Radio telescope probes on Axion dark matter

Kenji Kadota (CTPU, IBS)

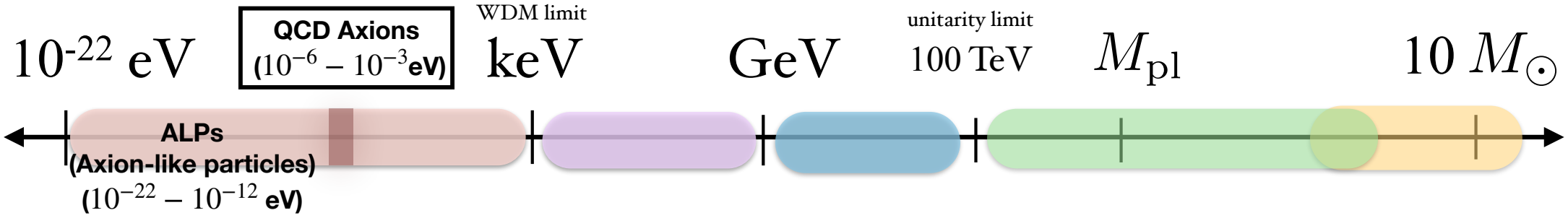
Based on the collaboration with
Fa-Peng Huang (Univ. of Washington), Kiyotomo Ichiki (Nagoya Univ), Toyokazu Sekiguchi (KEK), Hayato Shimabukuro (Yunnann Univ), Hiroyuki Tashiro (Nagoya Univ)

(1)Radio signals from the neutron stars

(through axion-photon conversion)

(2) 21cm probes on small scale structure evolutions

(through huge axion fluctuations at small scales)



``Ultralight" DM

non-thermal
bosonic fields

``Light" DM

dark sectors
sterile ν
can be thermal

WIMP

Composite DM
(Q-balls, nuggets, etc)

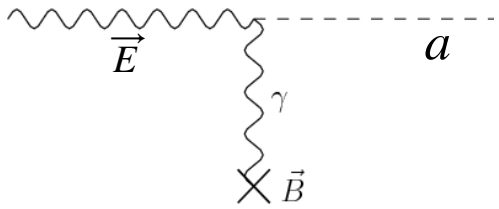
Primordial
black holes

Lin (2019)

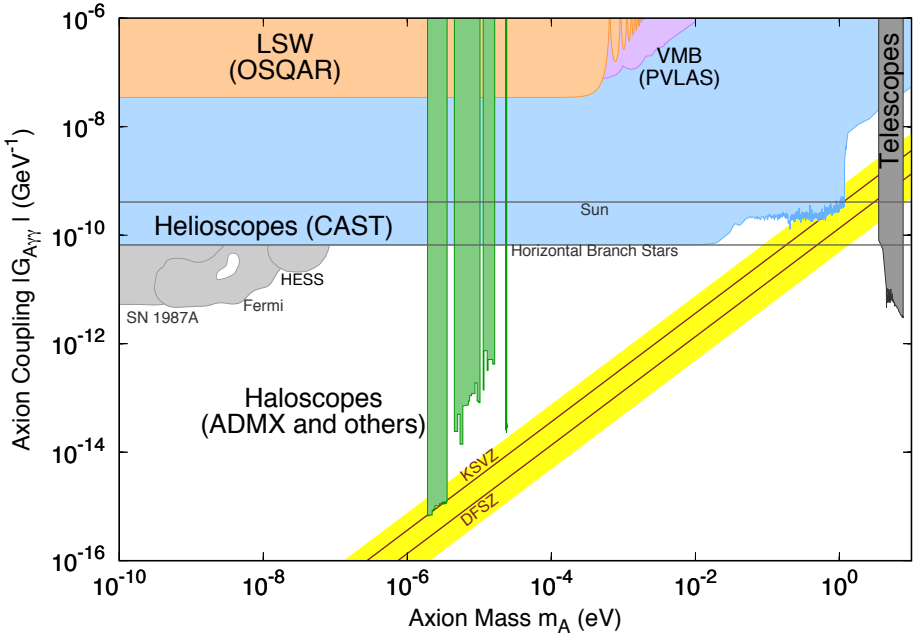
If QCD axion is CDM:

Target mass: $\mu eV - meV(0.1GHz - 100GHz)$

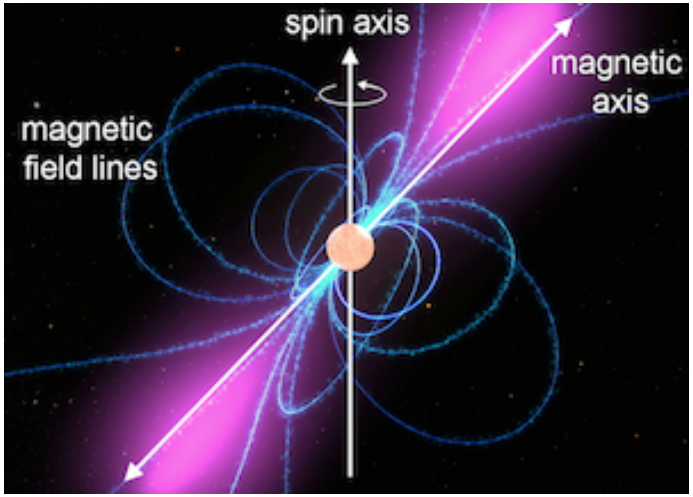
Primakoff effect $g_{a\gamma\gamma} a\mathbf{E}\cdot\mathbf{B}$



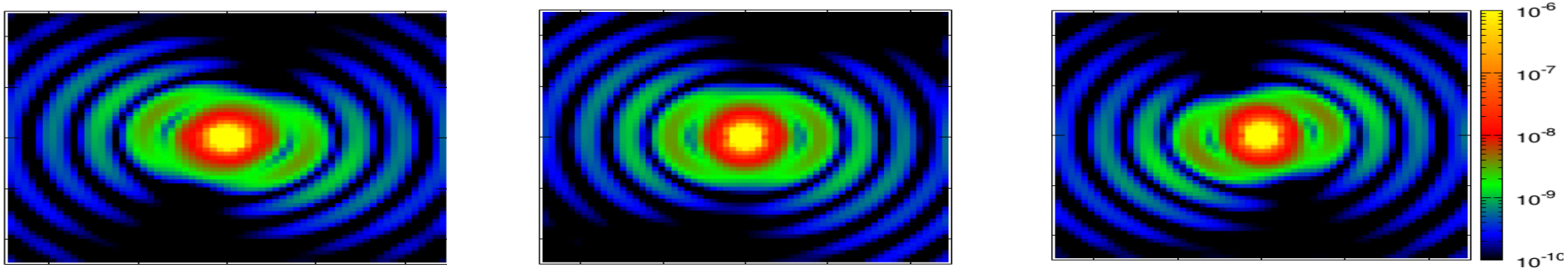
Radio Line signal $f \sim \frac{m_a}{2\pi} \sim 240\left(\frac{m_a}{\mu eV}\right) MHz$

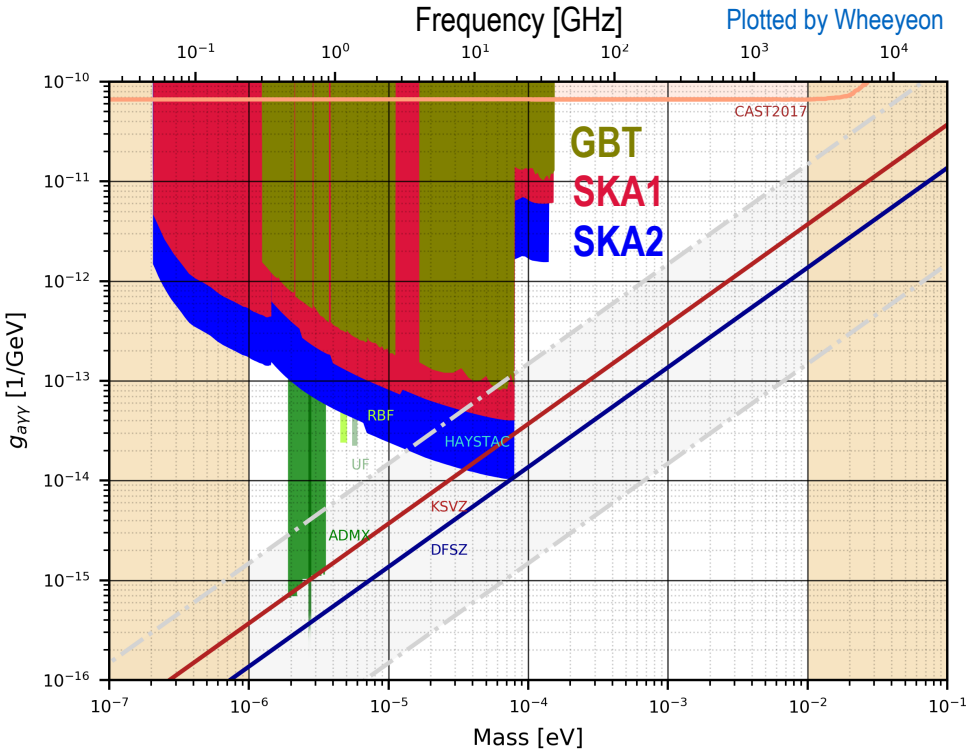


The radio telescope search for the resonant conversion of cold dark matter axions from the neutron stars (Huang, KK, Sekiguchi and Tashiro (2018), Hook,Kahn,Safdi and Sun (2018))



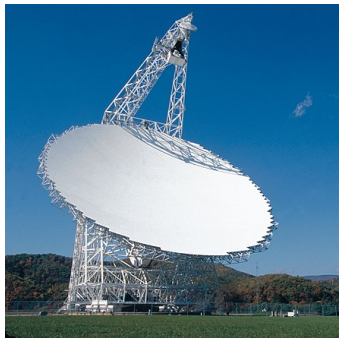
(KK & Kitajima, to appear)



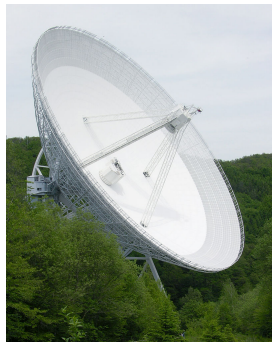


First results with actual data

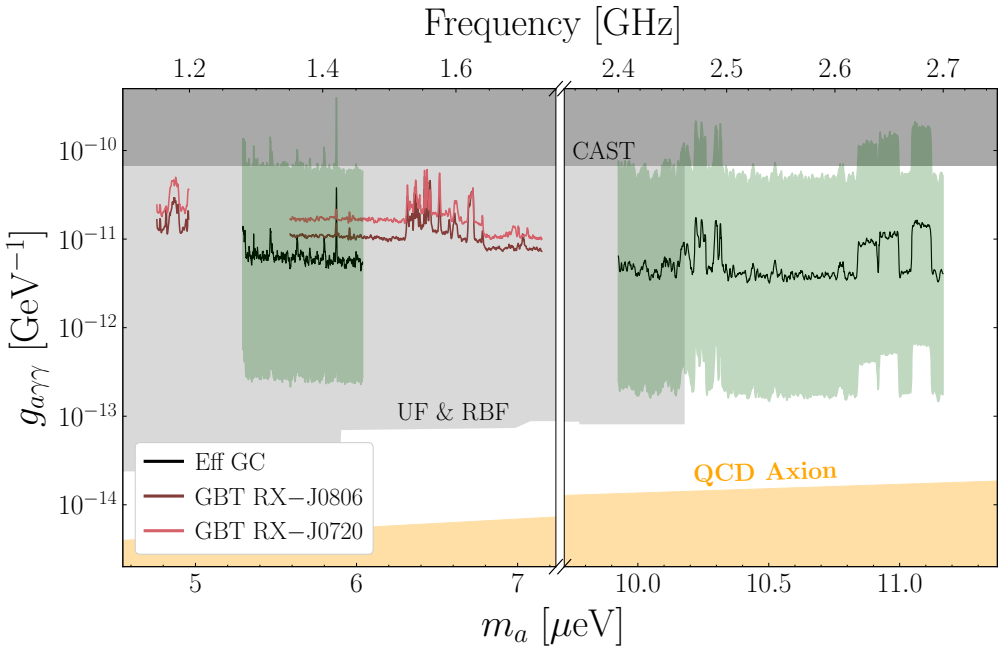
(Foster et al [2004.00011])



(Green Bank Telescope)



(Effelsberg Radio Telescope)



Radio telescope probes on Axion dark matter

Based on the collaboration with
Fa-Peng Huang (Univ. of Washington), Kiyotomo Ichiki (Nagoya Univ), Toyokazu Sekiguchi (KEK), Hayato Shimabukuro (Yunnann Univ), Hiroyuki Tashiro (Nagoya Univ)

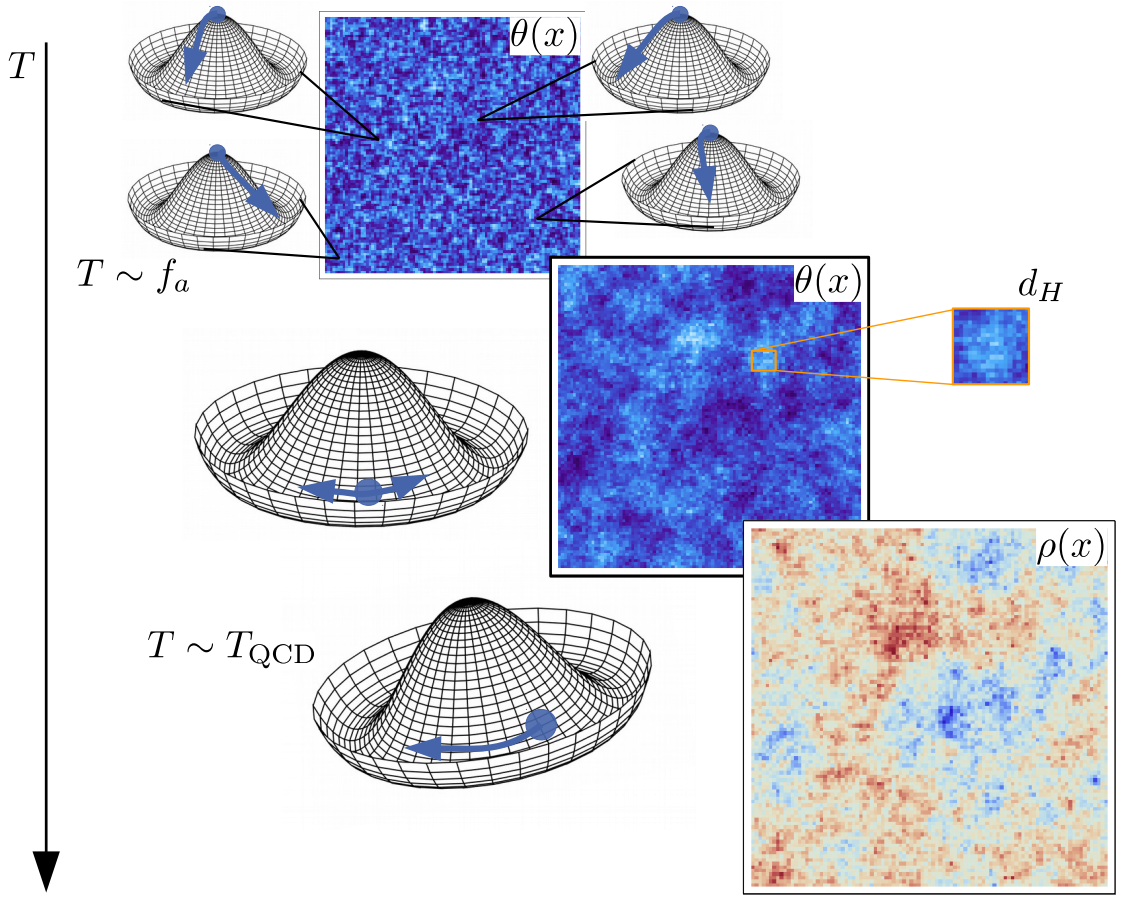
(1)Radio signals from the neutron stars

(through axion-photon conversion)

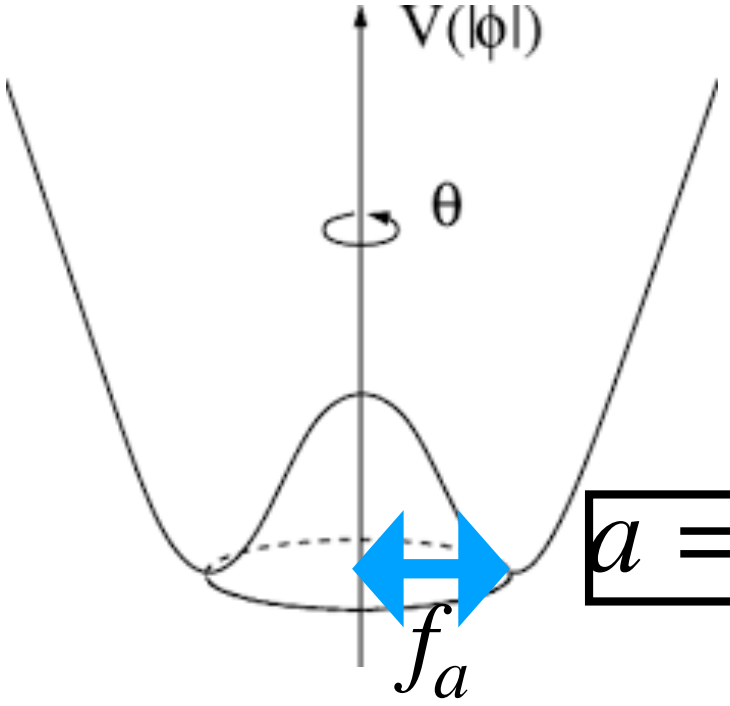
(2) 21cm probes on small scale structure evolutions

(through huge axion fluctuations at small scales)

Axion-like particles in the **post-inflation** symmetry breaking scenarios



Credit: Pargner



$$a = f_a \theta$$

$$\rho_a \sim m_a^2 a^2 \sim \theta^2$$

$$\delta_a \equiv (\rho_a - \bar{\rho}_a)/\bar{\rho}_a$$

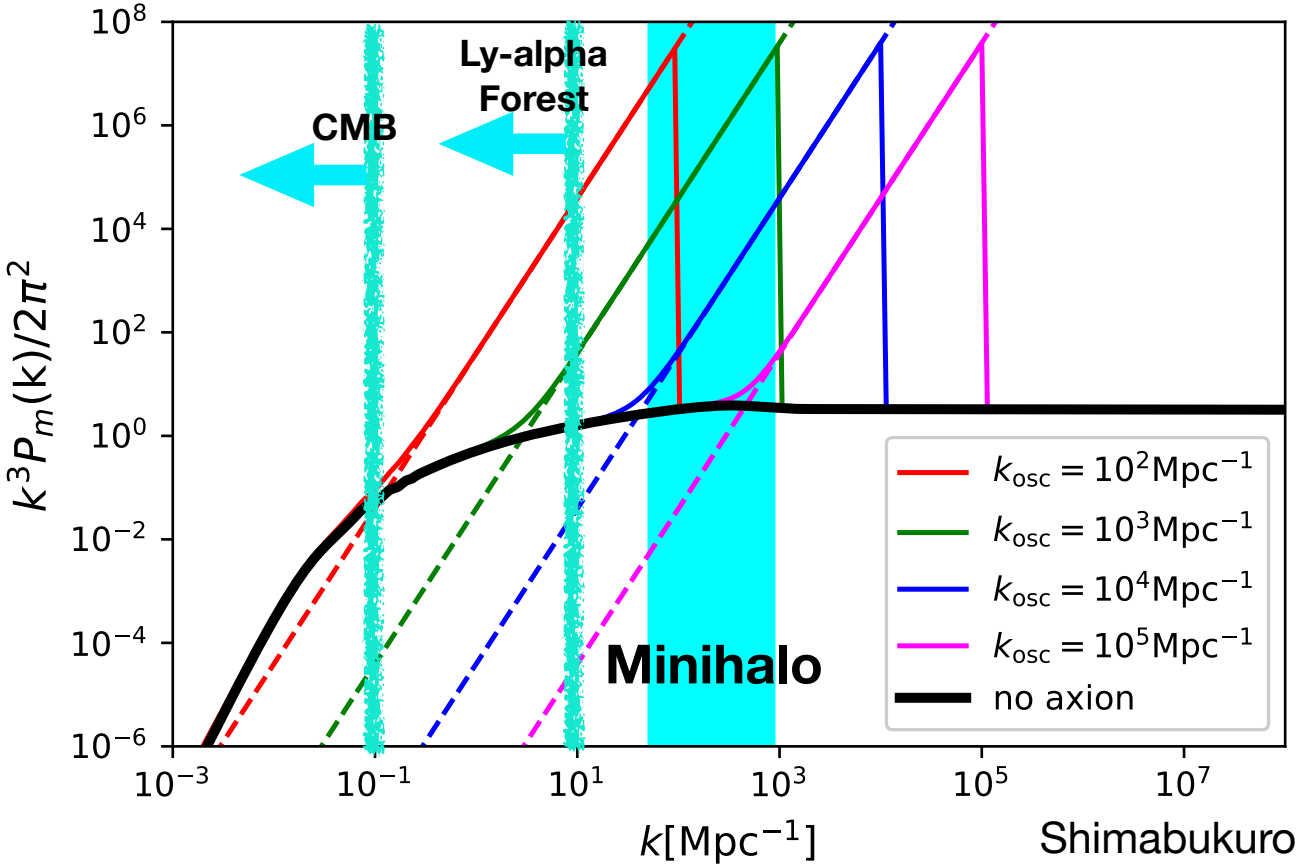
$$\sigma^2 \equiv \langle \delta_a^2 \rangle = (2\pi)^{-3} \int_0^{k_{osc}} d^3k P(k) = \frac{4}{5}$$

$$P_{iso} \propto \frac{1}{k_{osc}^3} \Theta(k_{osc} - k)$$

Enhancement of minihalo abundance

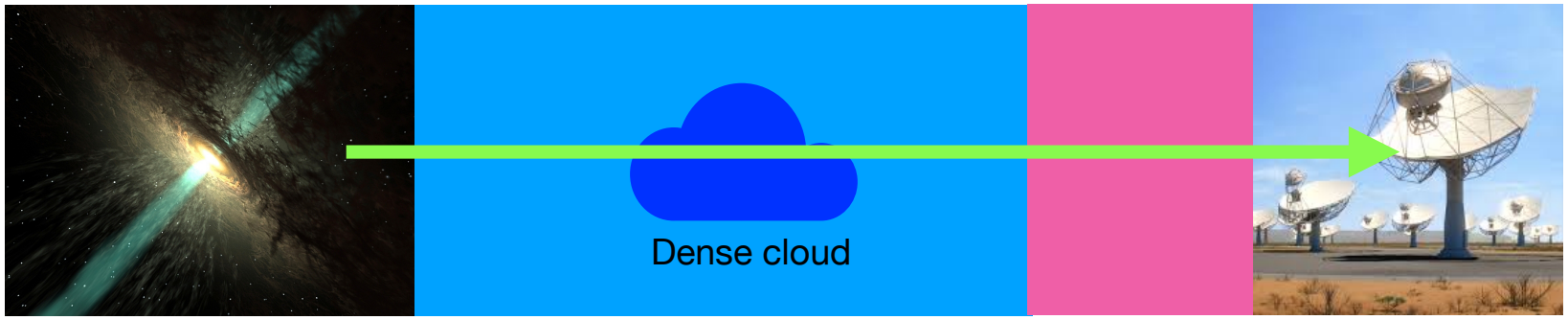
$$P_{total} = P_{adi} + P_{iso} \quad (P_{iso} \propto 1/k_{osc}^3)$$

Minihalo: $10^4 M_{sun} \lesssim M \lesssim 10^8 M_{sun}$



Shimabukuro, Ichiki, KK (2020)

21cm forest

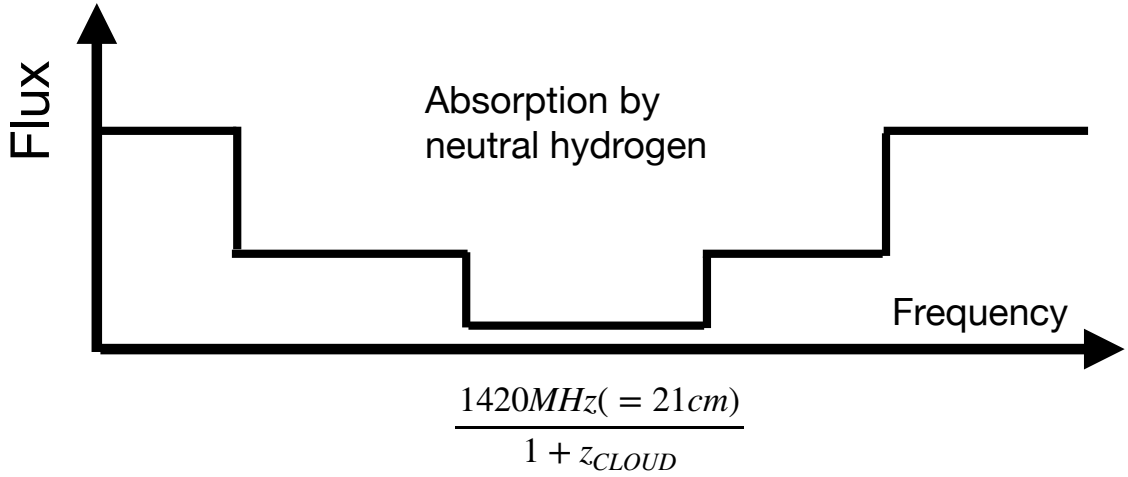


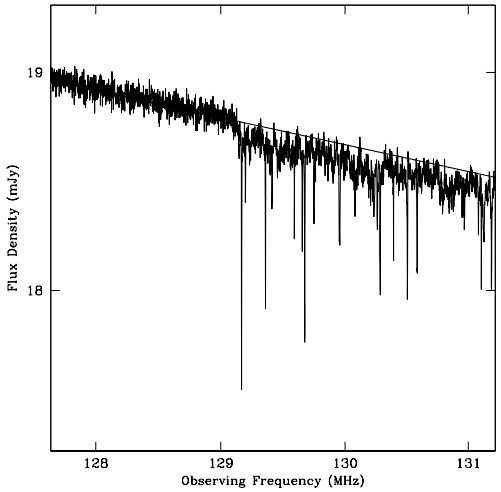
21cm signals from minihalo:

1) Radio background: Shimabukuro, Ichiki, KK (2020)

2) CMB background: KK, Sekiguchi, Tashiro (2020)

21cm: $m_a > 10^{-13} eV$ **Ly-alpha:** $m_a > 10^{-17} eV$ **CMB:** $m_a > 10^{-20} eV$





(Carilli+ 2002)

Conclusion/Possible discussions with Nagoya groups

1) Radio search from the magnetosphere around the neutron stars

So far, done only for Greenbank and Effelsberg radio telescope data (a total observation of 2 hours)

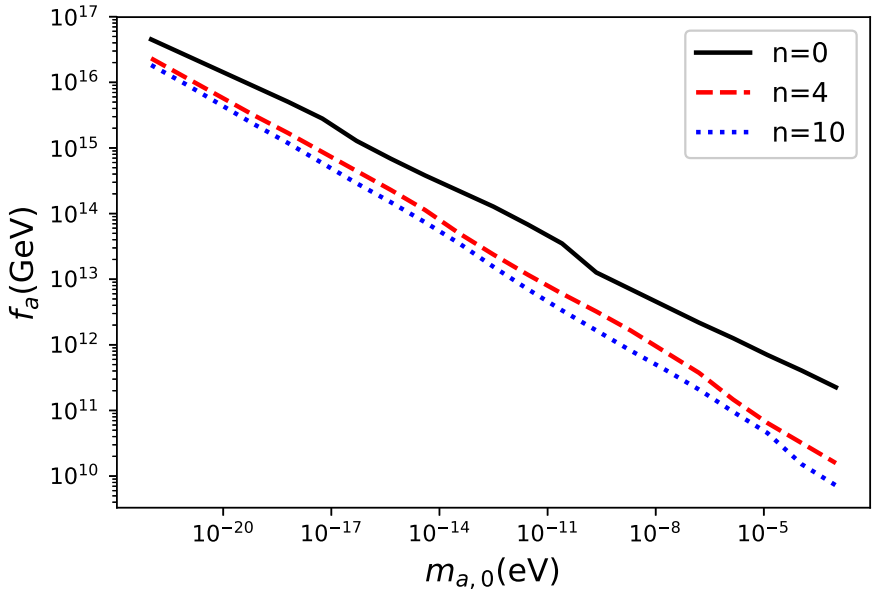
Possible discussions:
Using other available radio data
(the interferometer (e.g. MWA, LOFAR) data and the FAST data)

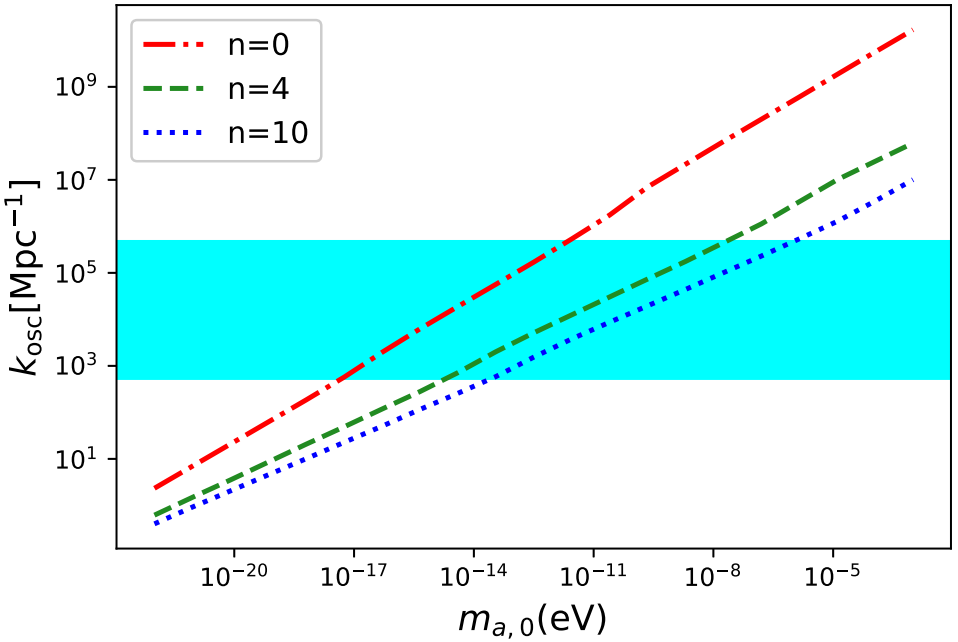
2) The effects of the large isocurvature perturbations at the small scales

I discussed the 21cm signals

Possible discussions:
Using other cosmological data
(Gravitational lensing, CMB, gravitational wave etc)

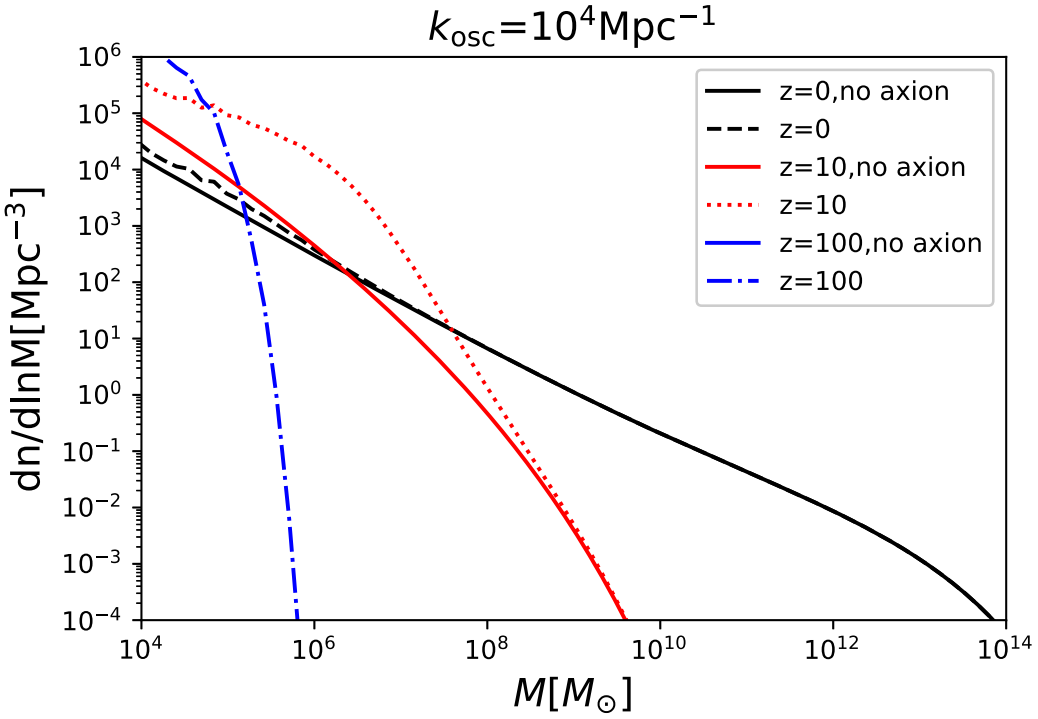
Post-inflation breaking?

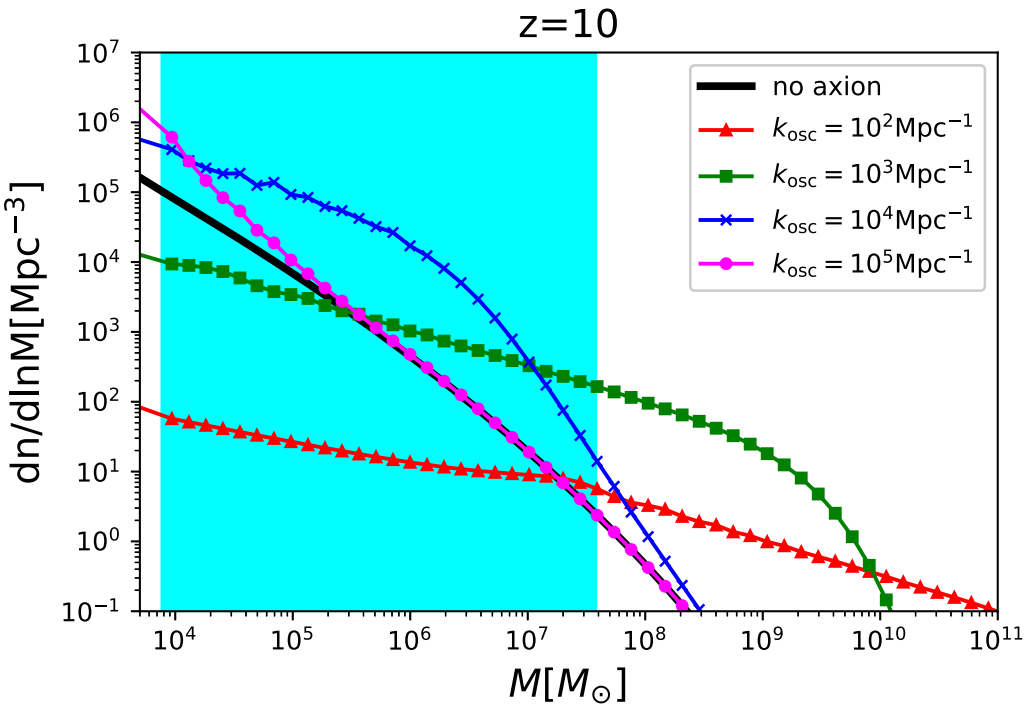




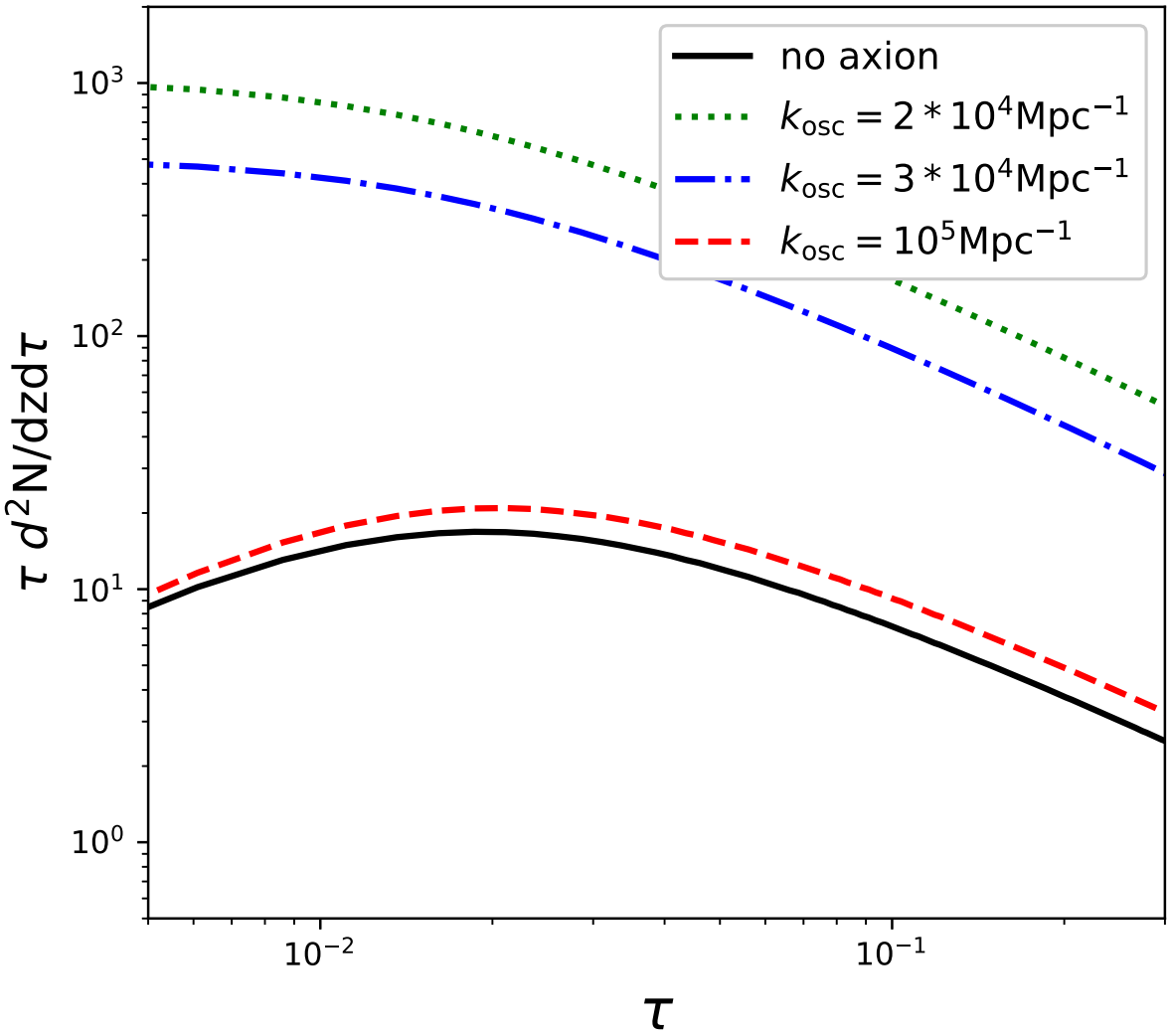
$$m_a = m_{a0}(T/\mu)^{-n}$$

$$\mu = \sqrt{m_{a0} f_a}$$





Shimabukuro, Ichiki, KK (2020)



Shimabukuro, Ichiki, KK (2020)

Banados+(2018)