

Radio telescope probes on axions

Kenji Kadota
IBS Center for Theoretical Physics of the Universe (CTPU)
Institute for Basic Science, Korea



✓ Axion(-like) Particle

Axion-photon conversion

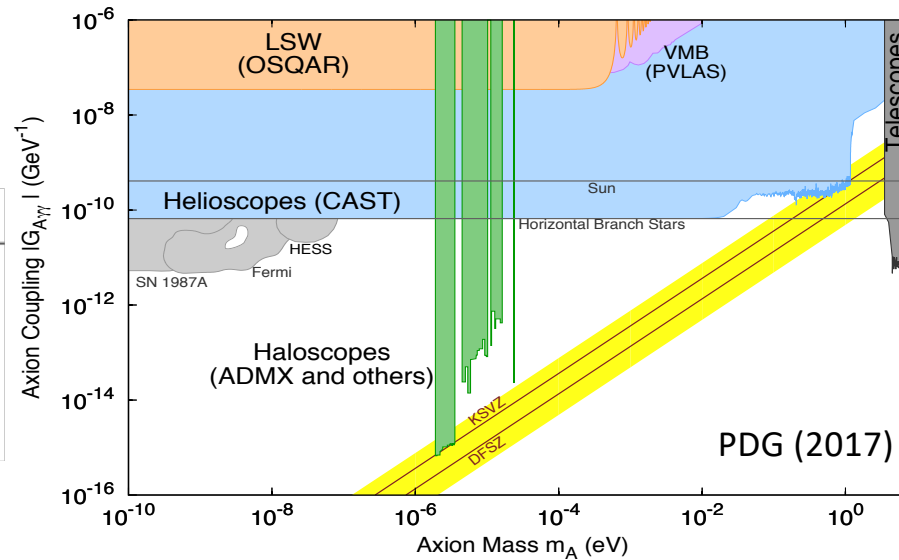
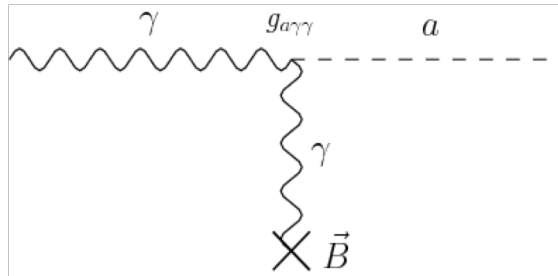
✓ Ultra-light axion-like particle

21 cm

➤ Conclusion

Primakoff effect

$$\frac{g_{a\gamma\gamma}}{4} a F \tilde{F} = -g_{a\gamma\gamma} a \mathbf{E} \cdot \mathbf{B}$$



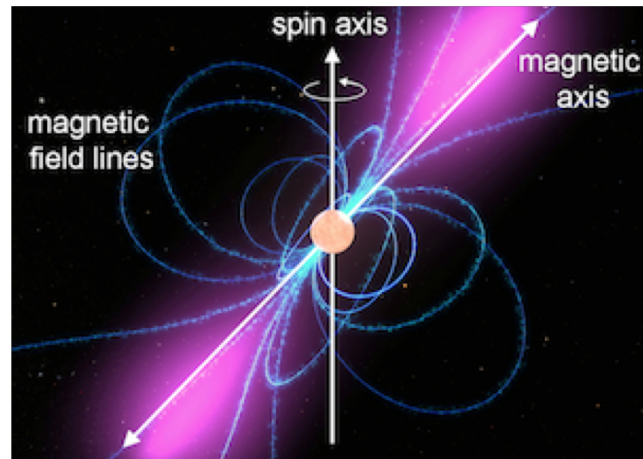
QCD axion as a CDM candidate : mass range $\mu\text{eV} \sim \text{meV}$ ($0.1\text{GHz} \sim 100\text{GHz}$)

New works: How about the astrophysically sourced magnetic fields?

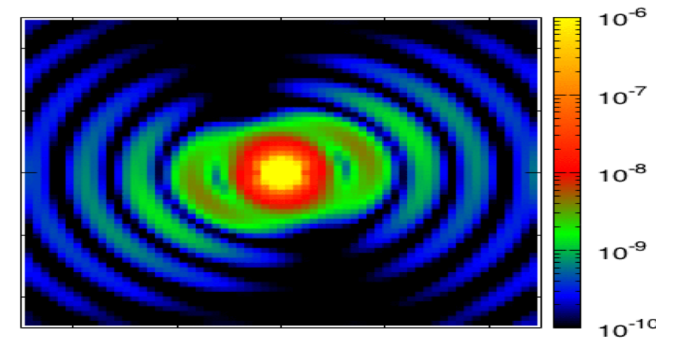
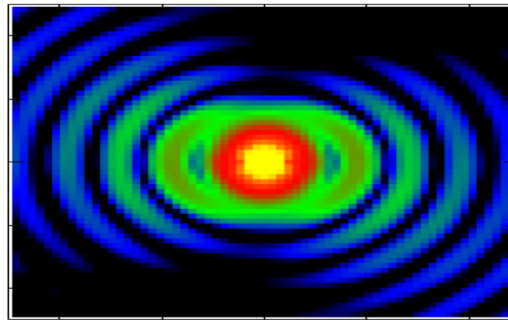
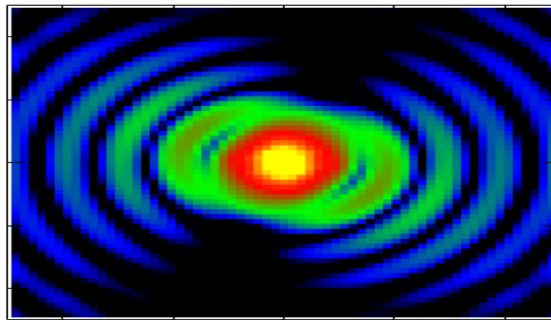
Non-resonant conversion: Kelley and Quinn (2017), Sigl (2017)

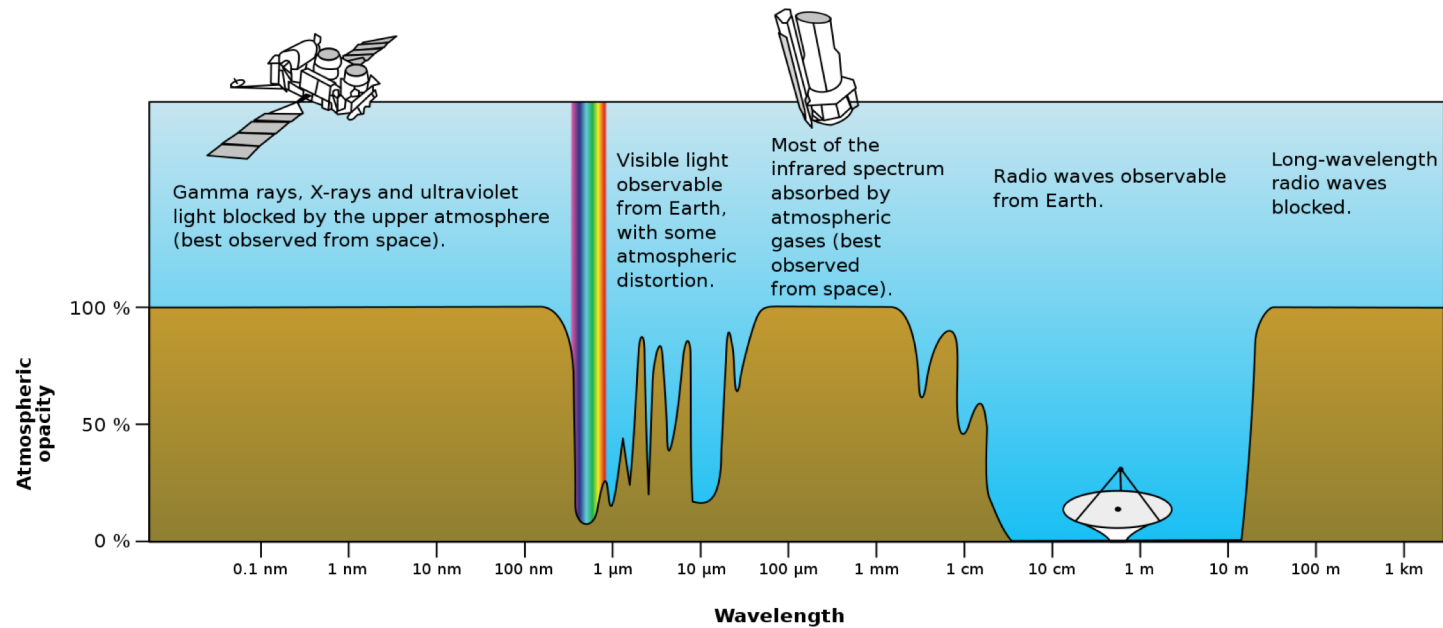
Resonant conversion: Huang, KK, Sekiguchi and Tashiro (2018), Hook, Kahn, Safdi and Sun (2018)

Line-like radio signal for non-relativistic axion conversion: $f \sim \frac{m_a}{2\pi} \sim 240 \left(\frac{m_a}{\mu\text{eV}} \right) \text{MHz}$



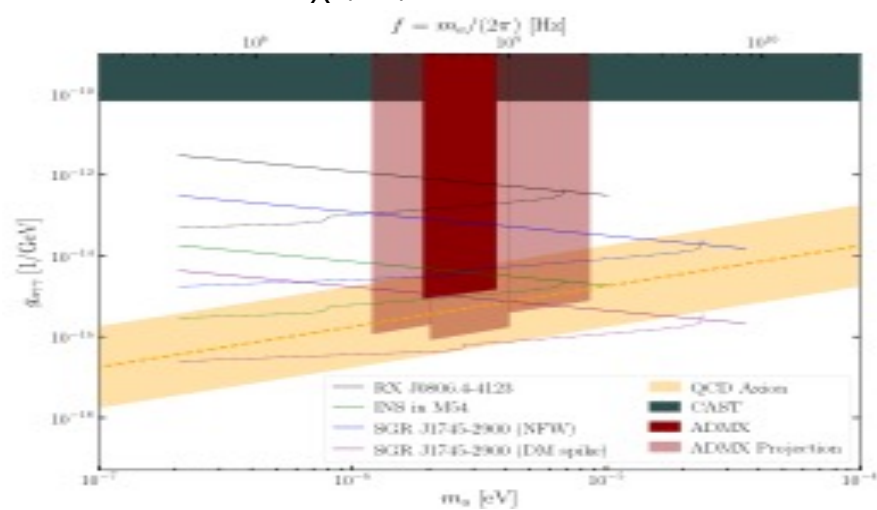
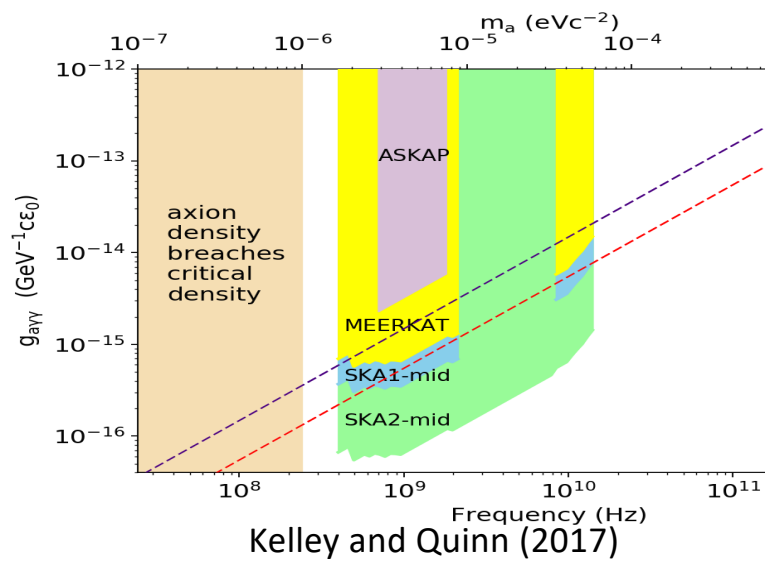
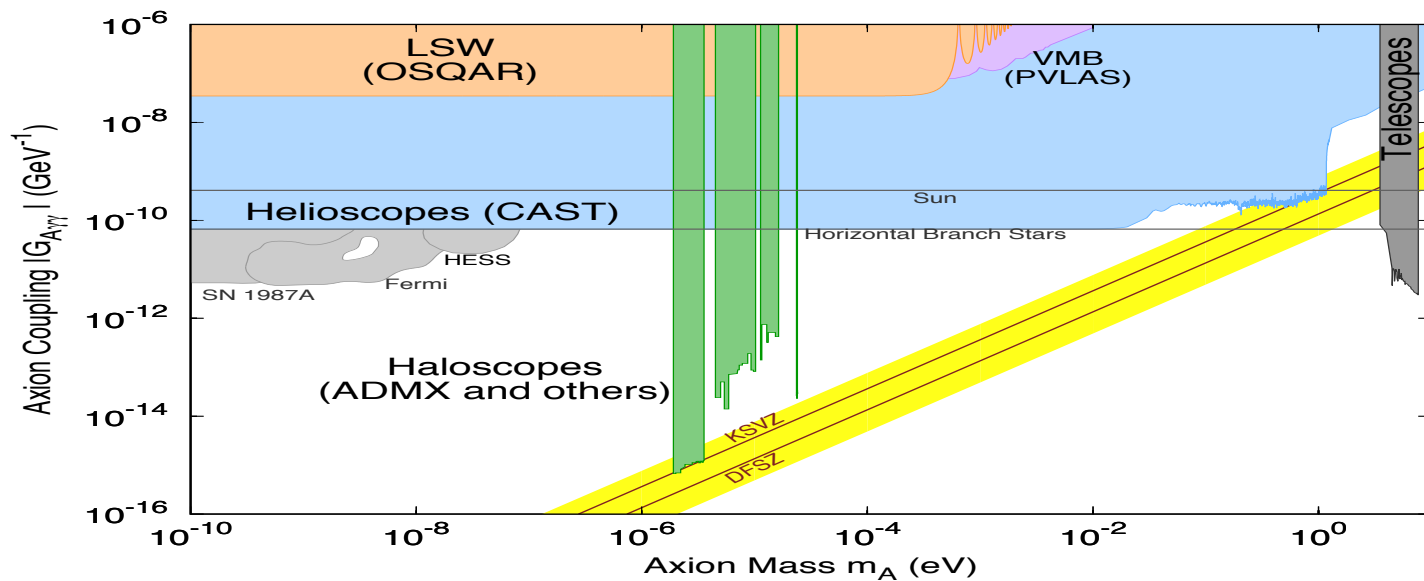
(KK & Kitajima, to appear)





Australia: SKA low: 50-350 MHz
 S. Africa: SKA mid: 350 MHz-14GHz
 Axion mass: $0.2 \sim 60 \mu\text{eV}$

QCD axion as a CDM candidate :
 Mass $\mu\text{eV} \sim \text{meV}$ (0.1GHz $\sim$ 100GHz)



Taiwan Dec 2018

Hook, Kahn, Safdi and Sun (2018)

Radio telescope probes on axions

Kenji Kadota
IBS Center for Theoretical Physics of the Universe (CTPU)
Institute for Basic Science, Korea



- ✓ Axion(-like) Particle

Axion-photon conversion

- ✓ Ultra-light axion-like particle

21 cm

- Conclusion

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

- Ultra-light mass :

$$m_u \sim H_0 \sim 10^{-33} \text{ eV}$$

DE (Barbieri et al (2005),...)

$$m_u \sim 10^{-22} \text{ eV}$$

Fuzzy DM (Hu (2000),...)

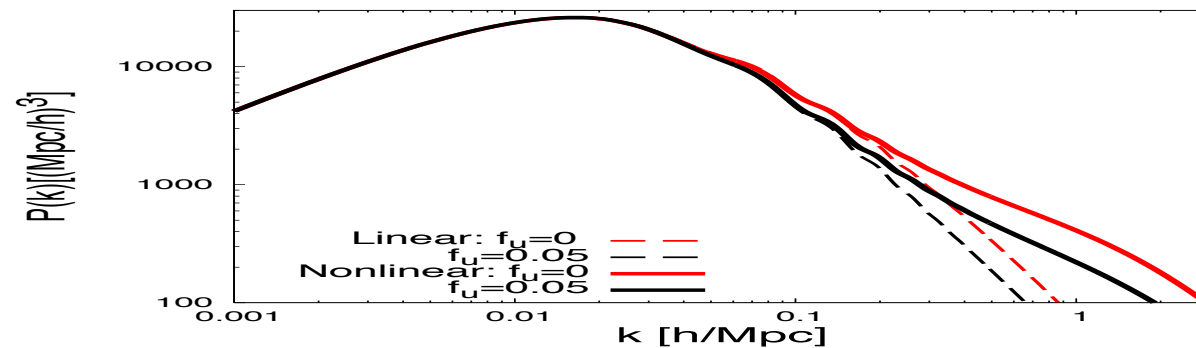
$$m_u \sim 10^{-22} \text{ eV} - 10^{-10} \text{ eV} \quad \text{String axiverse (Arvanitaki et al (2009),...)}$$

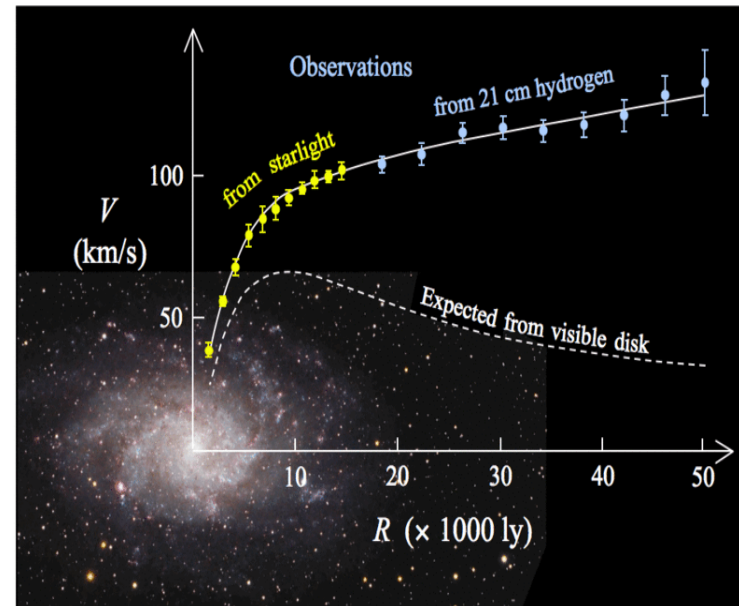
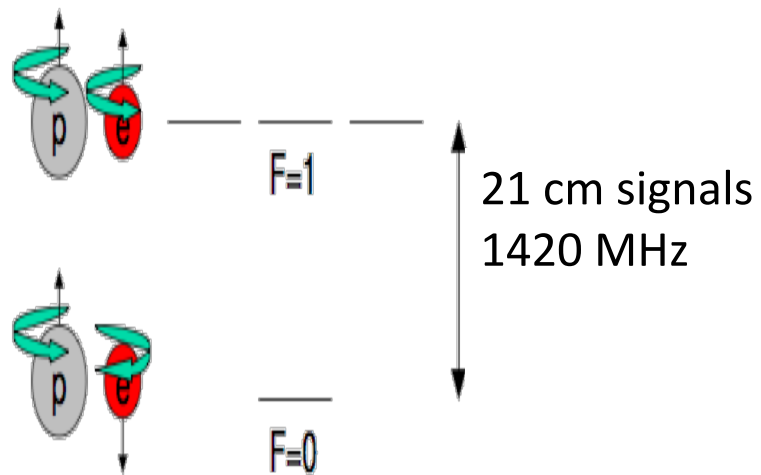
$$m_u, f_u = \Omega_u / \Omega_m \sim O(0.01)$$

$$m_u \leq H(t) : \rho_u = \text{const}$$

$$m_u > H(t) : \rho_u \propto 1/a^3$$

KK, Mao, Ichiki, Silk (2014)



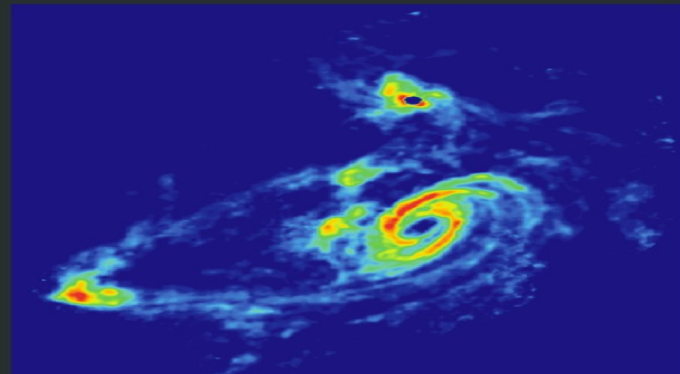


TIDAL INTERACTIONS IN M81 GROUP

Stellar Light Distribution



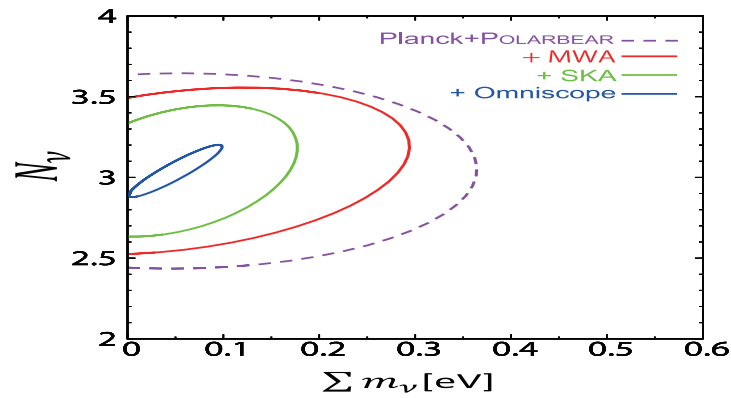
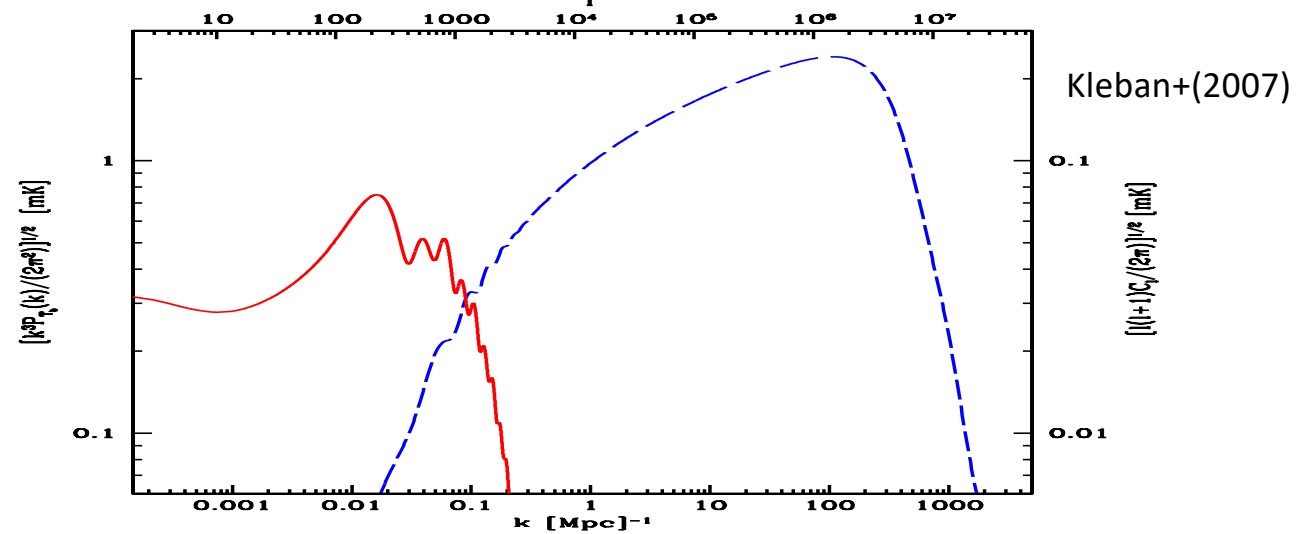
21 cm HI Distribution



What can we do with 21cm?

High precision on small-scale power spectrum

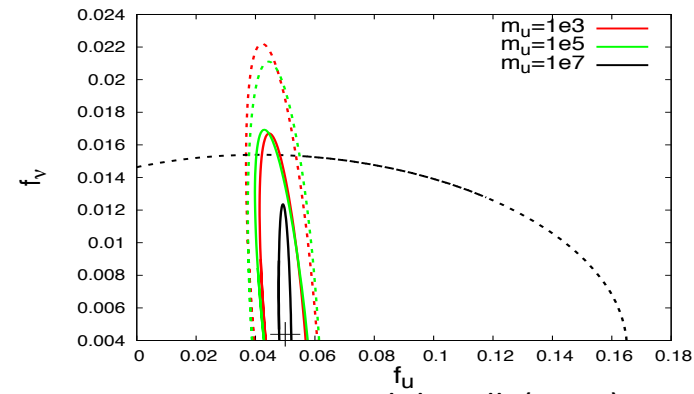
$$\Delta P / P \sim 1 / \sqrt{N}$$



Kenji Kadota (IBS)

Oyama+(2013)

Taiwan Dec 2018



KK, Mao, Ichiki, Silk (2014)

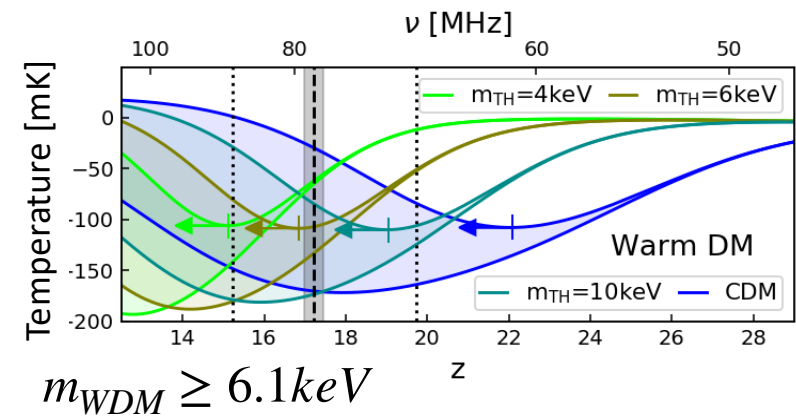
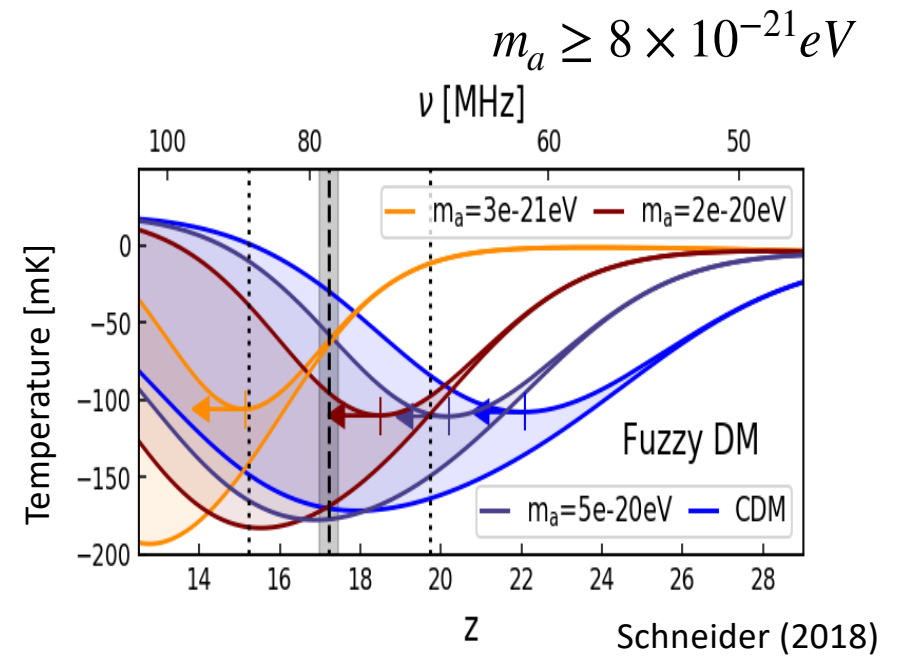
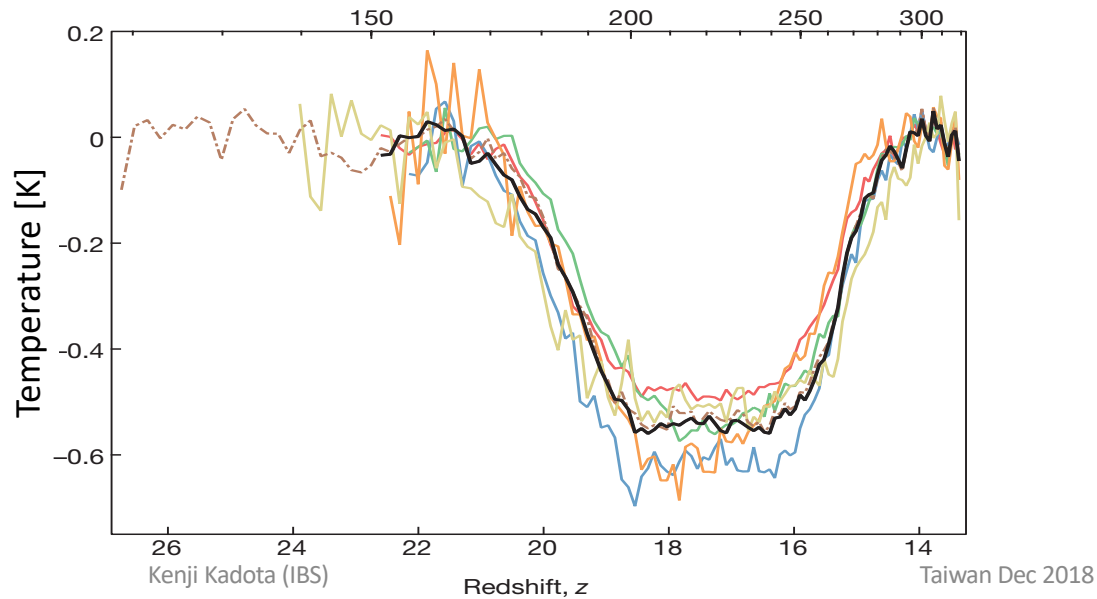


LETTER

doi:10.1038/nature25792

An absorption profile centred at 78 megahertz in the sky-averaged spectrum

Judd D. Bowman¹, Alan E. E. Rogers², Raul A. Monsalve^{1,3,4}, Thomas J. Mozdzen¹ & Nivedita Mahesh¹



Radio telescope probes on axions

Kenji Kadota
IBS Center for Theoretical Physics of the Universe (CTPU)
Institute for Basic Science, Korea



- ✓ Axion(-like) Particle

Axion-photon conversion

- ✓ Ultra-light axion-like particle

21 cm

➤ Conclusion

Experimental probes on light dark matter
Complementarity among different probes