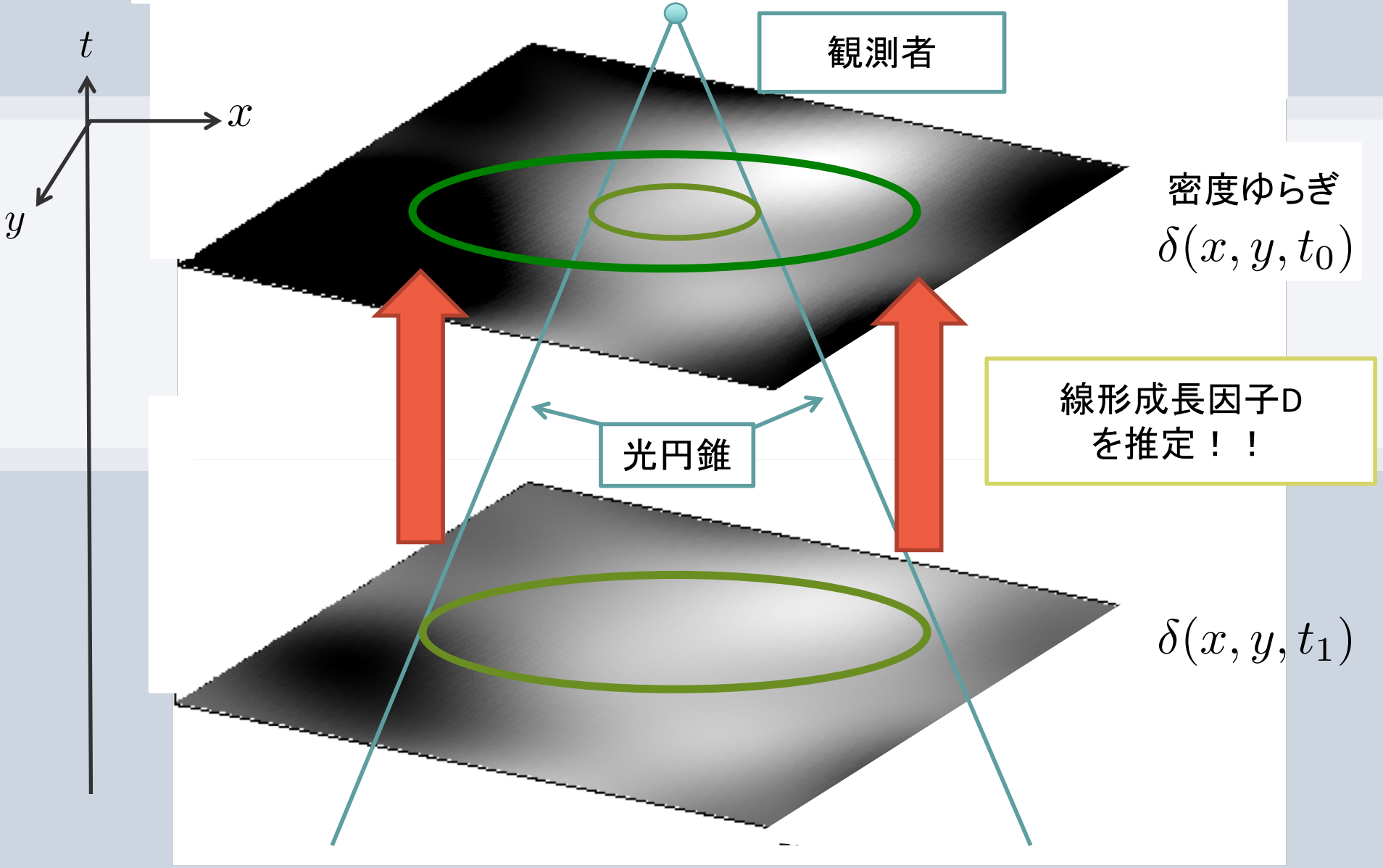
ガウシアンプロセスを用いた宇宙密度揺らぎの再構築

“Reconstruction of primordial density fluctuations with Gaussian process”
K. Yoshida, A.J. Nishizawa, K. Ichiki, N. Sugiyama and N. Aghanim, in progress

密度ゆらぎの再構築

観測するゆらぎ

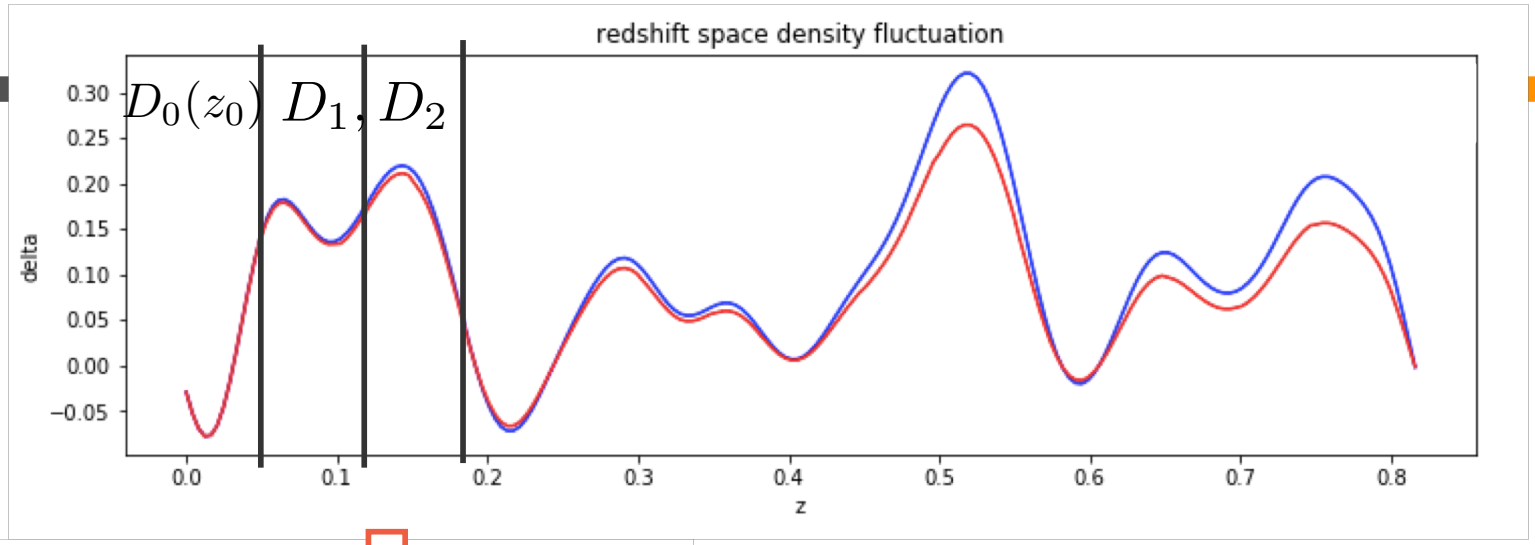
復元したいゆらぎ

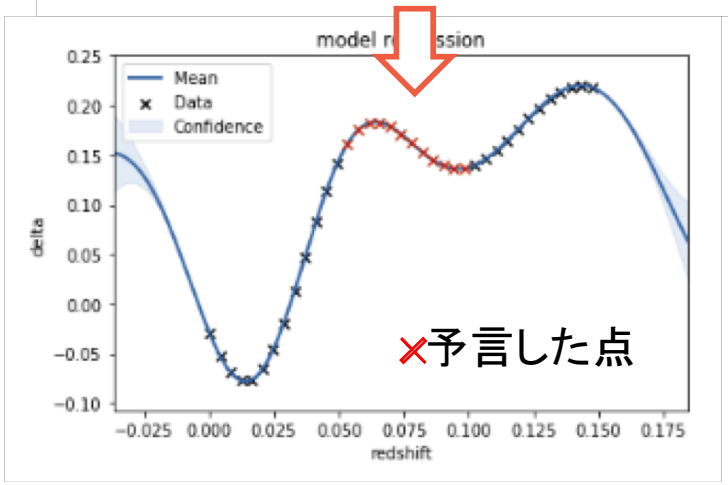


解析手法

「ガウス過程」という機械学習を使用

現在のゆらぎ
観測するゆらぎ

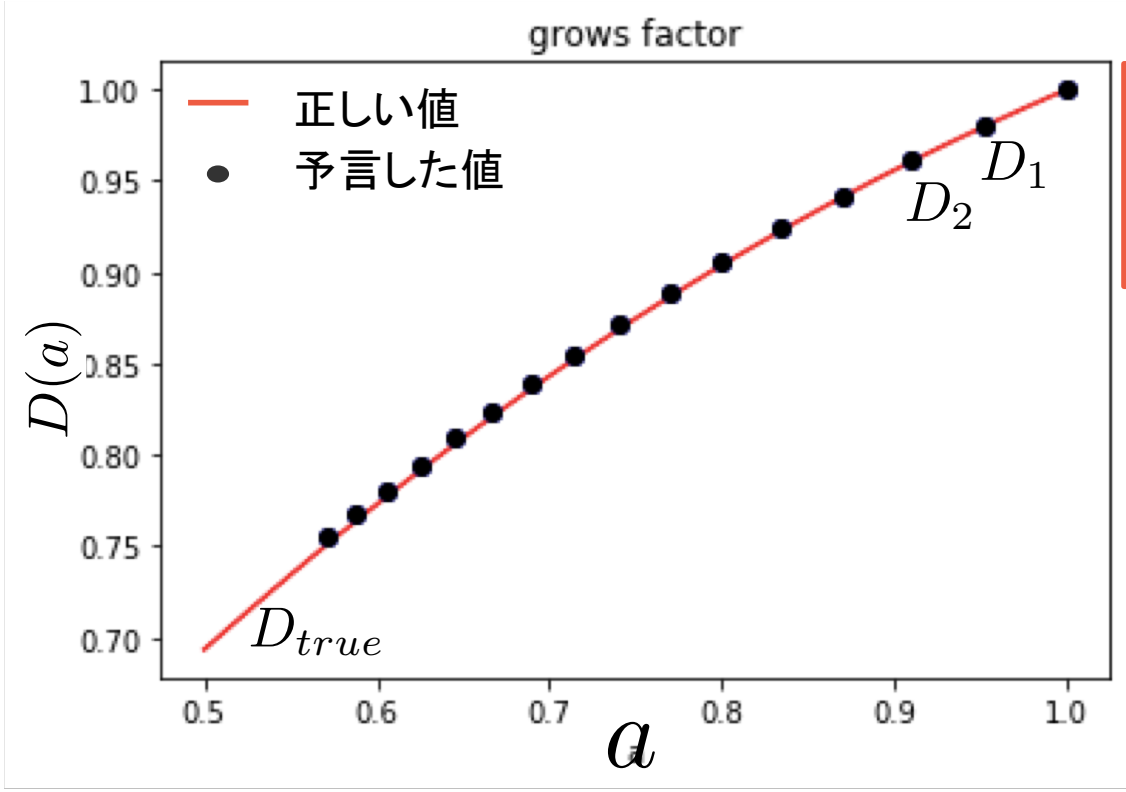




・線形成長因子を離散化
・現在のゆらぎをガウス過程で予測

・観測量の振幅と位相情報を使い
D_1, D_2 の同時推定

シミュレーション結果



宇宙論パラメータ推定

$$\Omega_{m0} = 0.29921 \pm 0.0013$$

線形成長因子を用いた
新しい精密宇宙論へ