Axion(-like) Dark Matter

Kenji Kadota
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- ✓ Axion : Overview

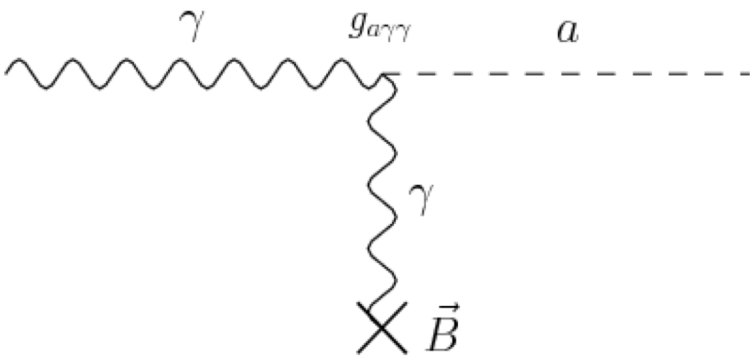
  Radio (SKA-like) survey : axion-photon conversion

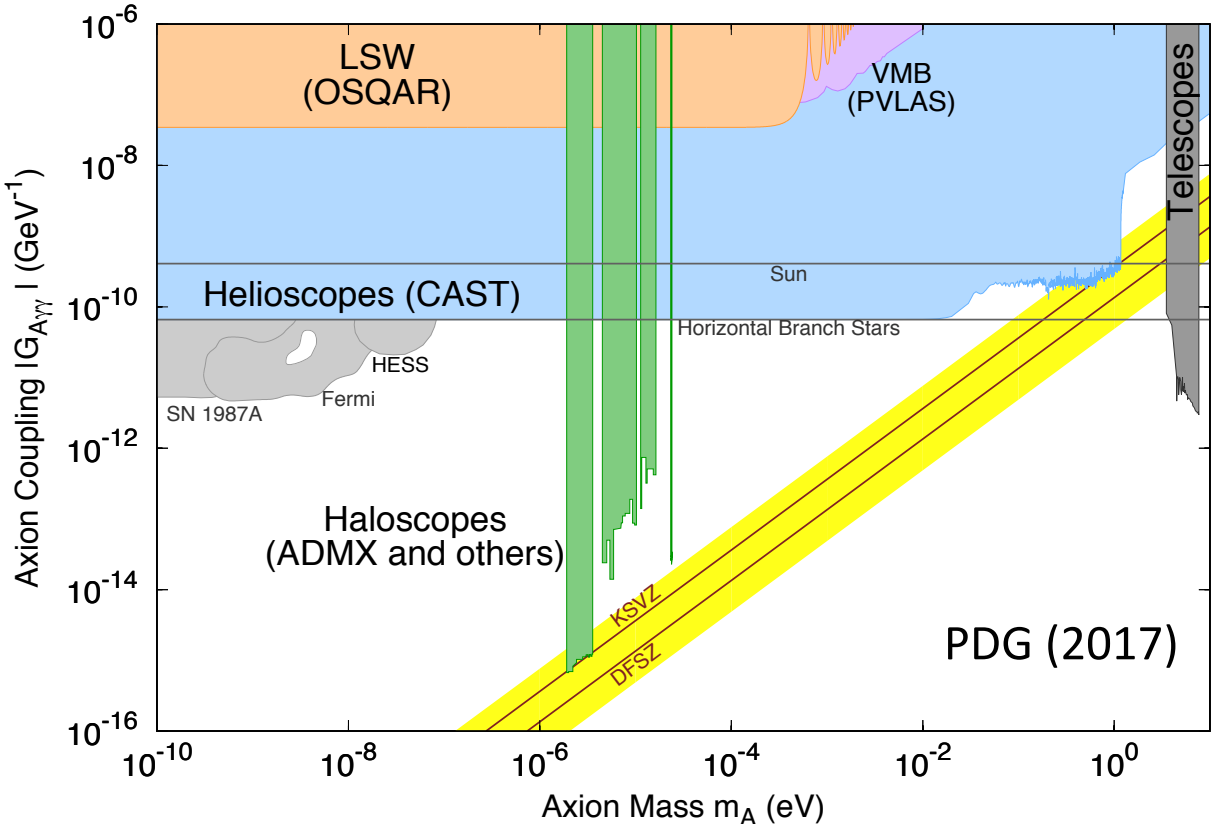
- ✓ Axion(-like) Particle : Ultra light particle

  Radio (SKA-like) survey : 21cm

Primakoff effect

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





QCD axion as a CDM candidate : mass range μeV ~ meV(0.1GHz ~ 100GHz)

Previous works: CDM axions converted into photons in the labs.

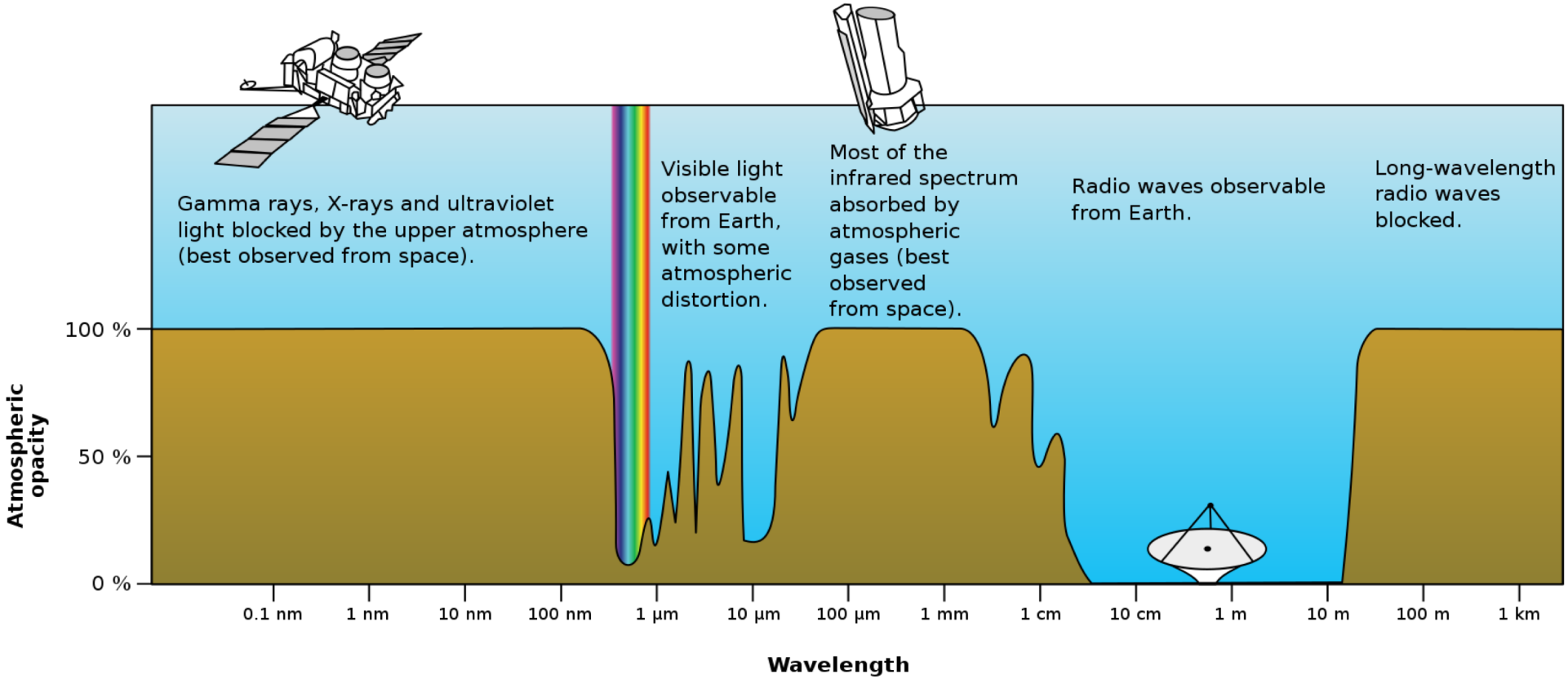
New works: How about the astrophysically sourced magnetic fields?

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:

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



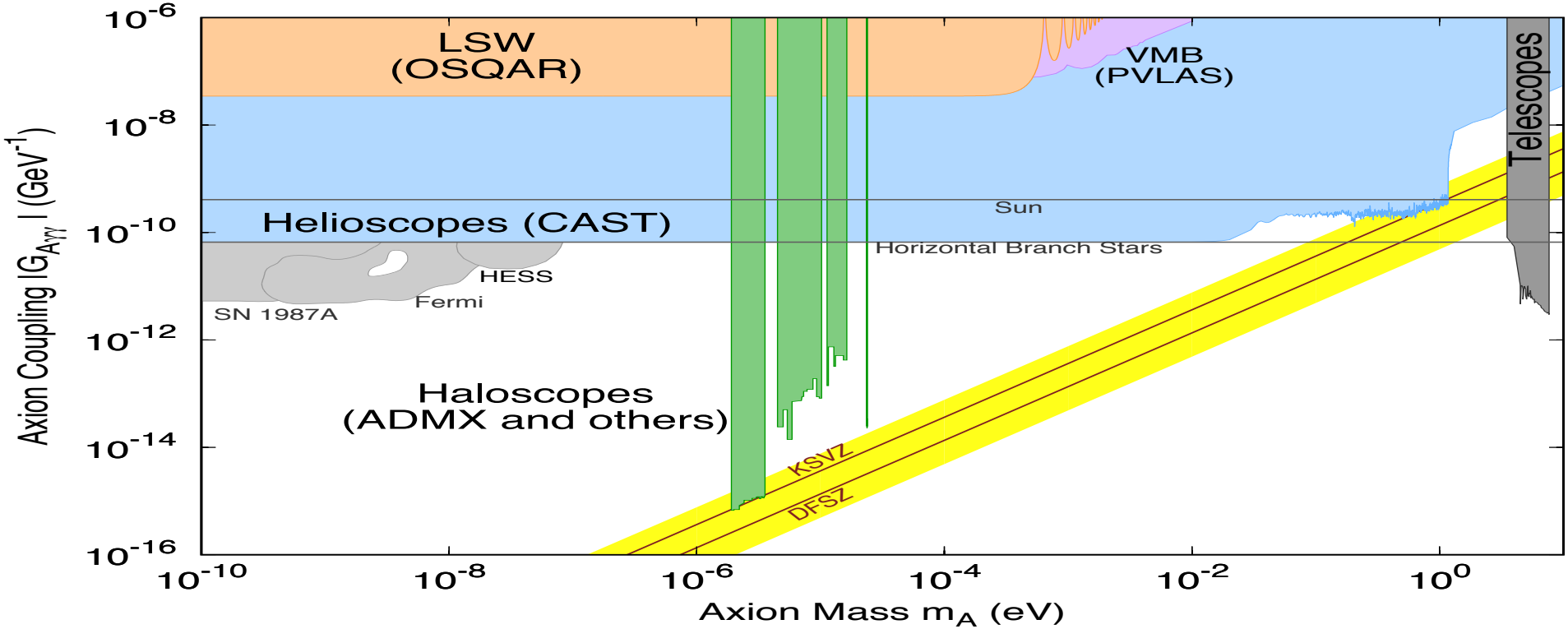
Australia: SKA low: 50-350 MHz

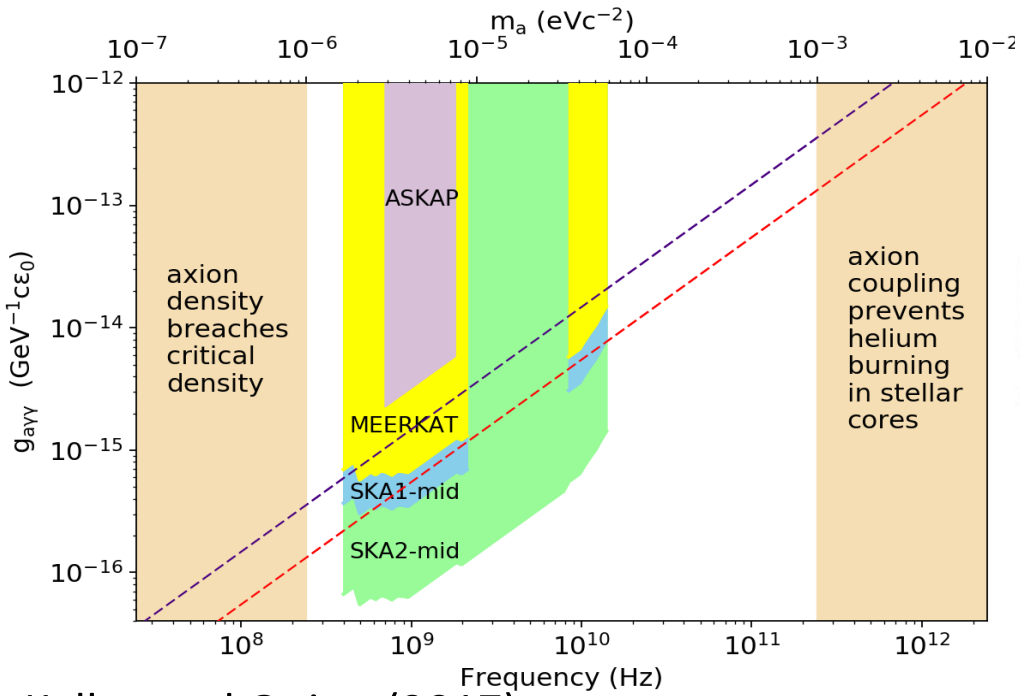
S. Africa: SKA mid: 350 MHz-14GHz

Axion mass: $0.2 \sim 60\ \mu eV$

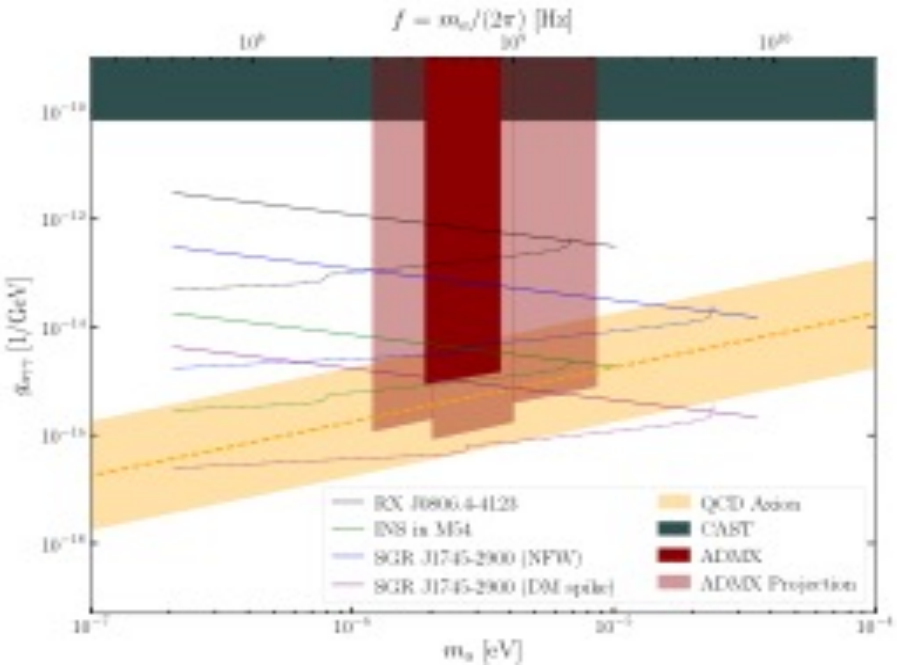
QCD axion as a CDM candidate :

Mass µeV ~ meV(0.1GHz ~ 100GHz)





Kelley and Quinn (2017)



Hook,Kahn,Safdi and Sun(2018)

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

- Ultra-light mass :

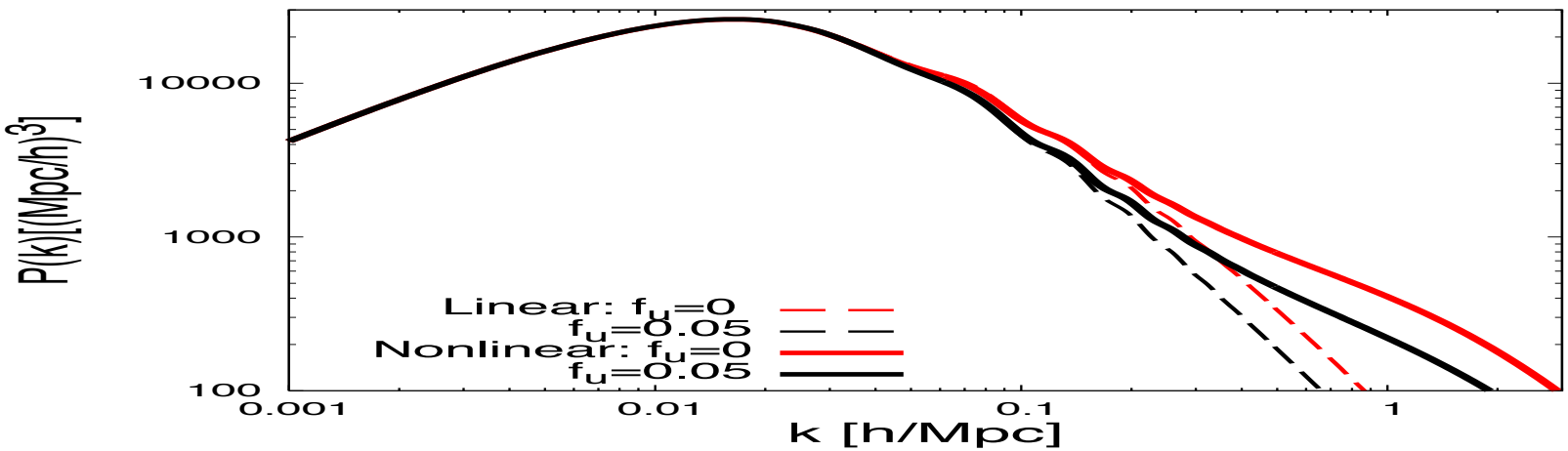
$m_u \sim H_0 \sim 10^{-33} eV$ DE (Barbieri et al (2005),…)

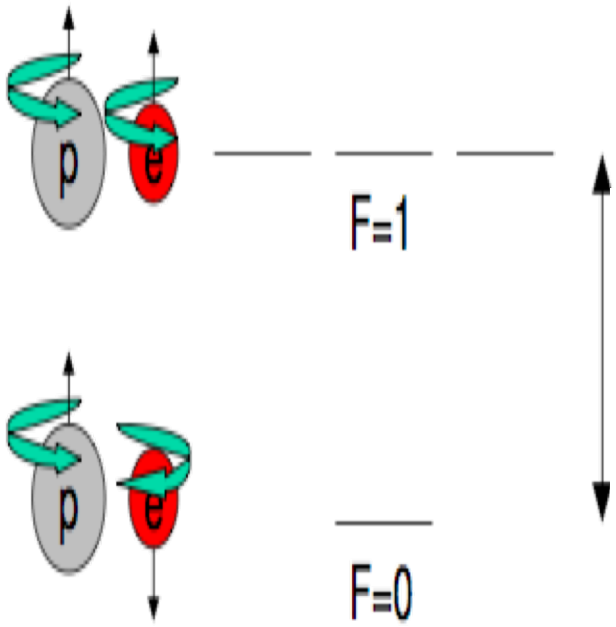
$m_u \sim 10^{-22} eV$ Fuzzy DM (Hu (2000),…)

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

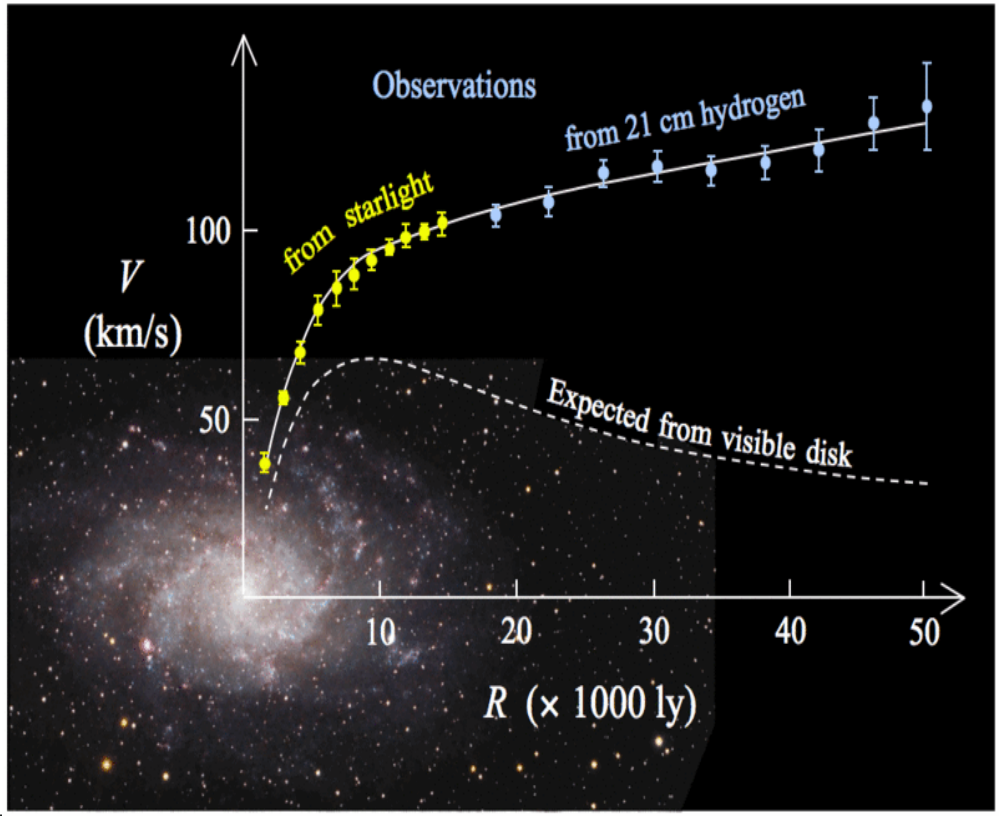
$$m_u, f_u = \Omega_u / \Omega_m \sim O(0.01)$$
$$m_u \leq H(t) : \rho_u = const$$
$$m_u > H(t) : \rho_u \propto 1/a^3$$

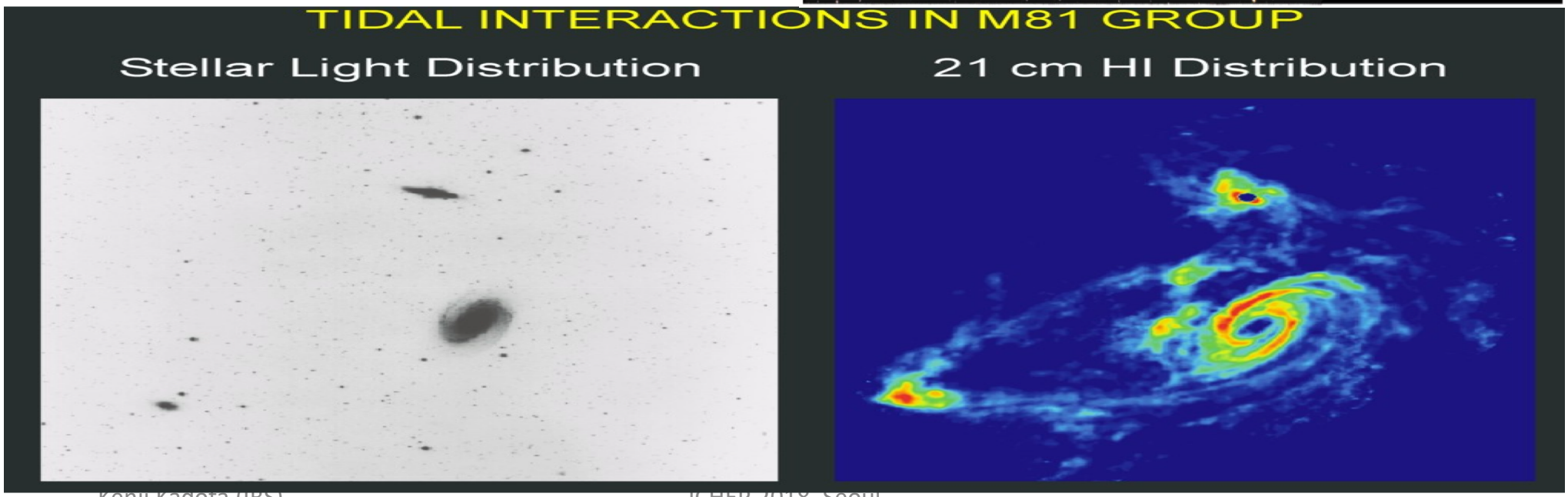
KK, Mao, Ichiki, Silk (2014)





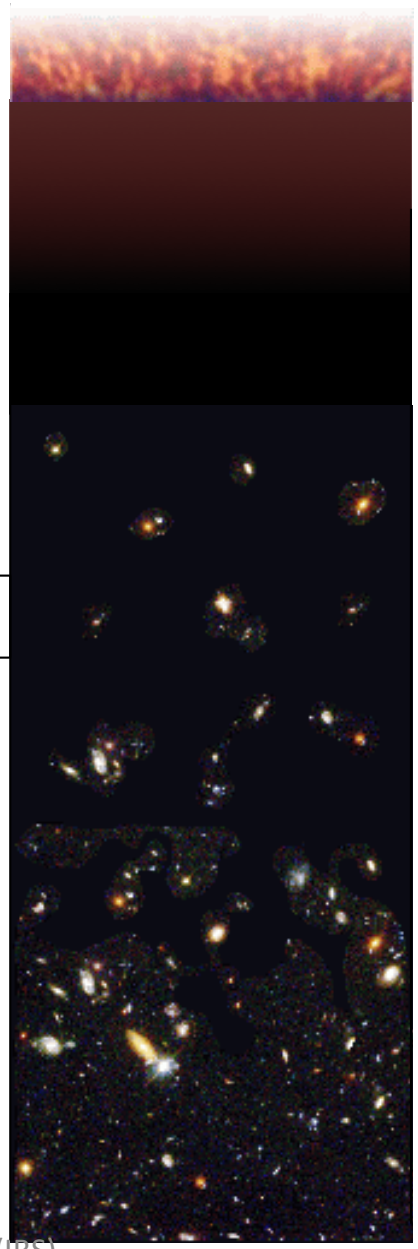
21 cm signals
1420 MHz





Brief History of Universe

Years since the Big Bang



~300000 (z~1000)

← Big Bang: the Universe is filled with ionized gas

← Recombination: The gas cools and becomes neutral

Dark Ages

~100 million (z~20-40)

← The first structures begin to form.

Reionization starts (z ~12)

Reionization

~1 billion (z~6)

← Reionization is complete

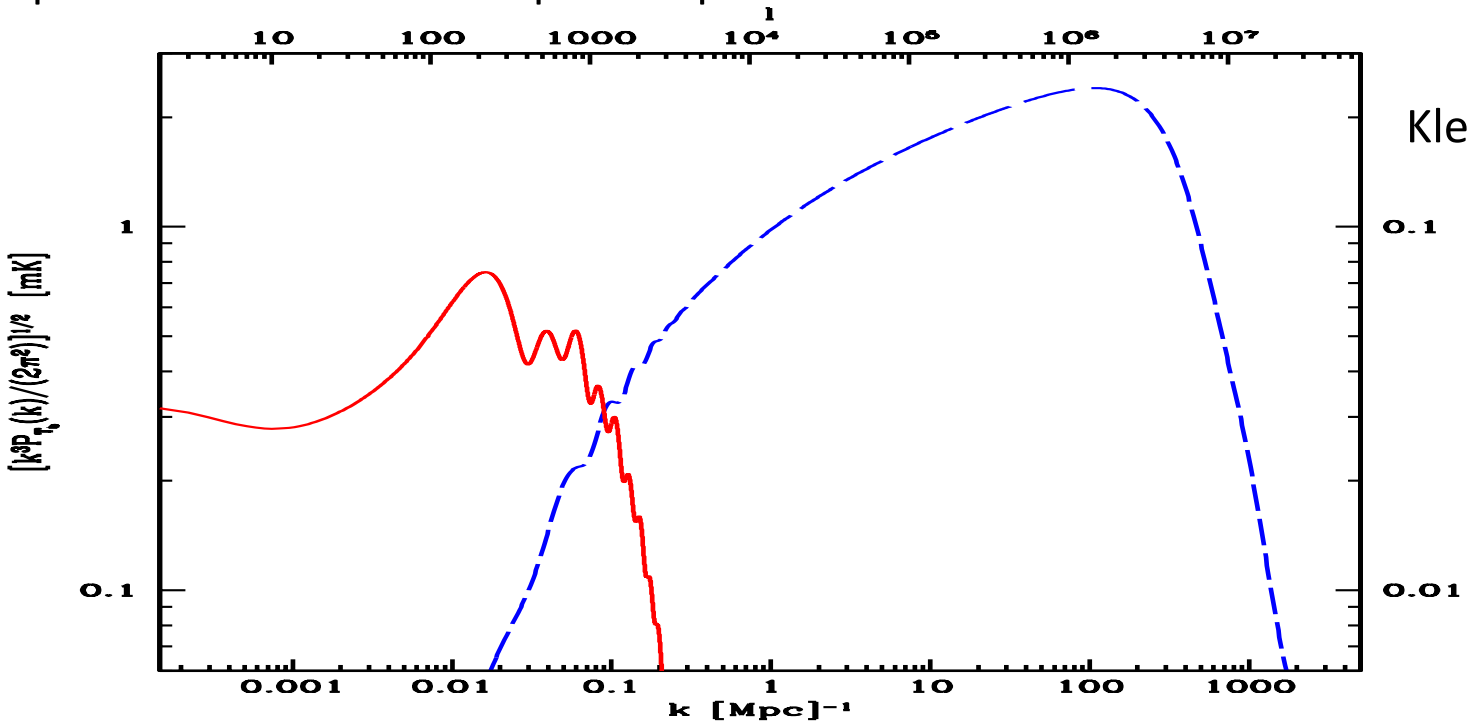
~13 billion (z=0)

← Today's structures

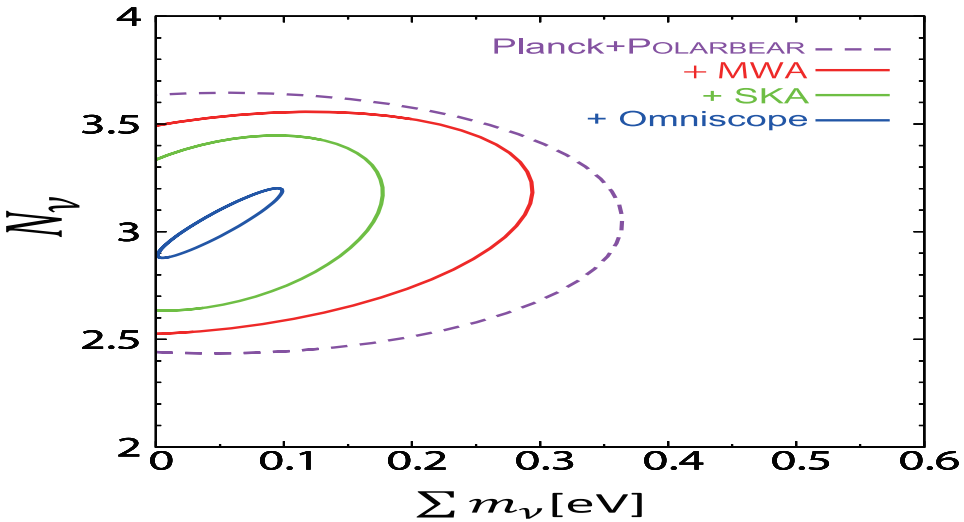
What can we do with 21cm?

High precision on small-scale power spectrum

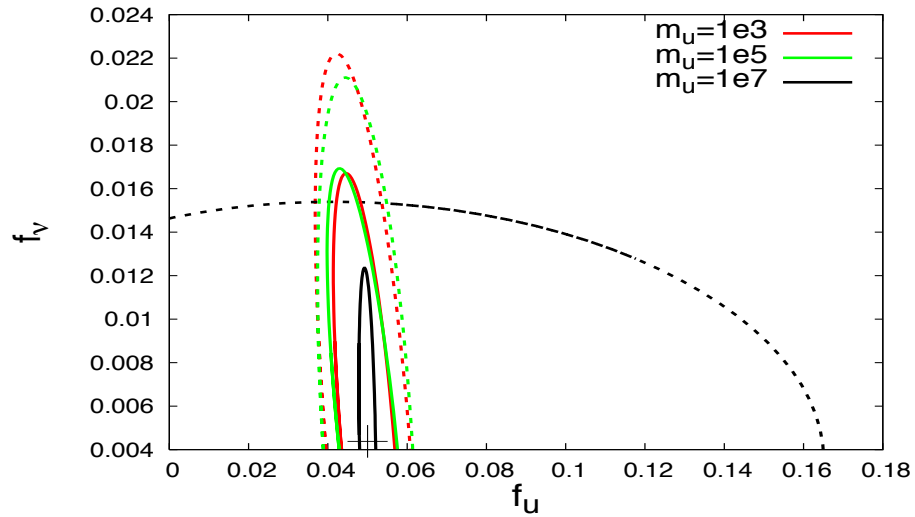
$$\Delta P / P \sim 1 / \sqrt{N}$$



Kleban+(2007)



Oyama+(2013)



KK, Mao, Ichiki, Silk (2014)

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- ✓ Conclusion

Let us be open minded.
Can go beyond the electroweak scale dark matter mass range.
Can go beyond CDM paradigm in LambdaCDM.