Research status of A02

Feb. 11 2018 @“Why does the Universe accelerate?
-Exhaustive study and challenge for the future”

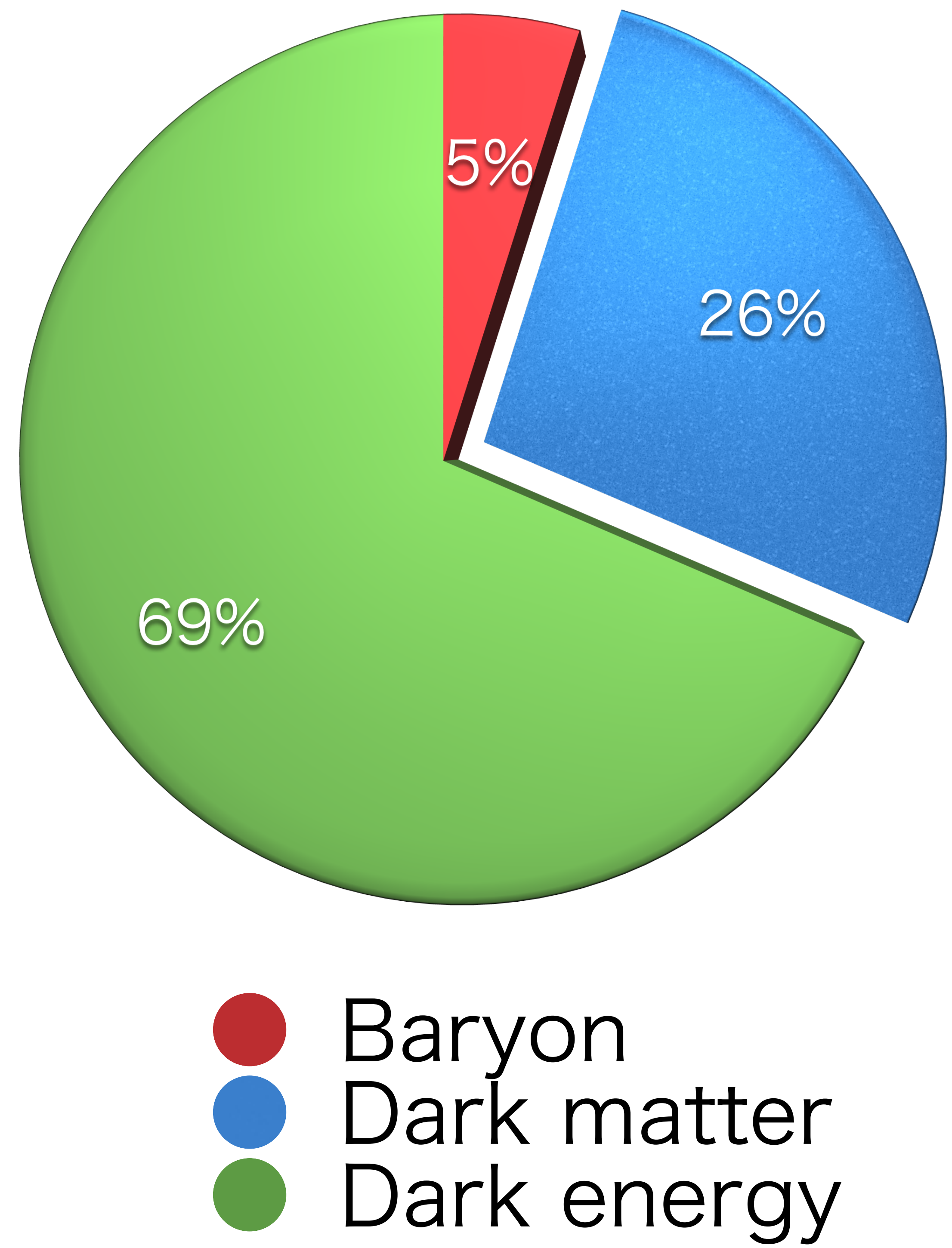
Fumi Takahashi
(Tohoku)

Dark Matter

The presence of DM has been firmly established.

$$\Omega_{\rm DM} \simeq 0.26$$

However, we do not know what DM is made of.



✓ **What is DM?**

- Why long-lived? **Symmetry, light mass, or very weak int.?**
- How produced?
- Cold or warm? Non-gravitational couplings?

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- How produced?
- Cold or warm? Non-gravitational couplings?

✓ **DM density perturbations**

✓ **DM decay/annihilation**

See talk by Torii

✓ **Non-linear gravitational evolution**

✓ **DM distribution** in dSphs, galaxies, and clusters.

- Any tension with LCDM and N-body simulations?

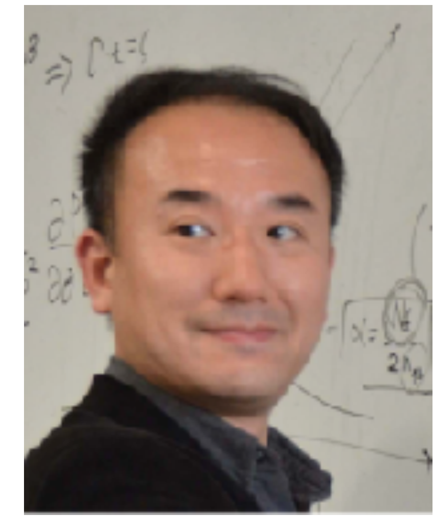
See talk by Okamoto

✓ **Any relation with inflation and/or DE?**

✓ **Any predictions for exp. or obs.?**

Members

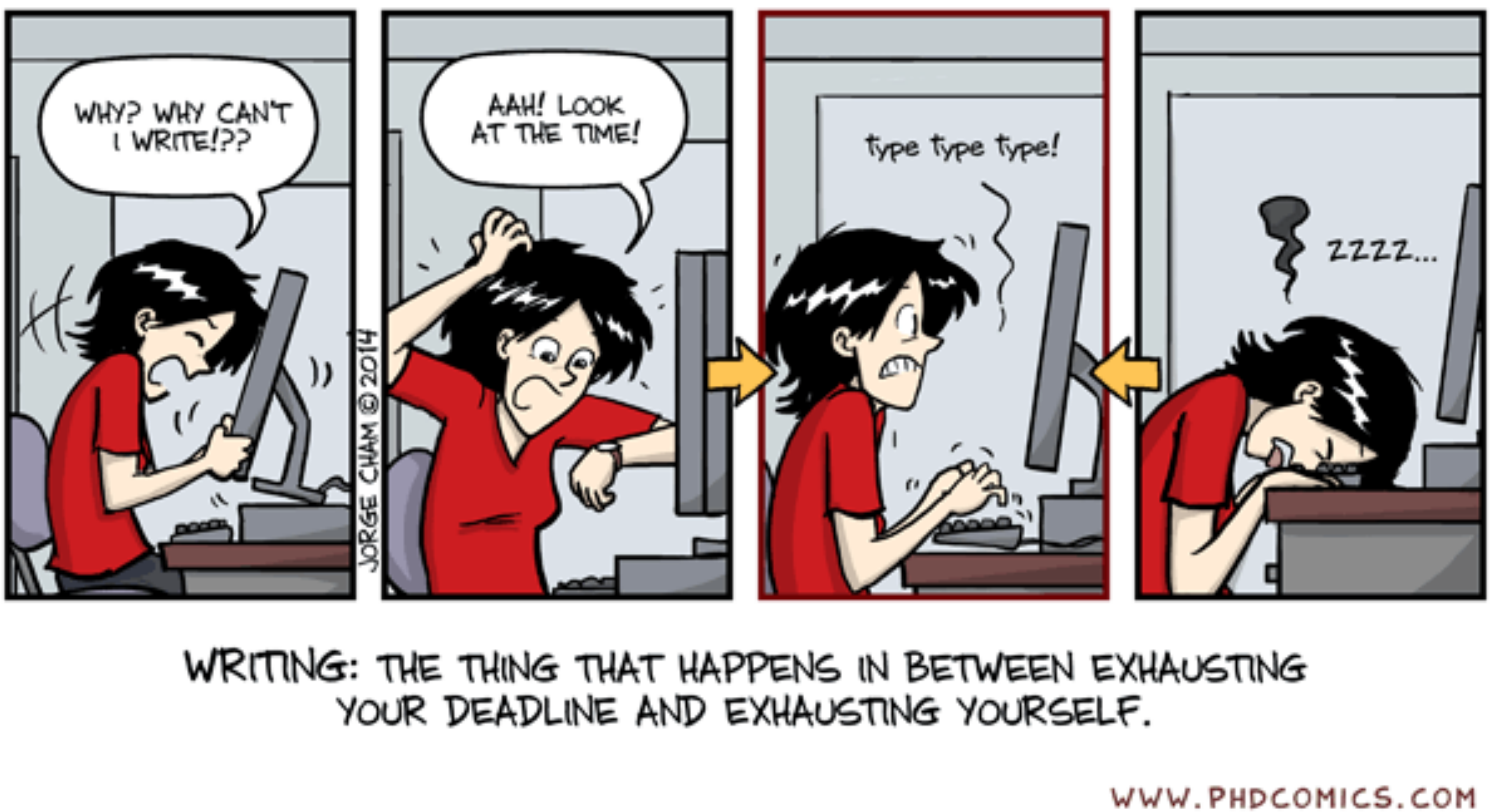
- Masahiro Kawasaki (ICRR)
- Kazunori Kohri (KEK)
- Fuminobu Takahashi (Tohoku)
- Atsushi Taruya (Kyoto)
- Masashi Chiba (Tohoku)
- Masahiro Ibe (ICRR)
- Norimi Yokozaki (Tohoku)




Papers

34 papers (Apr. 2017 - present), 98 papers in total from A02 group.



Workshop

Workshop on Beyond Standard Model and the Early Universe

25-27 October, 2017, Tohoku University, Sendai, Japan

Home | Registration | Program | Participants | Access | Contact Us

Overview

The International Workshop on Beyond Standard Model and the Early Universe will be held at Tohoku University (Sendai, Japan) from October 25th to 27th 2017.

The aim of this workshop is to bring experts of particle physics and cosmology together, to have talks about recent progresses in such a field, and to discuss the future directions. We will have a plenty of time for discussion led by the experts, as well as short talks and posters which registered participants can apply for.

News

25 September 2017

Registration is now open. The deadline is 10/6.

List of Discussion Leaders Includes

- Chuan-Ren Chen (Taiwan, Natl. Normal U.)
- Kiwoon Choi (IBS-CTPU)
- Jason Evans (KIAS)
- Hiroyuki Ishida (NCTS, Hsinchu)
- Sho Iwamoto (U. of Padova)
- Kwang Sik Jeong (Pusan Nat. U.)
- Kohei Kamada (Arizona State U.)
- Ryosuke Sato (Weizmann Inst.)
- Toyokazu Sekiguchi (RESCEU, U. of Tokyo)
- Eibun Senaha (IBS-CTPU)
- Masaki Yamada (Tufts U.)

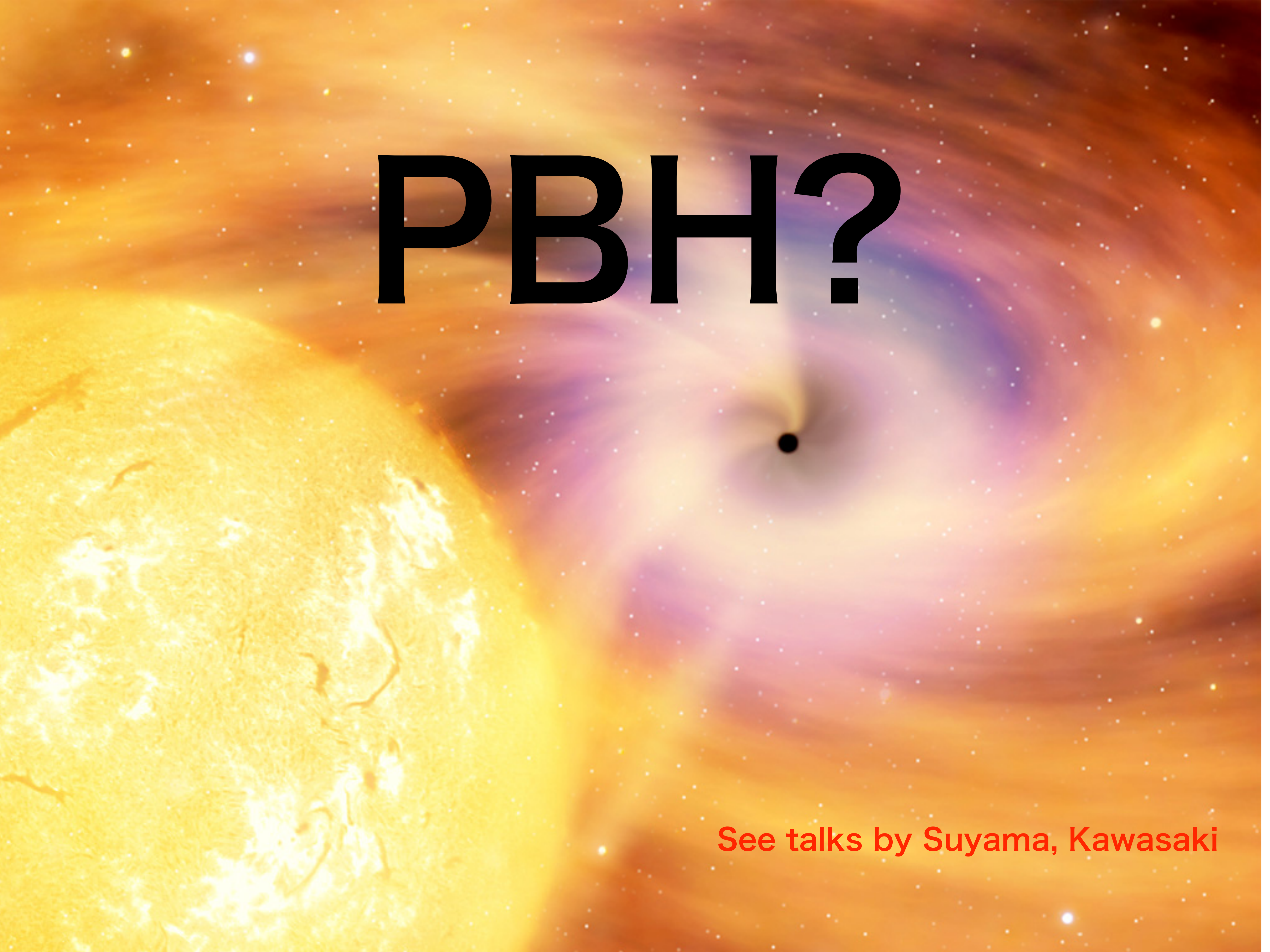
36 participants

This workshop is supported by

- Grants-in-Aid for Scientific Research (KAKENHI), JSPS
  - MEXT Grant-in-aid for Scientific Research on Innovative Areas, 15H05889
  - MEXT Grant-in-aid for Scientific Research on Innovative Areas, 16H06490
  - MEXT Grant-in-Aid for Scientific Research (B), 17H02875
  - MEXT Grant-in-Aid for Scientific Research (A), 26247042

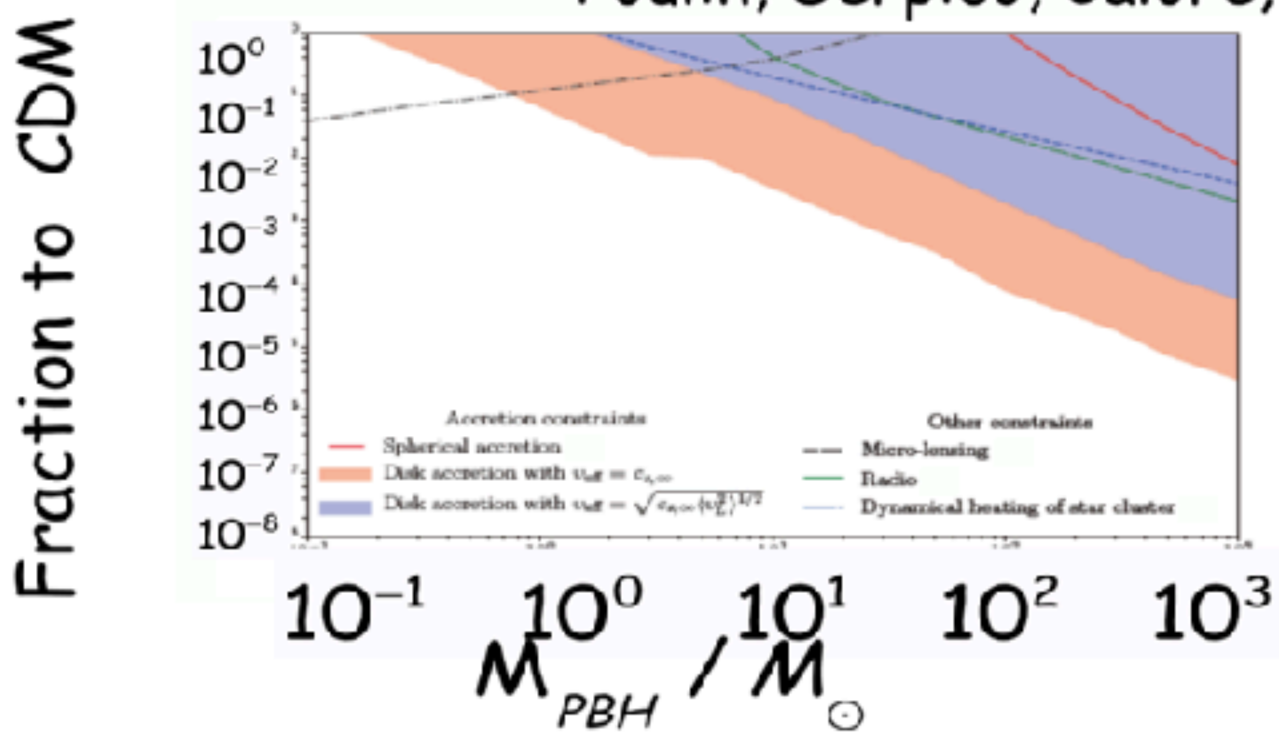
Highlights

- Formation of PBH DM (Kawasaki) **See talk by Kawasaki**
- CMB bound and abundance of PBH (Kohri)
- Perturbation theory kernels (Taruya) **See talk by Taruya**
- Axionic unification of inflation and DM (FT)
- Discovery of new ultra faint satellites and dusty dwarf galaxy (Chiba) **See talk by Chiba**
- Dark matter detection (Ibe)
- Enhanced $g_{a\gamma\gamma}$ in GUT w/ $U(1)_H$ (Yokozaki)


PBH?
See talks by Suyama, Kawasaki

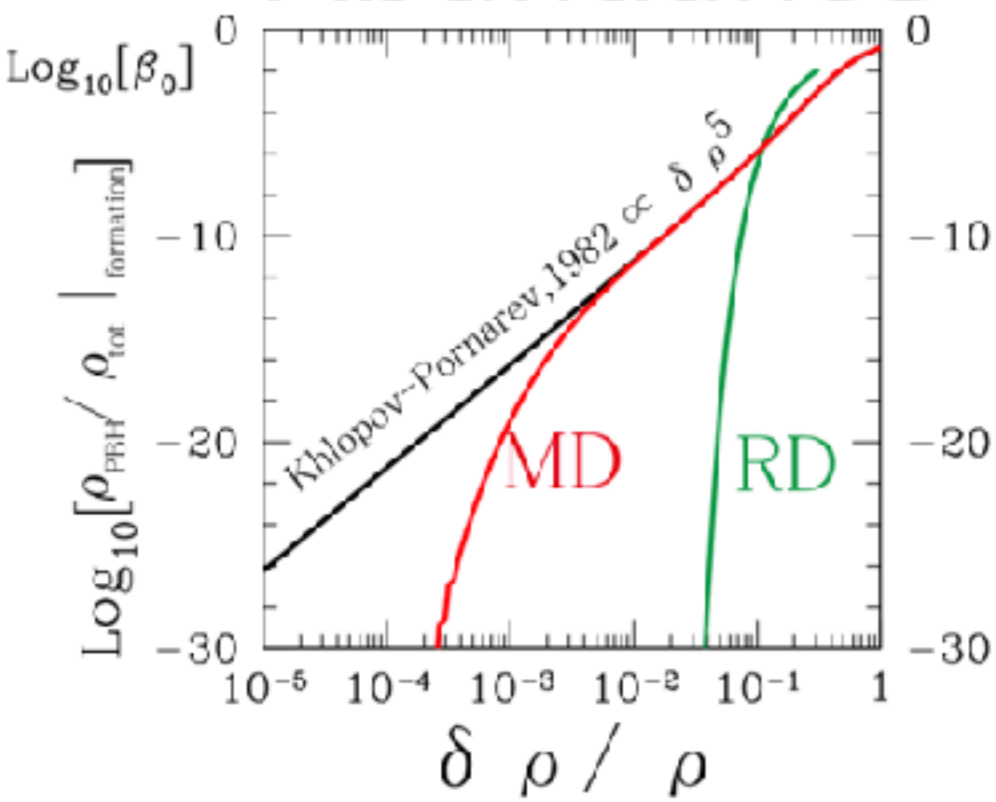
CMB bound on PBHs with disk-accretions

Poulin, Serpico, Calore, Clesse, Kohri, arXiv:1707.04206

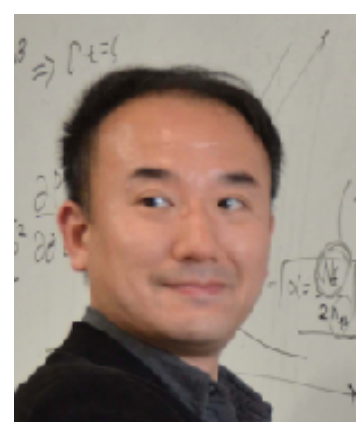


- A non-spherical accretion disk around a PBH, which is inevitably-formed by angular momentum conservation, definitely emit radiation. From the current CMB observations, we can constrain the number density of PBHs.

Abundance of PBHs formed in MD



Harada, Yoo, Kohri, Nakao, arXiv:1707.03595



- Abundances of PBHs formed in MD are highly-suppressed by non-zero angular momentum. It is notable that the abundances are still larger than those formed in RD for smaller perturbation with $\delta\rho/\rho < 0.1$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Lemon
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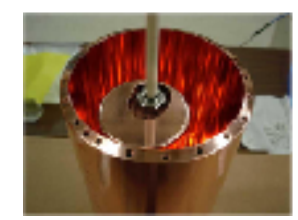
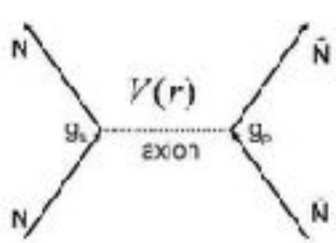
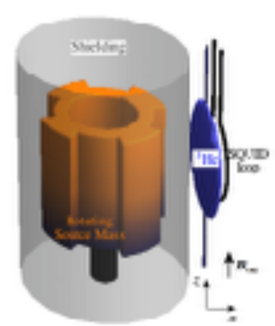
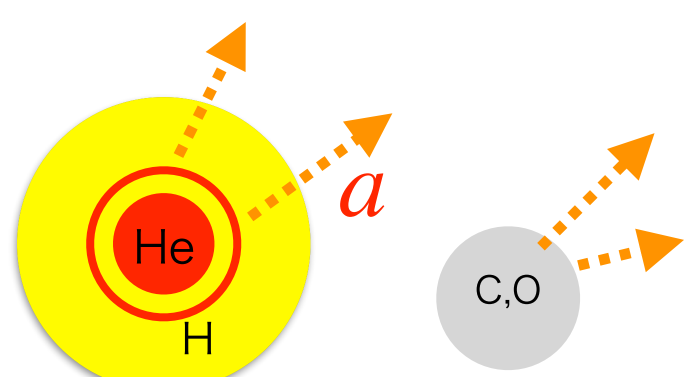
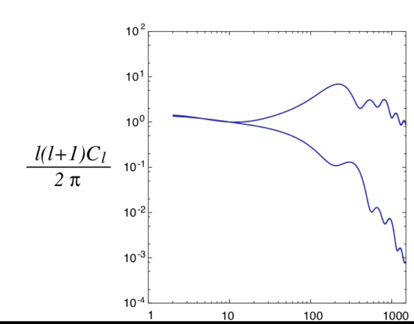
• Available in paste and gel format.
• Sizes available: 200g, 350g, 750g, 300g gel
Green Tea
• Provides powerful grease removal performance with 99% antibacterial action from the fresh scent of Green Tea.
• Available in paste format only.
• Sizes available: 350g, 750g
Lime Pandan
• Provides powerful grease removal performance with anti odor action in the scent of Lime Pandan.
• Available in paste format only.
• Sizes available: 750g
*Based on 2011 Consumer Research

		Production		
		Terrestrial	**Celestial**	**Cosmological**
Detection	**Direct**	LSTW, Photon pol. ALPS, PVLAS, SAPPHIRES 	Solar axion CAST, IAXO, TASTE  	Axion DM ADMX, CAPP,ORPHEUS MADMAX, LC-circuits, ABRACADABRA, CASPEr, LUX,XMASS, EDELWISE,XENON100  
	Indirect	Fifth force ARIADNE  	Excessive cooling of WD, RGB, HB, and NS 	Isocurvature, DR, HDM, caustics, Spectral irreg. transparency Fermi, Chandra, IACT CMB, lensing, shear  

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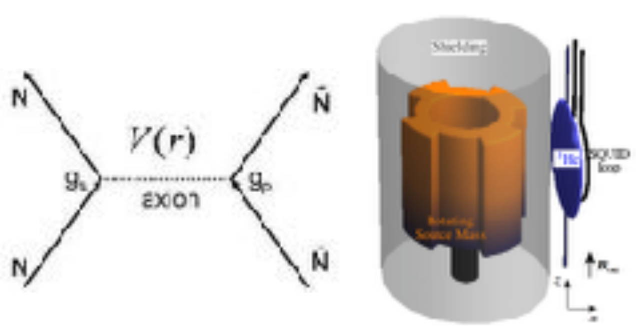
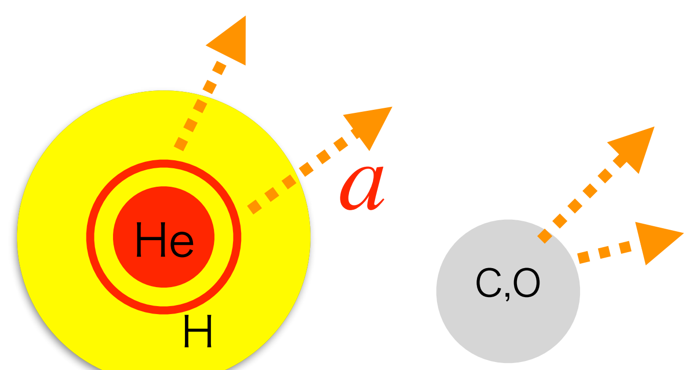
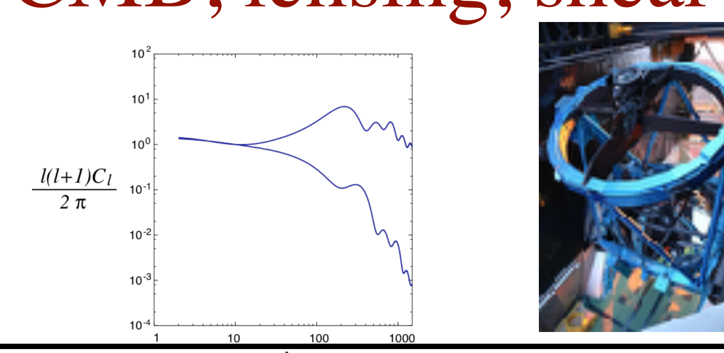
		Terrestrial	Celestial	Cosmological
Detection	Direct	LSTW, Photon pol. ALPS, PVLAS, SAPPHIRES   Homma (D01)	Solar axion CAST, IAXO, TASTE 	Axion DM ADMX, CAPP,ORPHEUS MADMAX, LC-circuits, ABRACADABRA, CASPEr, LUX,XMASS, EDELWISE,XENON100 
	Indirect	Fifth force ARIADNE 	Excessive cooling of WD, RGB, HB, and NS 	Isocurvature, DR, HDM, caustics, Spectral irreg. transparency Fermi, Chandra, IACT CMB, lensing, shear 

$U(1)_H$ GUT with QCD axion

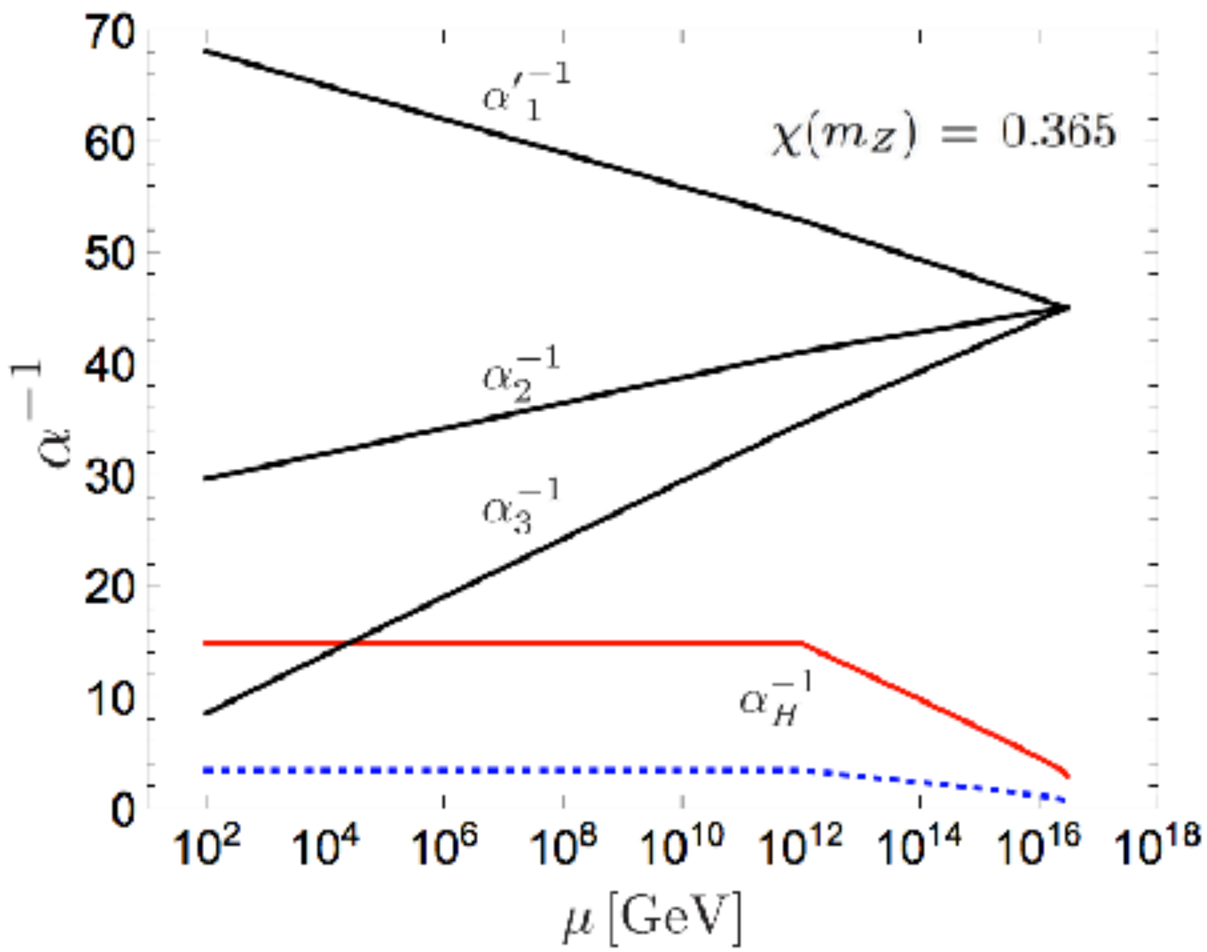
Consider $U(1)_H$ gauge symmetry which has a large kinetic mixing with $U(1)_Y$

$$\mathcal{L}_K = -\frac{1}{4}F'^{\mu\nu}_{Y} F'_{Y\mu\nu} - \frac{1}{4}F'^{\mu\nu}_{H} F'_{H\mu\nu} - \frac{\chi}{2}F'^{\mu\nu}_{Y} F'_{H\mu\nu}$$

$$- \left[\sqrt{2}\phi\overline{\psi}^{\mathrm{b}}_{5L}\psi^{\mathrm{b}}_{5R} + h.c.\right]$$

$(q_H=-1)$

ϕ : Peccei-Quinn field

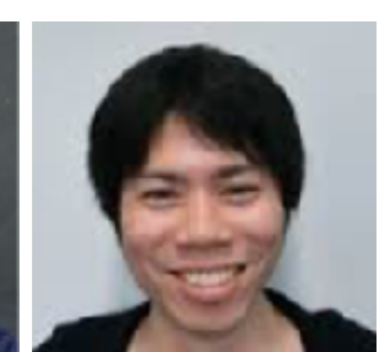


Axion-photon coupling:

$$g_{a\gamma\gamma} = \frac{\alpha_{\rm EM}}{2\pi f_a}\left(\frac{E}{N} - 1.92(4)\right)$$

Electromagnetic anomaly has a large extra contribution

$$\Delta E/N = 10\frac{\chi^2}{1-\chi^2}\frac{g_H^2}{g_Y^2}$$

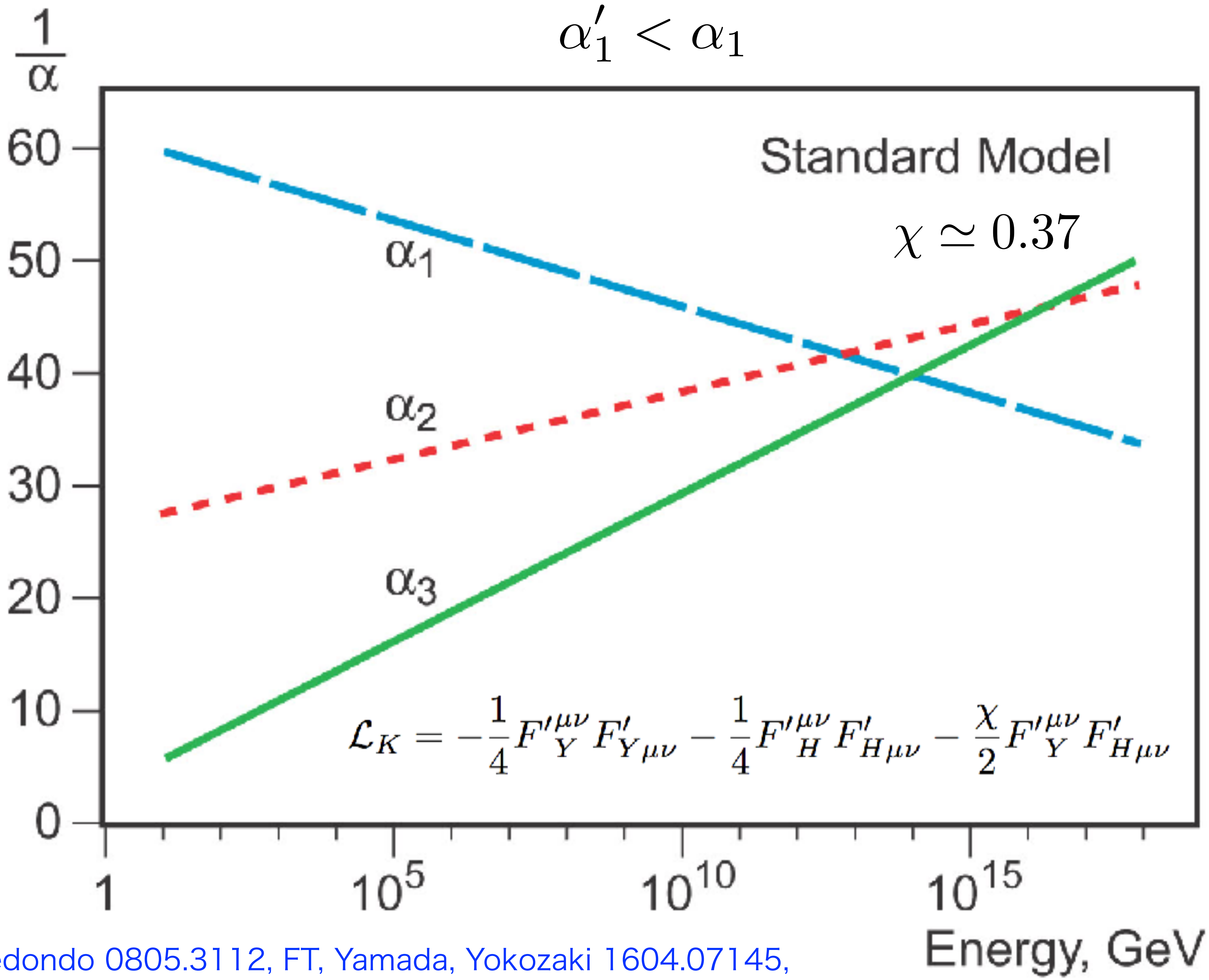



[arXiv: 1801.10344, Daido, FT, Yokozaki, 2018]

Gauge coupling unification w/ U(1)$_H$

$$g_3 = g_2 = g'_1 = \sqrt{1-\chi^2} g_1$$

$$\alpha'_1 < \alpha_1$$



Redondo 0805.3112, FT, Yamada, Yokozaki 1604.07145,
Daido, FT, Yokozaki 1610.00631

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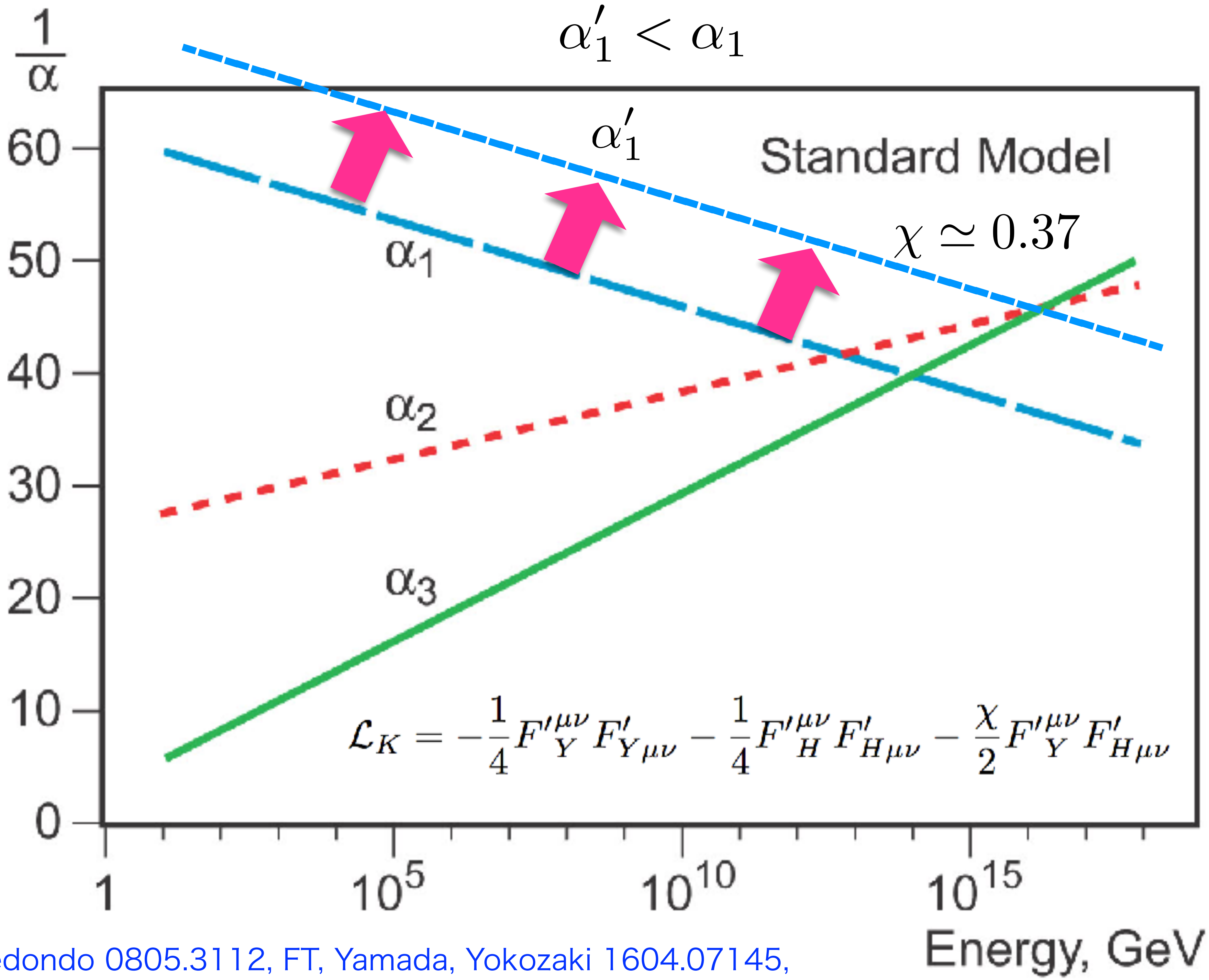

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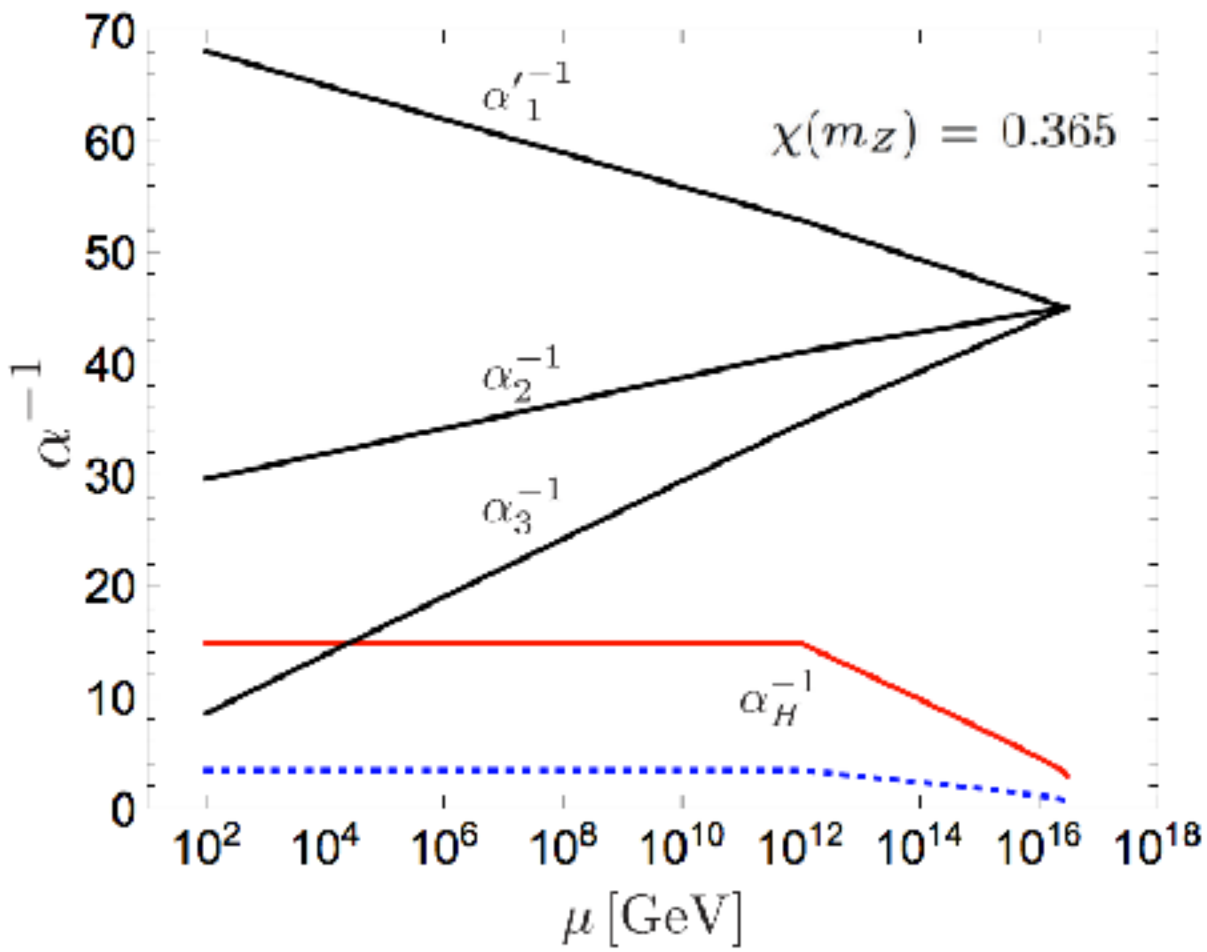
(qH=-1)



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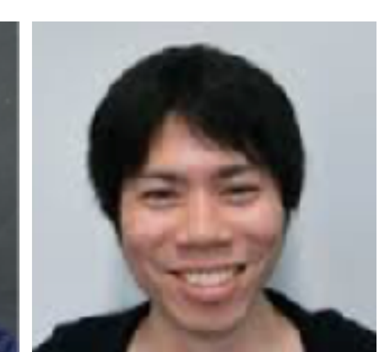
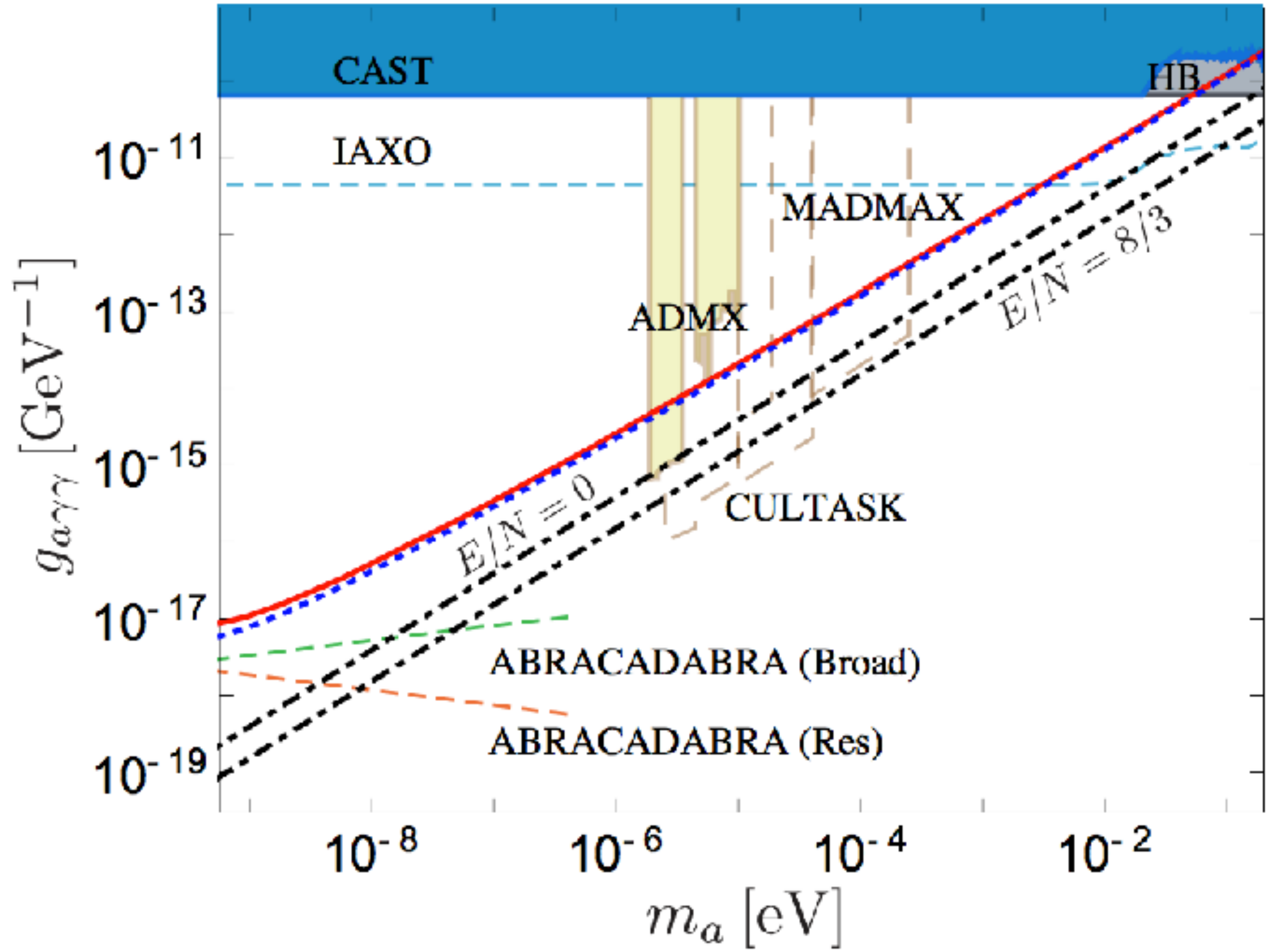


Axion photon coupling

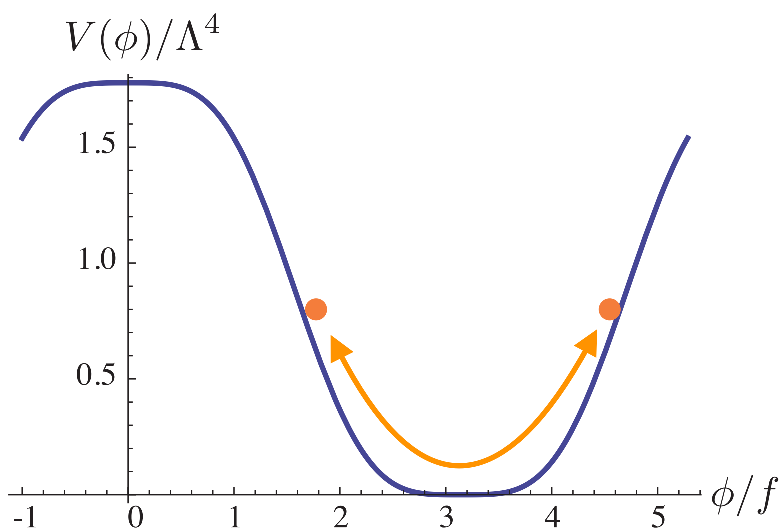


Axion-photon coupling is enhanced by a factor of 10-100, compared to the GUT axion model without $U(1)_H$ (E/N=8/3).

The enhanced coupling can be tested in on-going and future experiments.

[arXiv: 1801.10344, Daido, FT, Yokozaki, 2018]

Axionic unification of inflaton and DM



Inflaton (ALP) condensate

Decay & dissipation → Photons, SM particles

Thermalized → ALP Dark Radiation or HDM

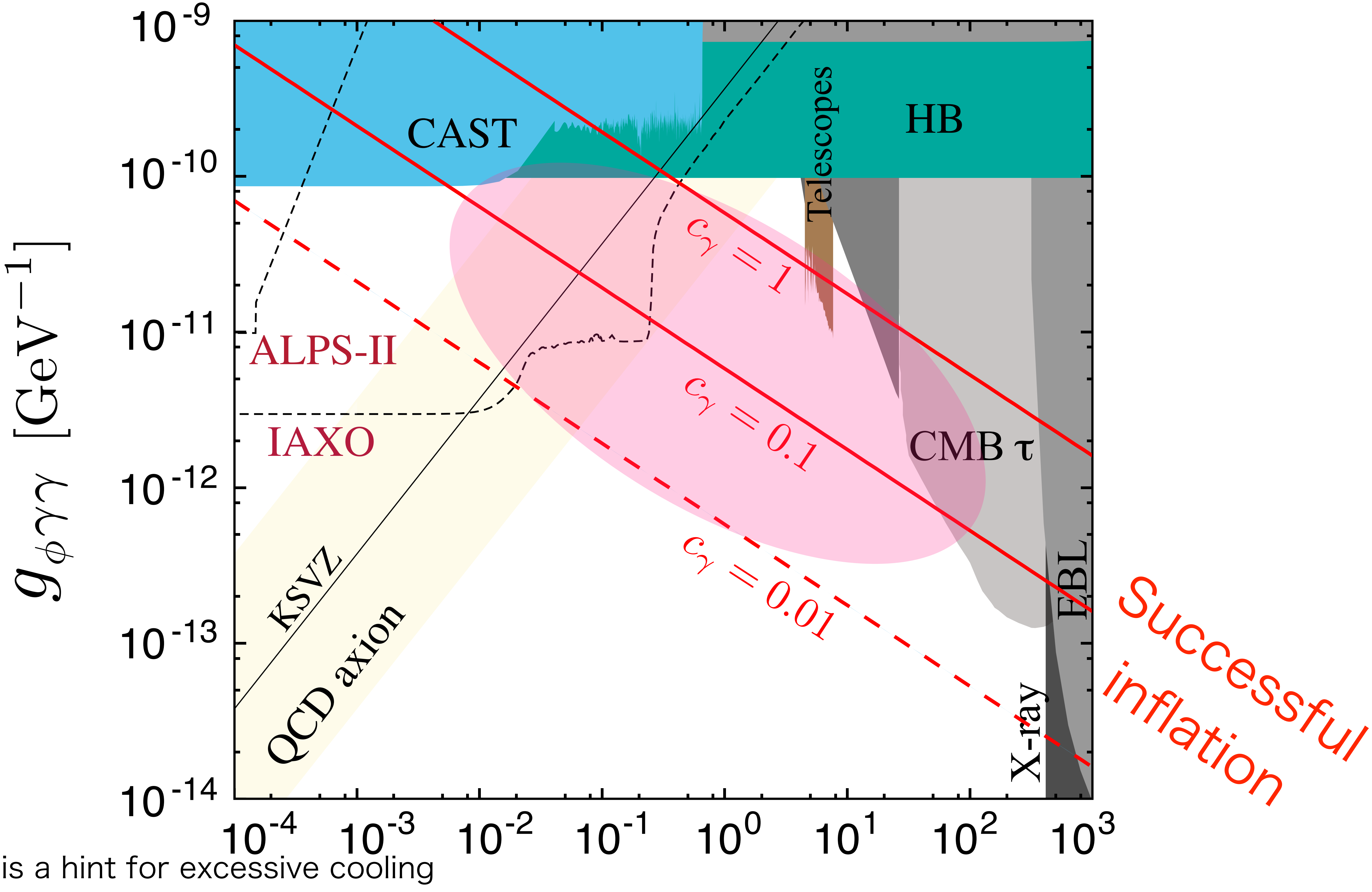
Remnant → ALP Dark Matter

$$\mathcal{L} = \frac{g_{\phi\gamma\gamma}}{4}\phi F_{\mu\nu}\tilde{F}^{\mu\nu}$$

$$V_{\rm inf}(\phi) = \Lambda^4\left(\cos\left(\frac{\phi}{f}+\theta\right) - \frac{\kappa}{n^2}\cos\left(\frac{n\phi}{f}\right)\right) + \text{const.}$$

$$= V_0 - \lambda\phi^4 - \theta\frac{\Lambda^4}{f}\phi + (\kappa-1)\frac{\Lambda^4}{2f^2}\phi^2 + \cdots$$

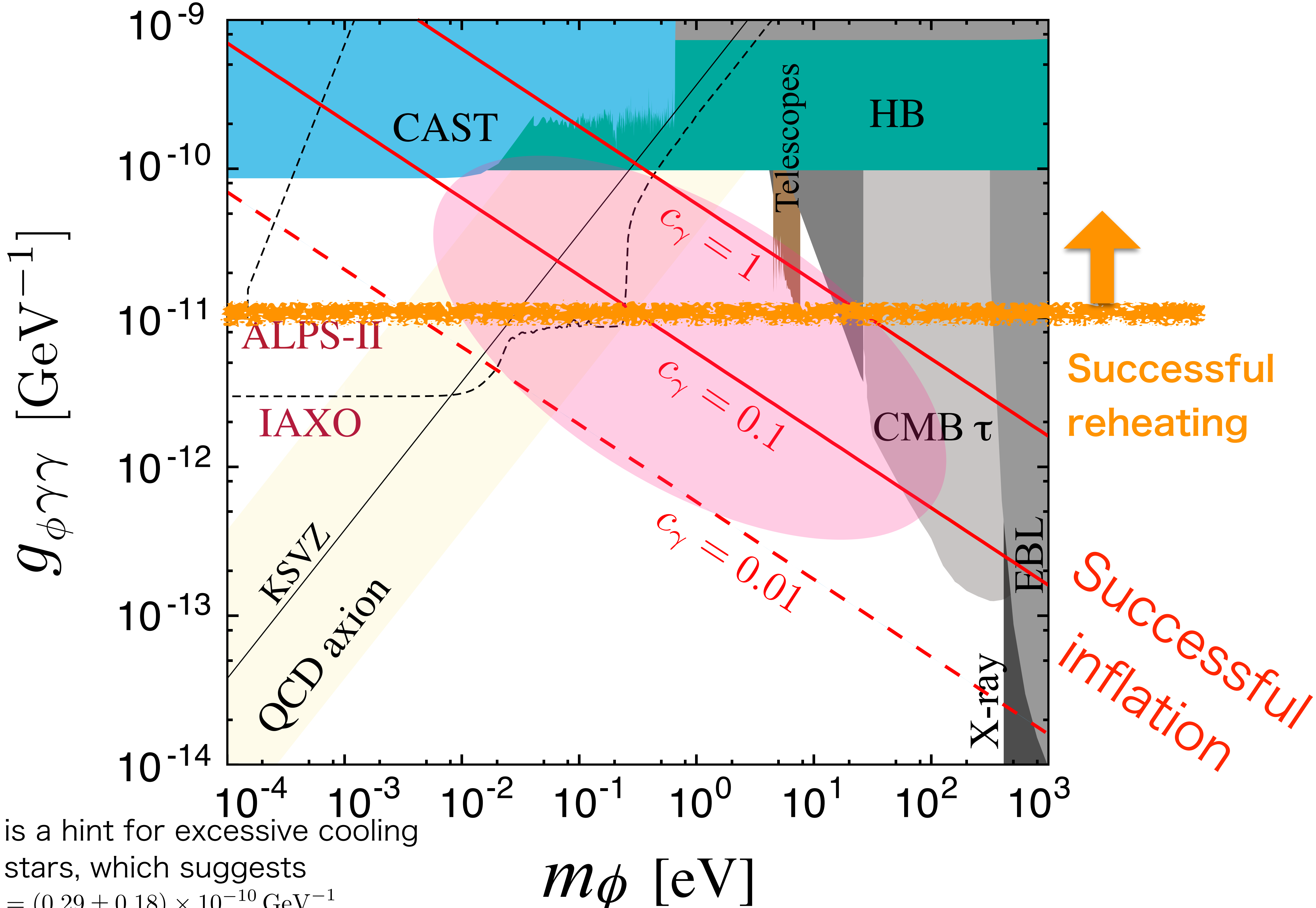
$$\lambda \sim \frac{\Lambda^4}{f^4}$$



There is a hint for excessive cooling of HB stars, which suggests

$$g_{\phi\gamma\gamma} = (0.29 \pm 0.18) \times 10^{-10}\,\mathrm{GeV}^{-1}$$

Ayala,et al, 1406.6053, DESY- PROC-2015-02



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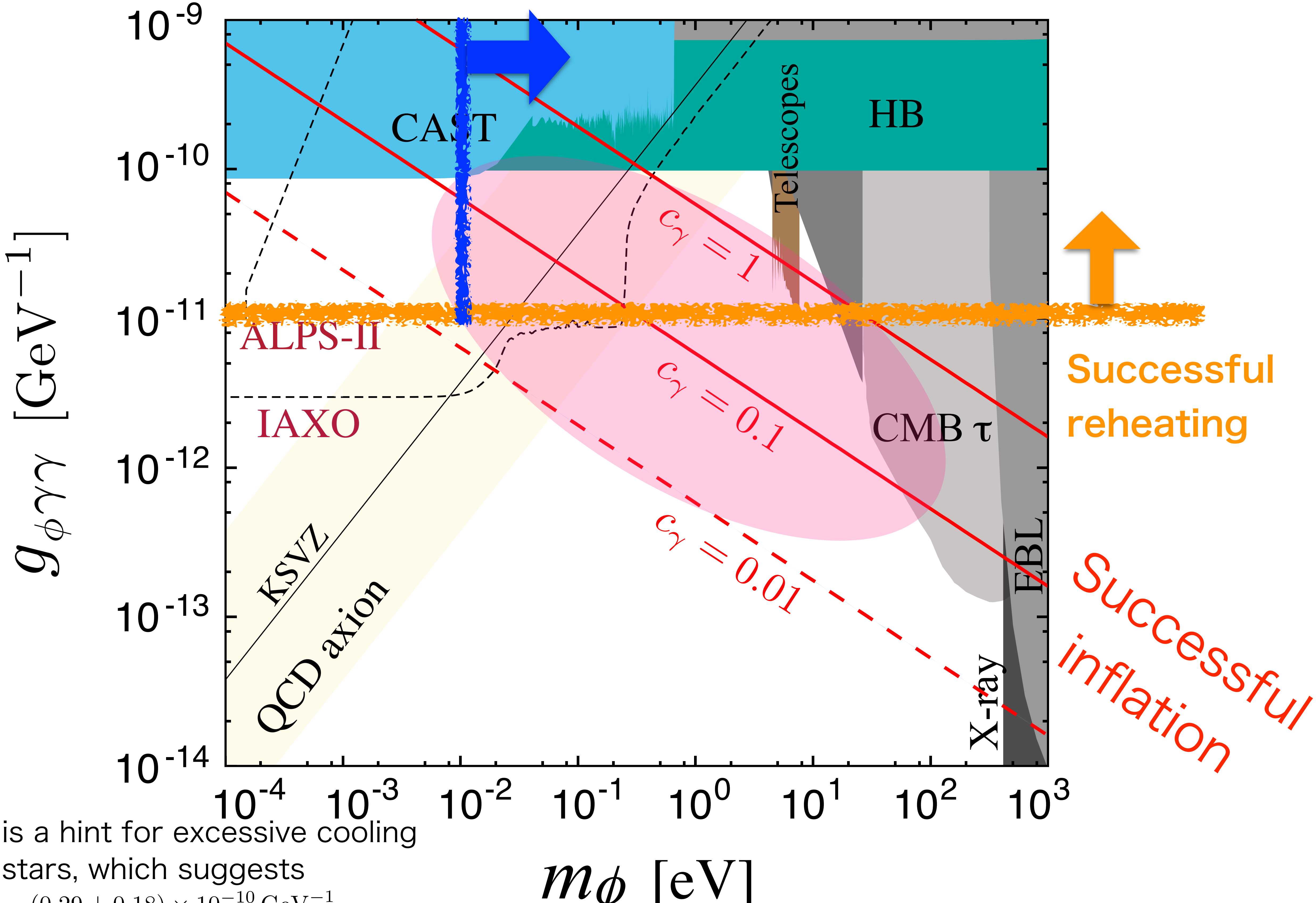
Small-scale structure constraint on ALP CDM



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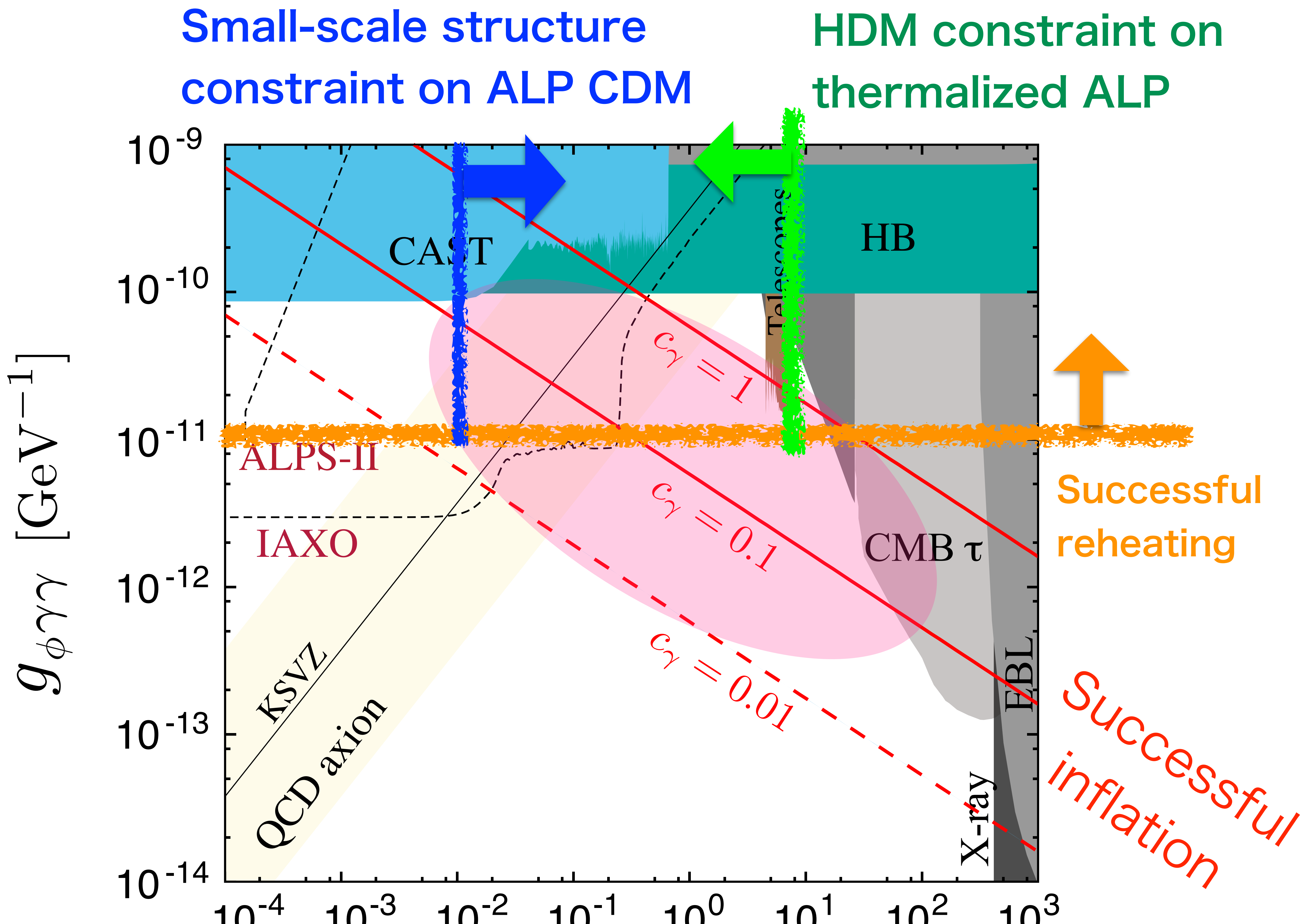

m_ϕ [eV]

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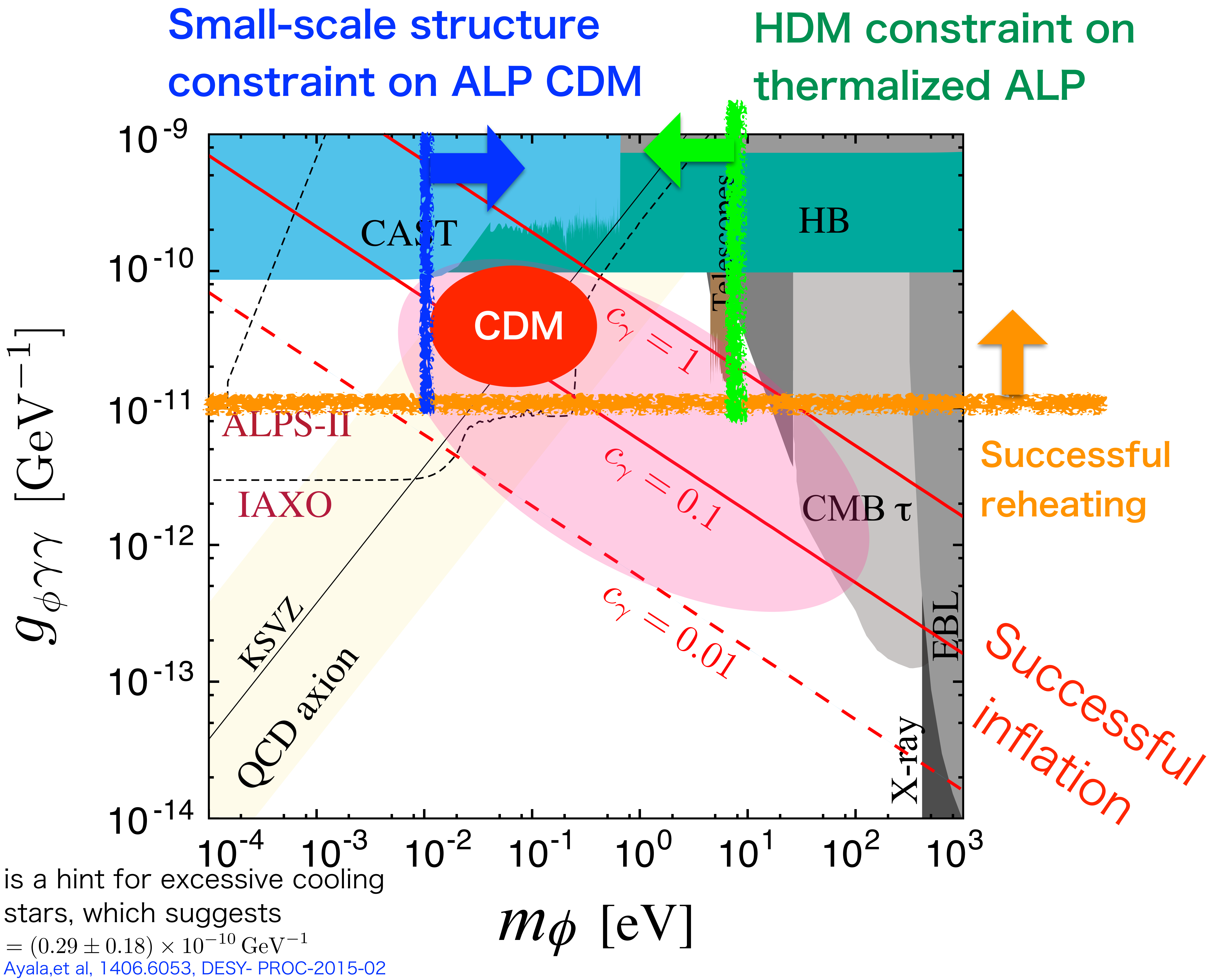

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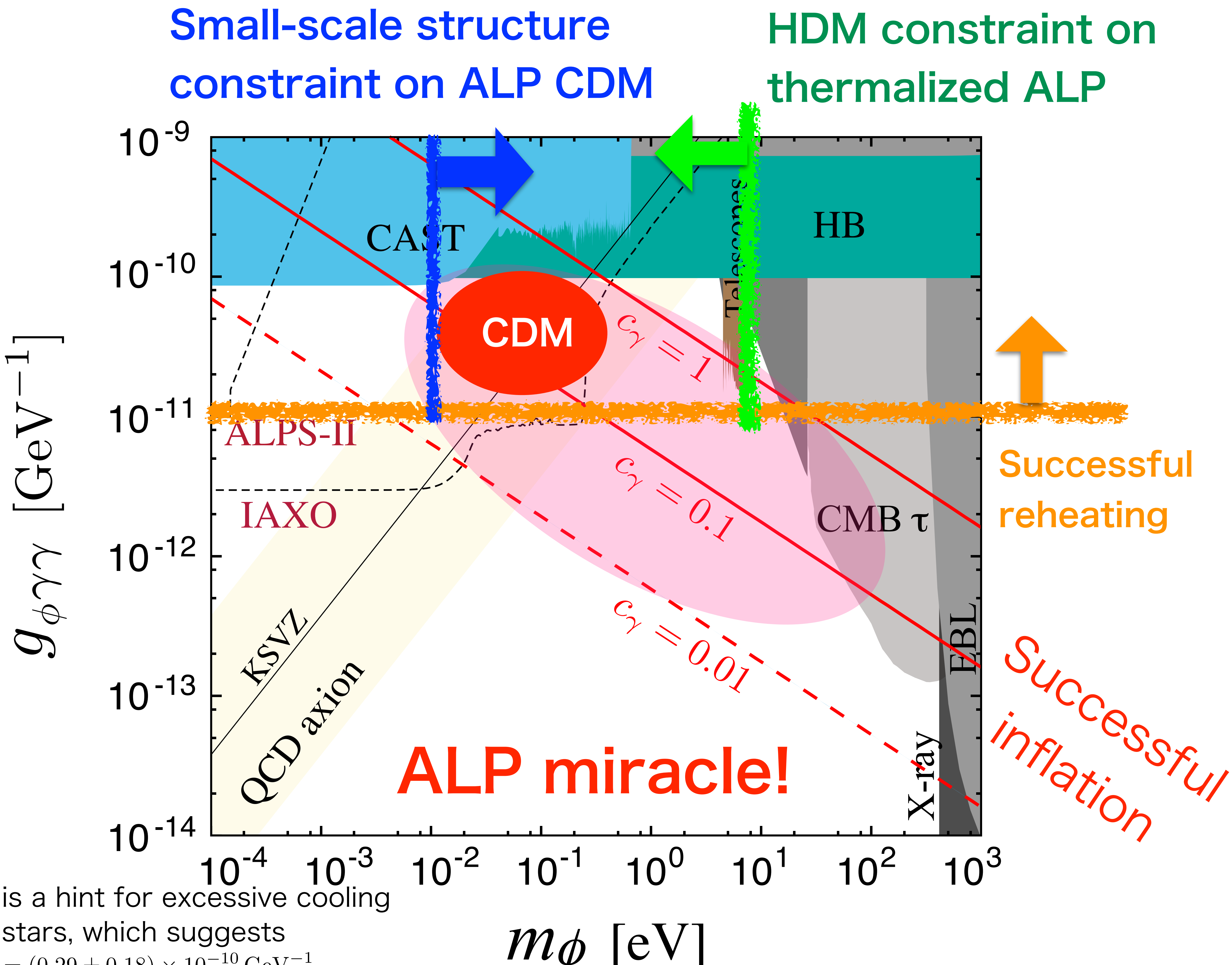

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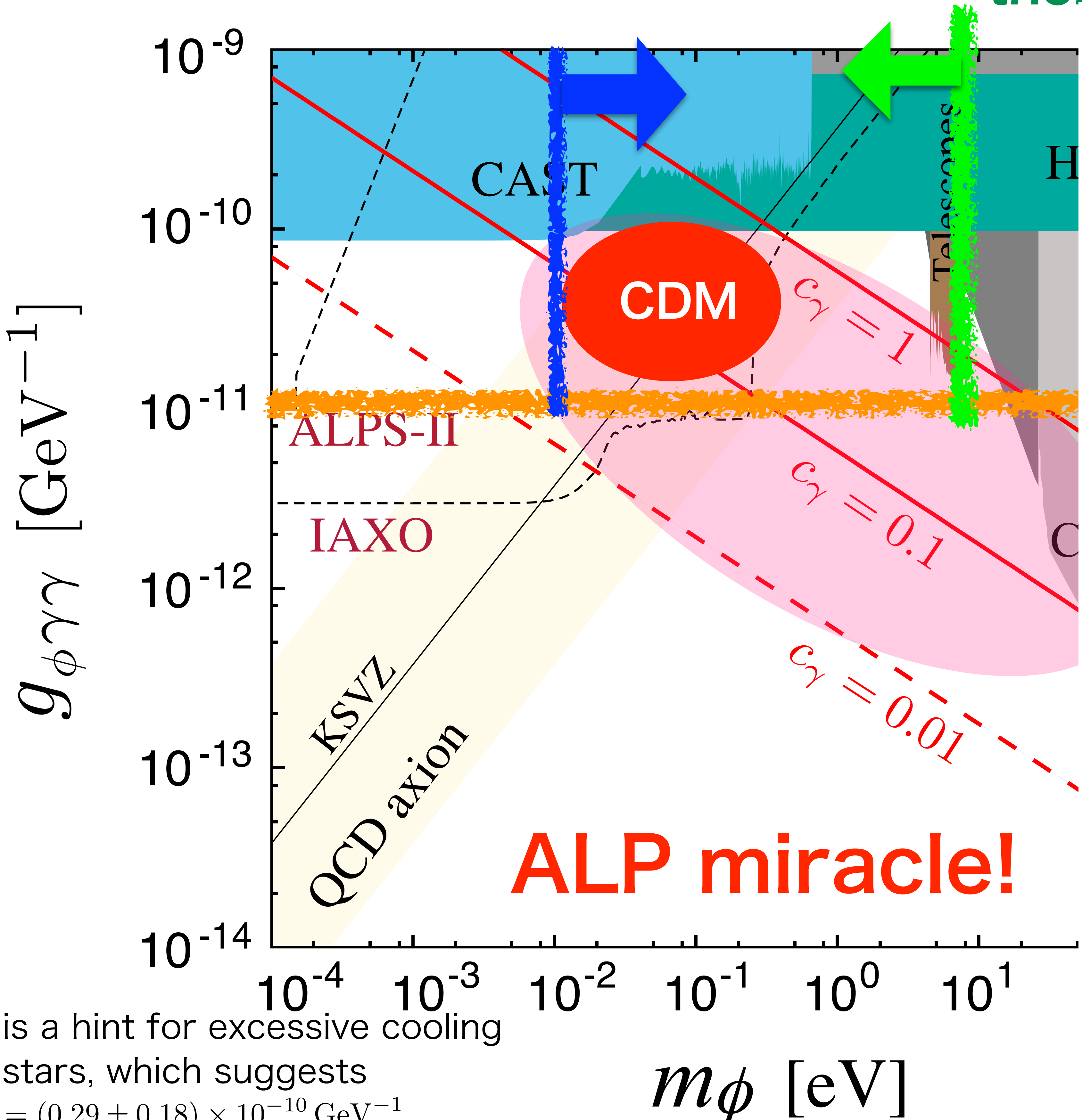
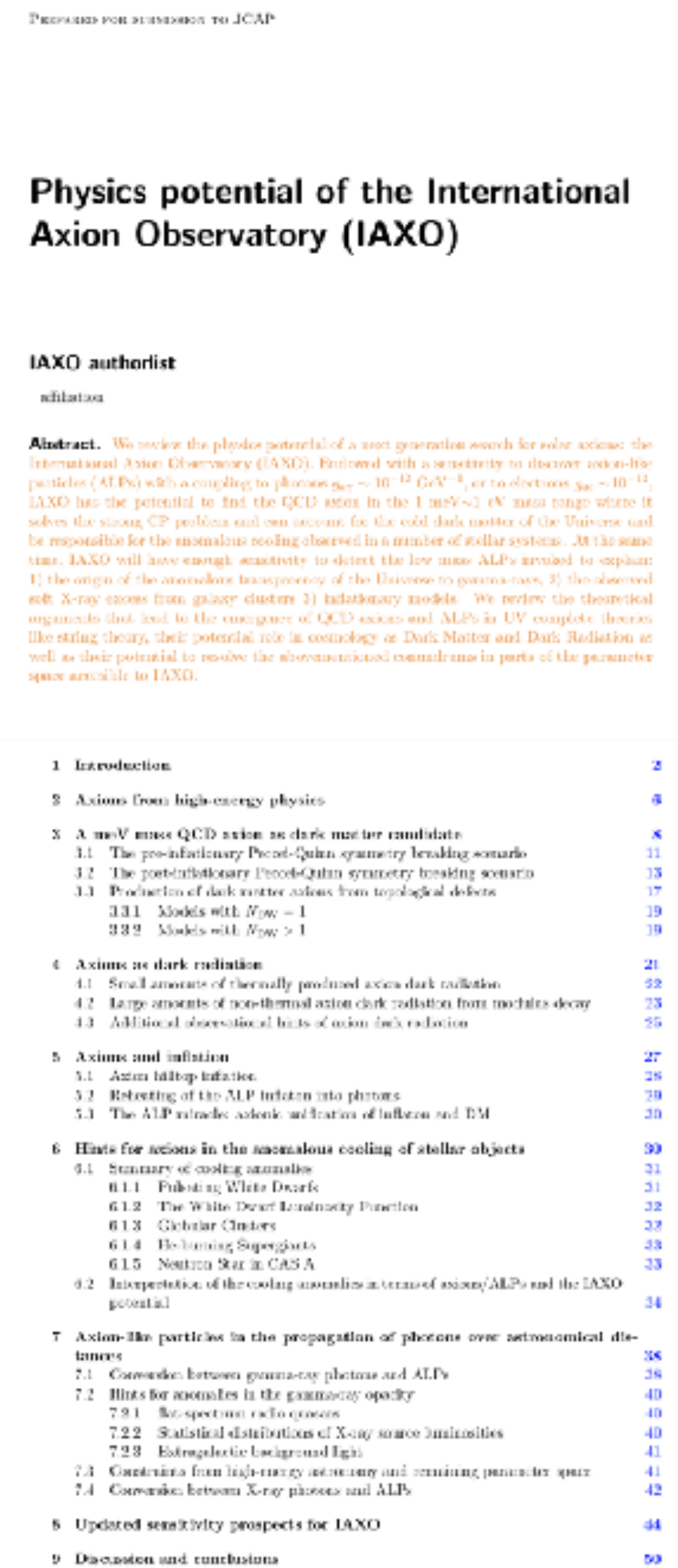
Small-scale structure constraint on ALP CDM

HDM constraint on thermalized ALP




Prepared for submission to JCAP

Physics potential of the International Axion Observatory (IAXO)

IAXO authorlist

affiliation

Abstract. We review the physics potential of a next generation search for solar axions: the International Axion Observatory (IAXO). Endowed with a sensitivity to discover axion-like particles (ALPs) with a coupling to photons $g_{a\gamma} \sim 10^{-12}$ GeV^{-1}, or to electrons $g_{ae} \sim 10^{-13}$, IAXO has the potential to find the QCD axion in the 1 meV∼1 eV mass range where it solves the strong CP problem and can account for the cold dark matter of the Universe and be responsible for the anomalous cooling observed in a number of stellar systems. At the same time, IAXO will have enough sensitivity to detect the low mass ALPs invoked to explain: 1) the origin of the anomalous transparency of the Universe to gamma-rays, 2) the observed soft X-ray excess from galaxy clusters 3) inflationary models. We review the theoretical arguments that lead to the emergence of QCD axions and ALPs in UV complete theories like string theory, their potential role in cosmology as Dark Matter and Dark Radiation as well as their potential to resolve the abovementioned conundrums in parts of the parameter space accessible to IAXO.

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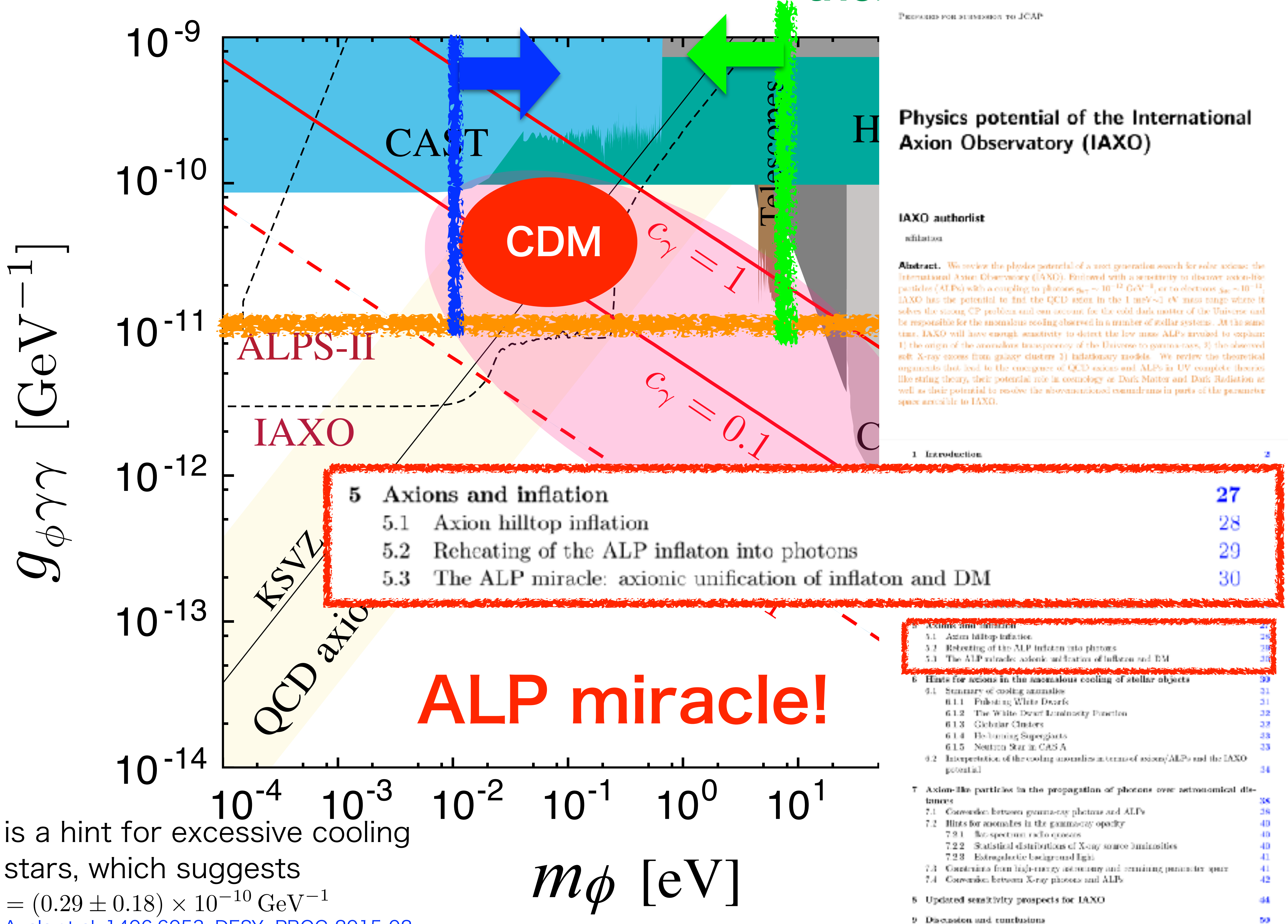

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