Varying electron mass solution to the Hubble tension and Big Bang Nucleosynthesis

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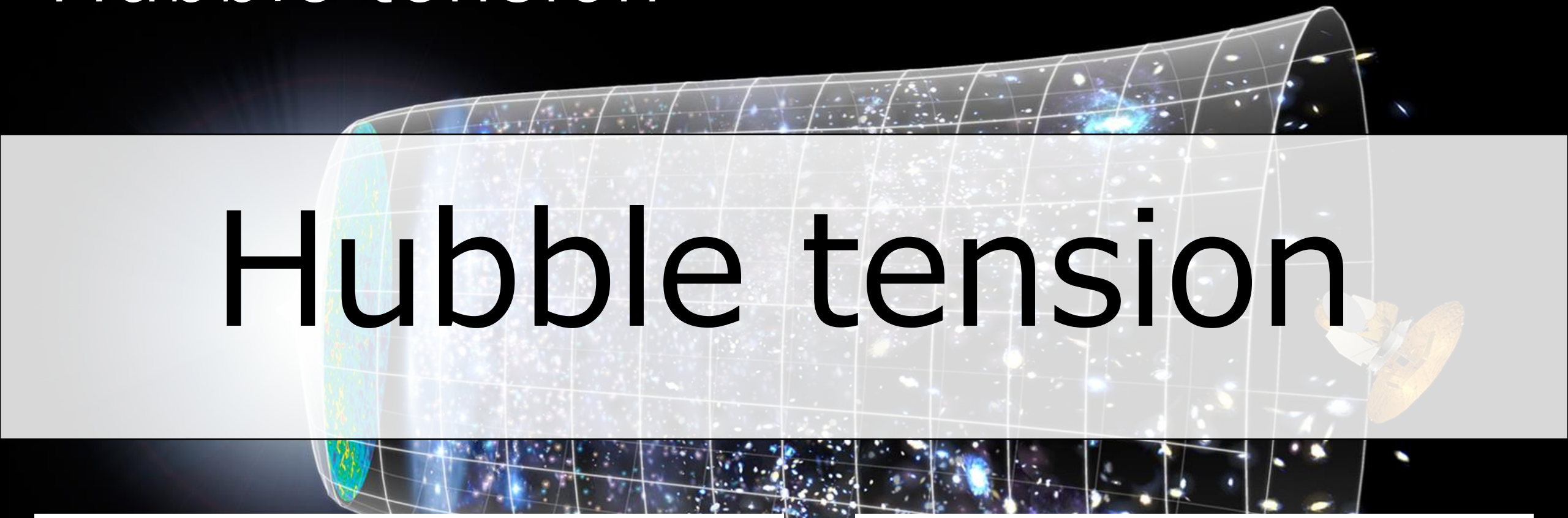
Hubble tension



Hubble tension

distant observation

$H_0 \fallingdotseq 67$km/s/Mpc

local observation

$H_0 \fallingdotseq 73$km/s/Mpc

HUBBLE TENSION SOLUTION

Model	$\Delta N_{\rm param}$	$\Delta\chi^2$	Finalist
ΛCDM	0	0.00	X
$\Delta N_{\rm ur}$	1	−6.10	X
SIDR	1	−9.57	✓ 3
mixed DR	2	−8.83	X
DR-DM	2	−8.92	X
SIν+DR	3	−4.98	X
Majoron	3	−15.49	✓ 2
primordial B	1	−11.42	✓ 3
varying m_e	1	−12.27	✓ 1
varying m_e+Ω_k	2	−17.26	✓ 1
EDE	3	−21.98	✓ 2
NEDE	3	−18.93	✓ 2
EMG	3	−18.56	✓ 2
CPL			
PED			
GHE			
DM			
DM			

varying electron mass

▼

fewer additional parameters
large improvement in $\Delta\chi^2$

varying m_e	1	−12.27	✓ 1
varying m_e+Ω_k	2	−17.26	✓ 1

In this presentation

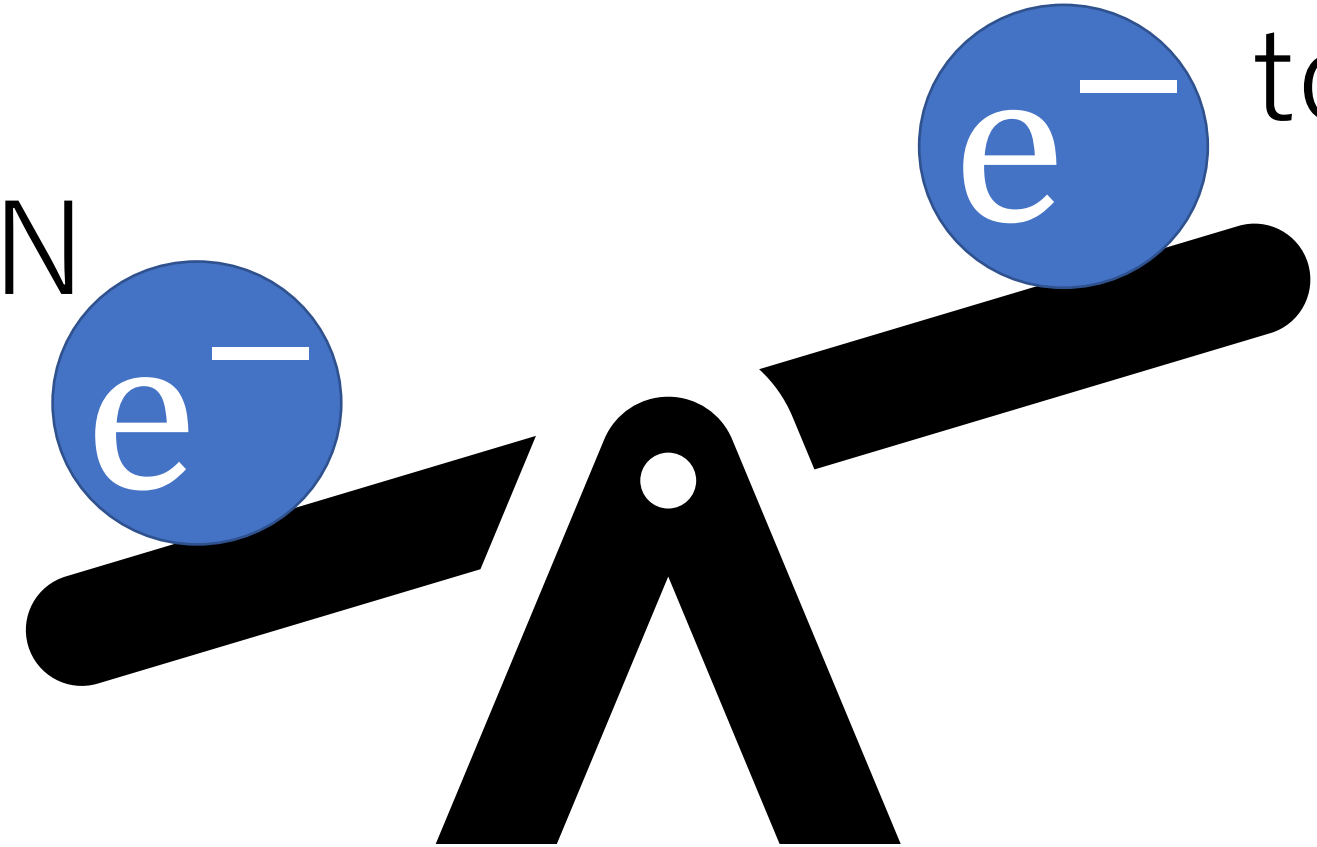
・Consider the varying electron mass model and its consistency with BBN

・Summarize that the varying electron mass model is limited by helium abundance Yp measurements

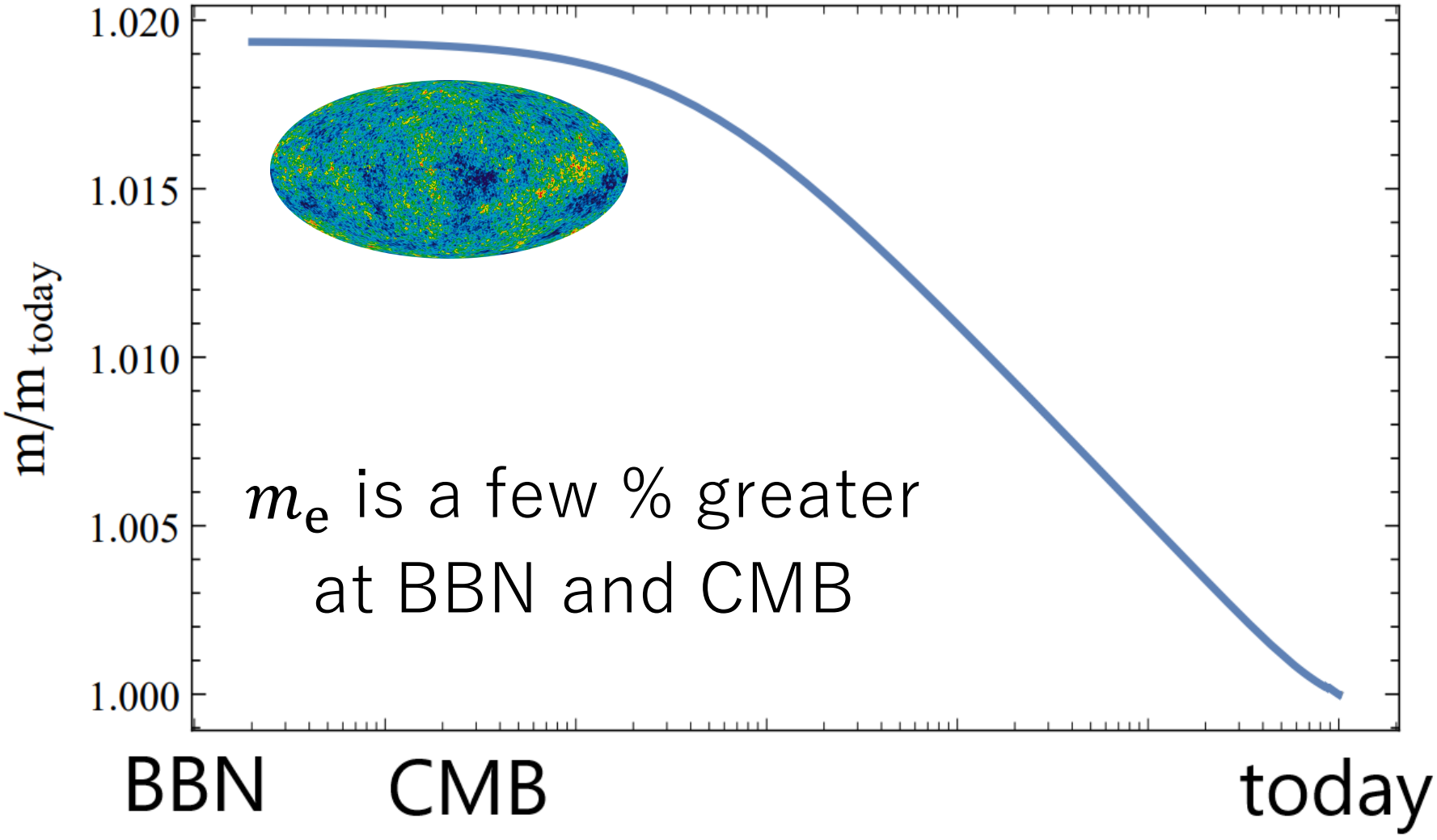
VARYING ELECTRON MASS MODEL

CMB, BBN

today



VARYING ELECTRON MASS MODEL



ELECTRON MASS AND CMB

Electron mass at last scattering was greater than today

$$m_{\mathrm{e}\,|\mathrm{Last\ Scatter}} / m_{\mathrm{e}\,|\mathrm{today}} > 1$$

▼

Photons lose energy earlier
to excite electrons in hydrogen

$$\because \text{energy level of hydrogen: } E \propto m_{\mathrm{e}}$$

▼

Recombination occurs earlier

▼

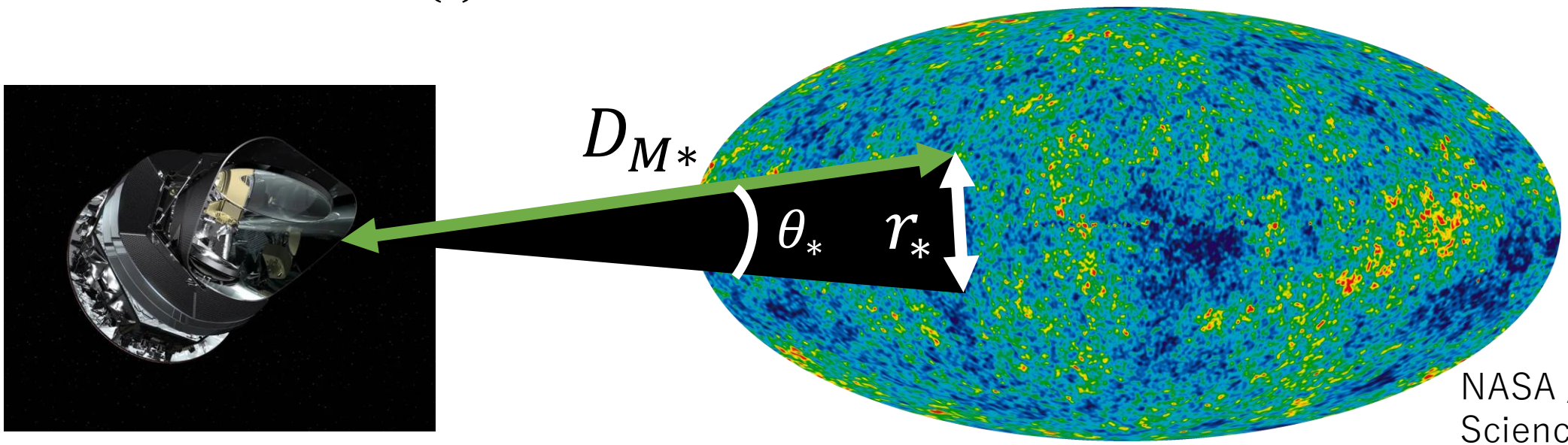
Last scattering time t_* gets shorter

ELECTRON MASS AND CMB

Angular Size : $\theta_* = \dfrac{r_*}{D_{M*}} = (1.0411 \pm 0.0003) \times 10^{-2}$

$r_* = \int_0^{t_*} \dfrac{c_s d\tilde{t}}{a(\tilde{t})}$: comoving sound horizon at recombination

$D_{M*} = \int_{t_*}^{t_0} \dfrac{d\tilde{t}}{a(\tilde{t})}$: comoving angular diameter distance



NASA / WMAP Science Team

ELECTRON MASS AND CMB

Angular Size : $\theta_* = \frac{r_*}{D_{M*}} = (1.0411 \pm 0.0003) \times 10^{-2}$

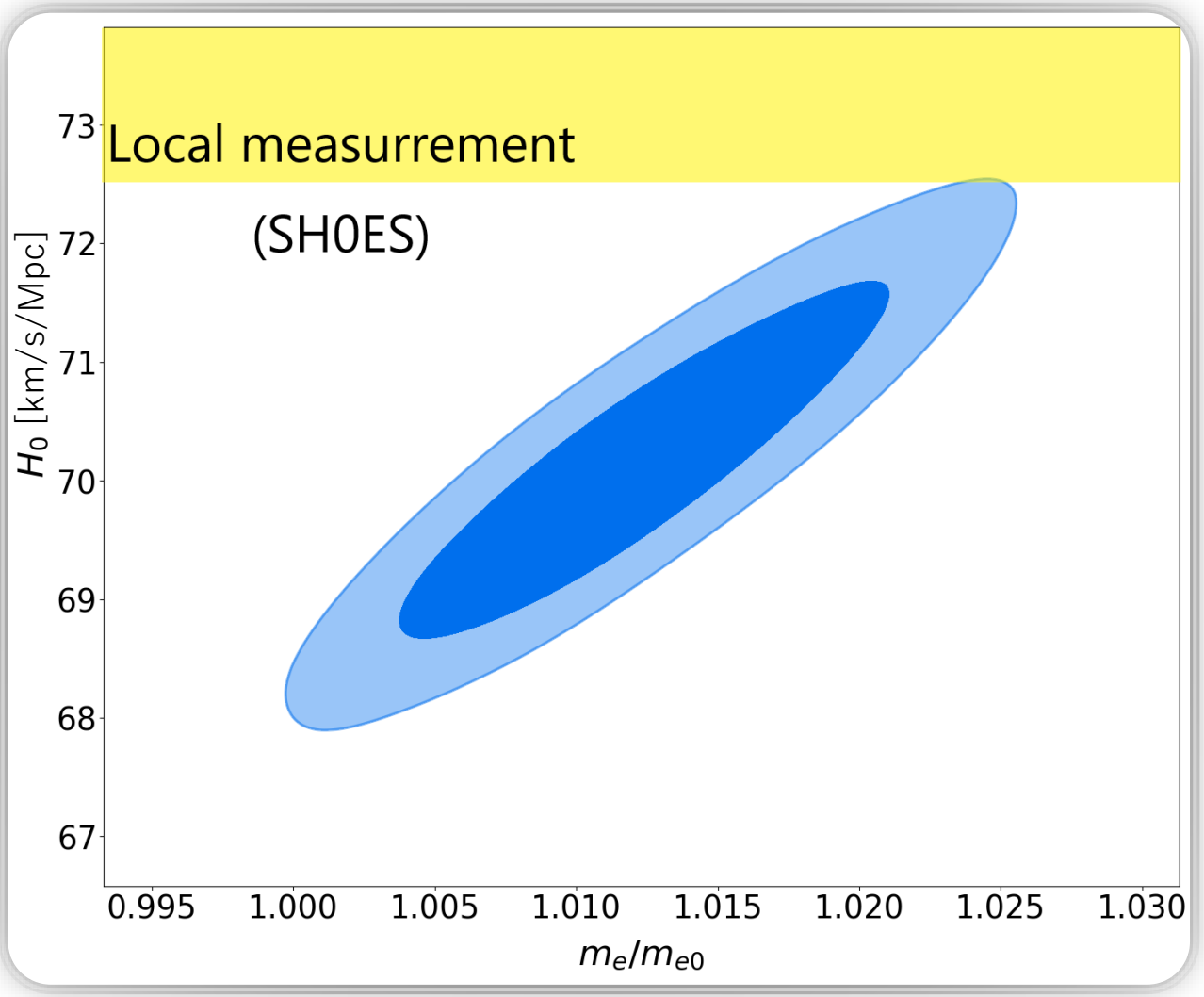
$$\propto H_0 \times r_*$$

Electron mass was greater than today and
last scattering time t_* gets shorter

▼ $r_* = \int_0^{t_*} \frac{c_s d\tilde{t}}{a(\tilde{t})}$: comoving sound horizon at recombination

Horizon r_* decreases and Hubble constant H_0 increases

ELECTRON MASS AND HUBBLE H_0



m_e/m_{e0} ↑

↓

Hubble constant H_0 ↑

Planck + BAO + SH0ES

BBN consistency

ELECTRON MASS AND BBN

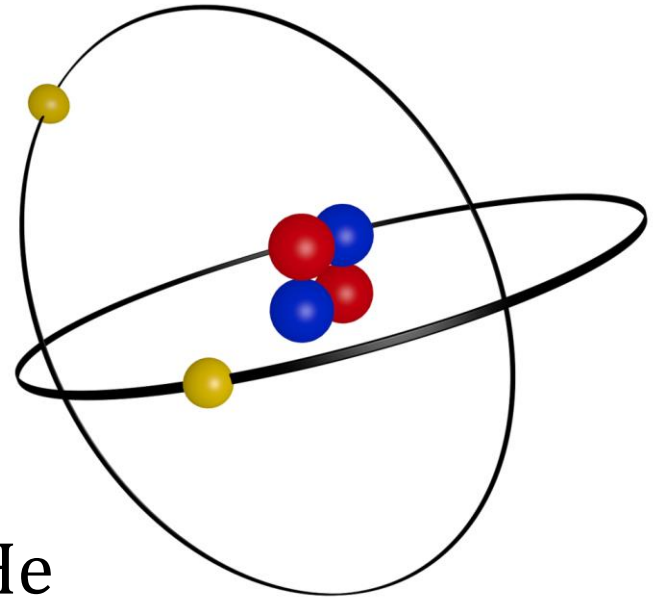
Electron mass at BBN was larger than today

$$m_{\mathrm{e}\,|\mathrm{BBN}} / m_{\mathrm{e}\,|\mathrm{today}} > 1$$

Neutron lifetime($n + \nu_e \rightarrow p + e^-$)gets longer

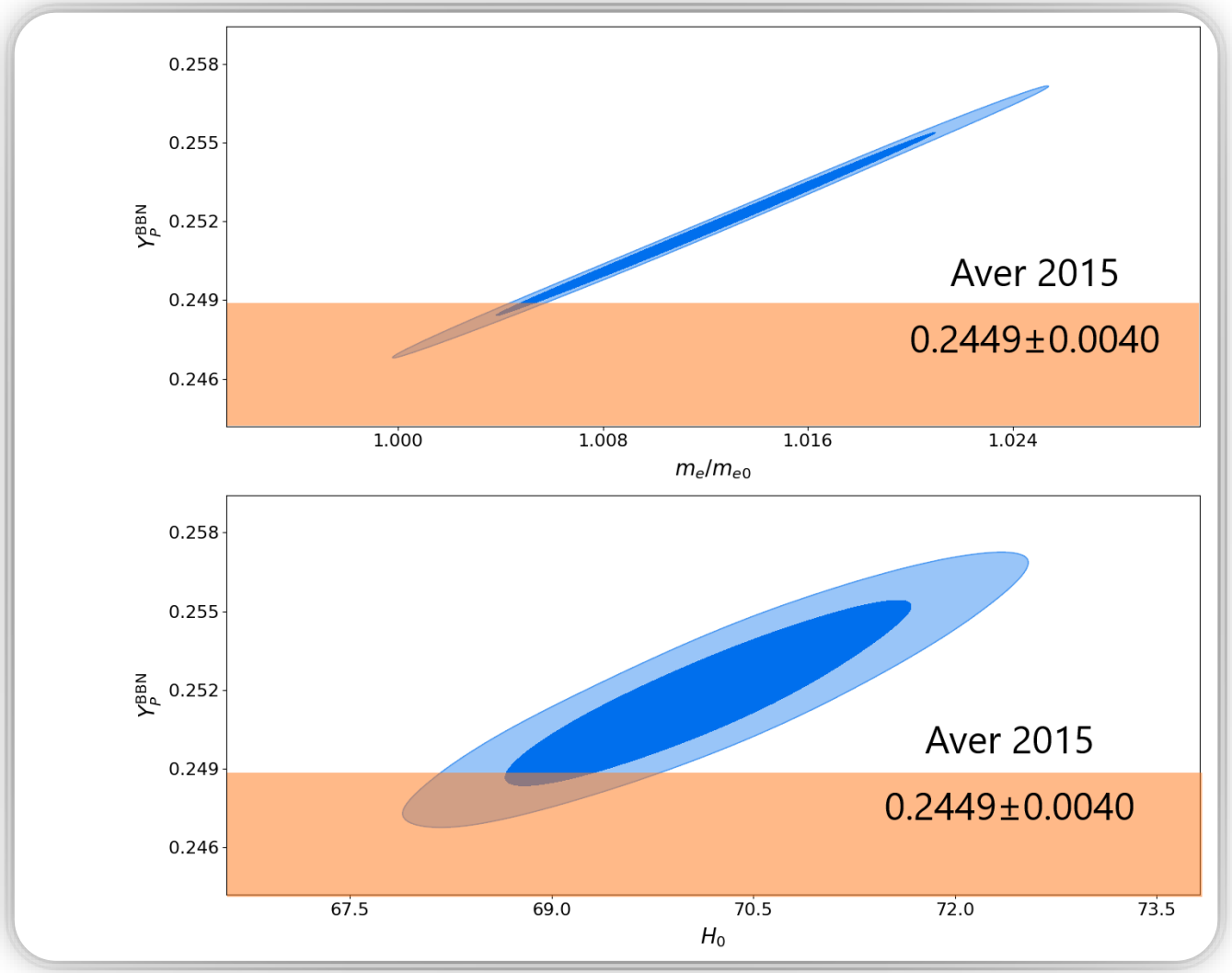
Neutron-to-proton ratio (n/p) increases

Helium mass fraction Y_P increases



$^4\mathrm{He}$

ELECTRON MASS AND HELIUM Y_P



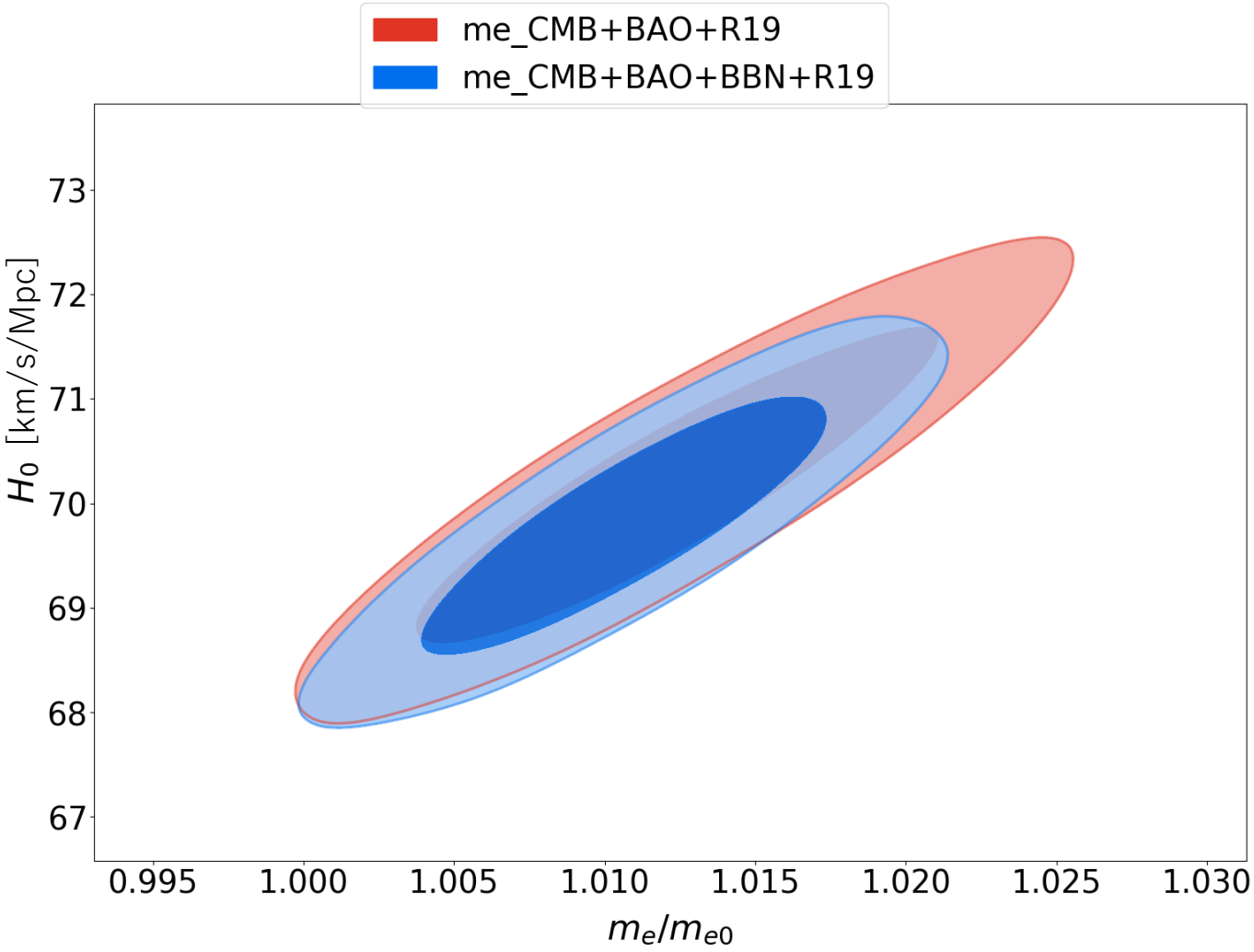
m_e/m_{e0} ↑

↓

helium Y_P ↑

Planck + BAO + SH0ES

ELECTRON MASS AND HUBBLE H_0



Greater m_e/m_{e0} is disfavored from Y_P measurement

Planck + BAO + SH0ES+(BBN)

TAKE-HOME MESSAGE

・The varying electron mass model is a promising solution to the Hubble tension.

・However, this model is limited by the helium abundance measurement.

Thank you
for your kind attention!

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