Update on the ω_m tension.

A. Blanchard

Paris, October 28th, 2024

About the Hubble tension...

H_0 can be measured "locally"...

Recording

(Merci, Brahim!)

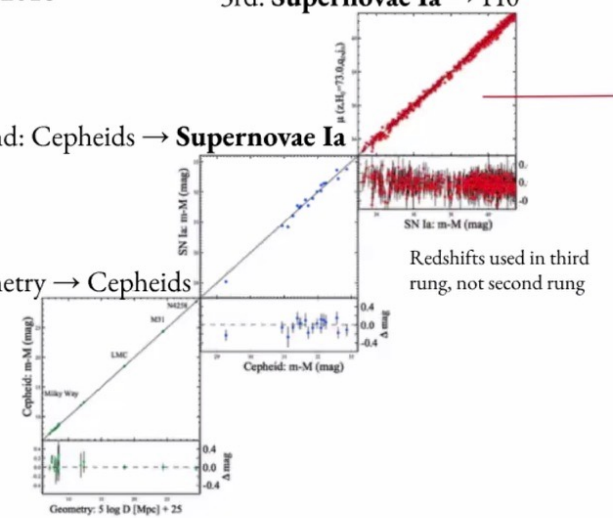
Type Ia Supernovae (SNe Ia) and Cepheids are standardizable candles

Riess et al. 2016

3rd: **Supernovae Ia** → H0

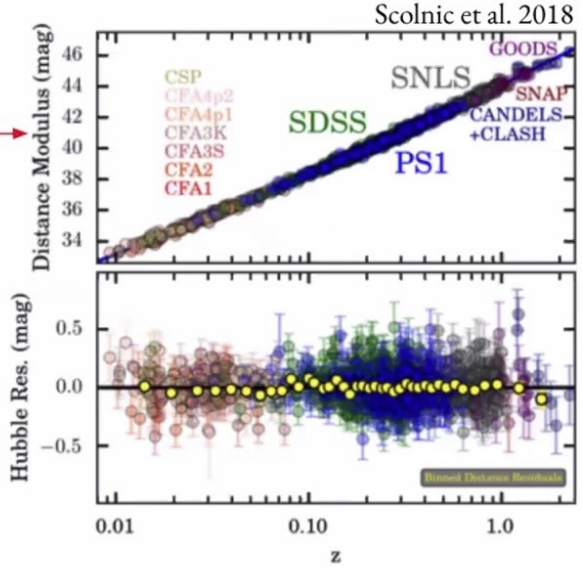
2nd: Cepheids → **Supernovae Ia**

1st: Geometry → Cepheids



Redshifts used in third rung, not second rung

Scolnic et al. 2018



The key (of our work) is to make SNe Ia (or Cepheids) *consistent between* their respective rungs, so impact of systematics is small. Only impact if there is a difference between objects in their different rungs.

H0 = 73,04±1 km/s/Mpc

H_0 tension

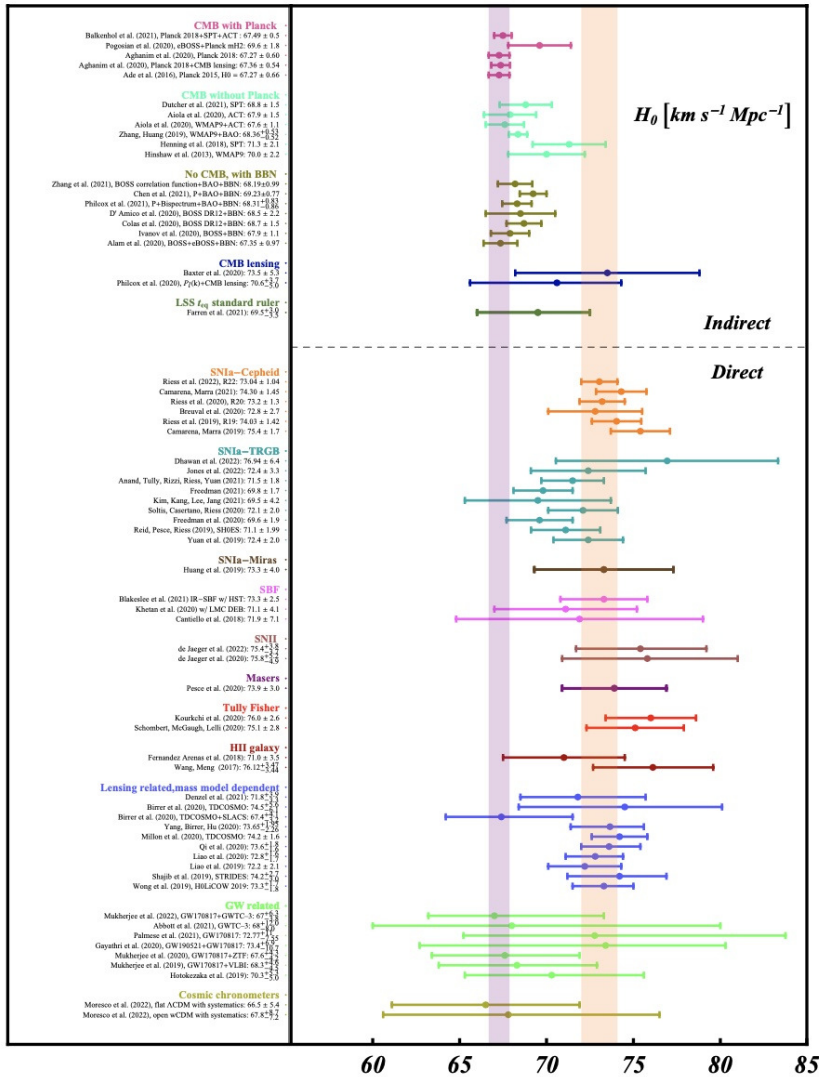
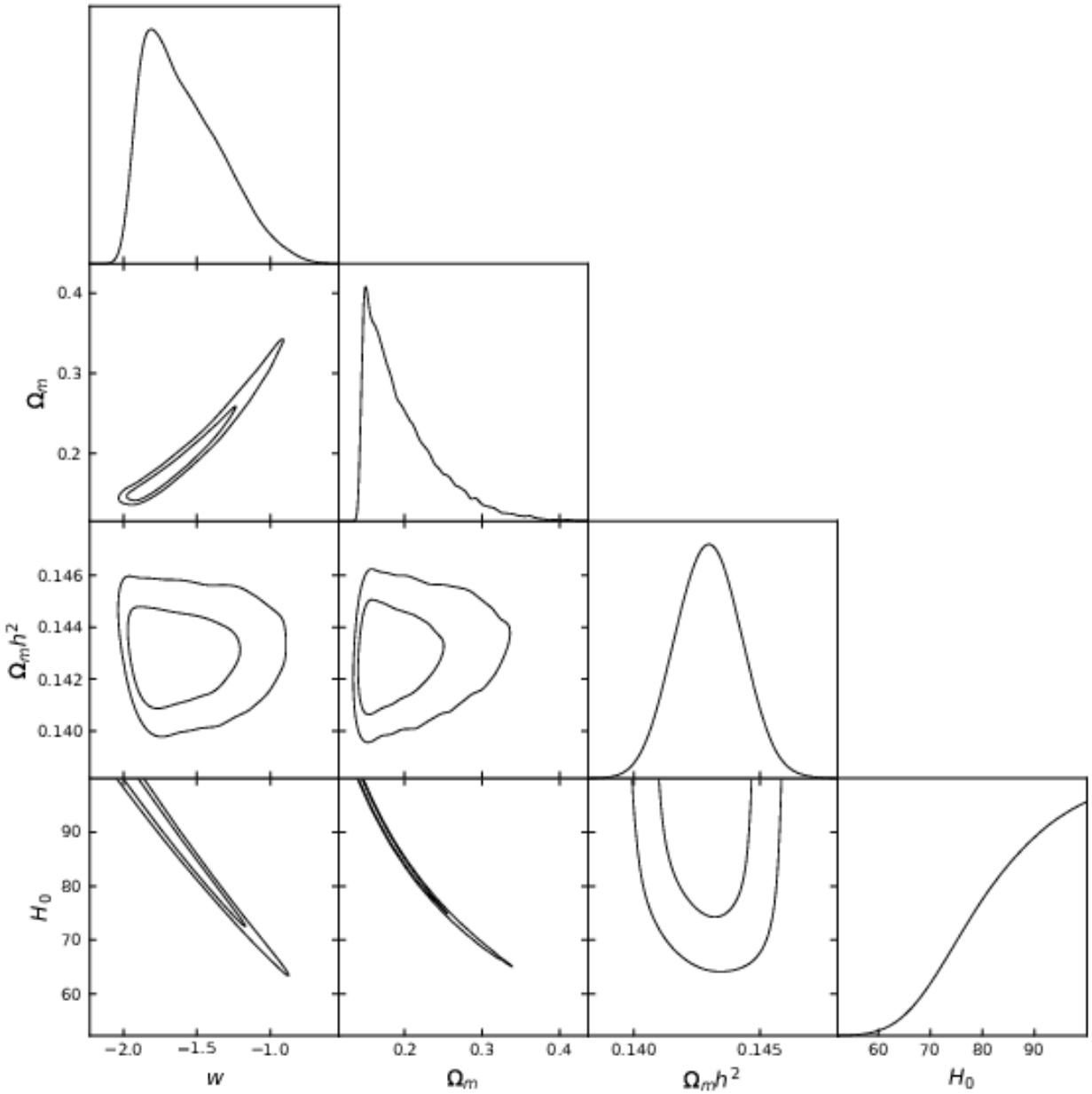


FIG. 2. 68% CL constraint on H_0 from different cosmological probes (based on Refs. [49, 50]).

in 5 σ tension with Planck, BAO, ...

H_0 and Planck



What Planck tells us ... and what it doesn't

Physics imprints the CMB from two periods:
Early universe ($z \leqslant 1100$) : plasma of photons, baryons, dark matter,
Late-time universe : expansion history (D_{ang}),
A. Blanchard (1984)
ISW, lensing,...
M. Vonlanthen, S. Räsaïen, and R. Durrer (2010)
Lemos and Lewis (2023):

$$\omega_M = 0.1414 \pm 0.0013$$

This value is indepedent of the late time universe!

So let's have a "local" determination of ω_m

Recipe:

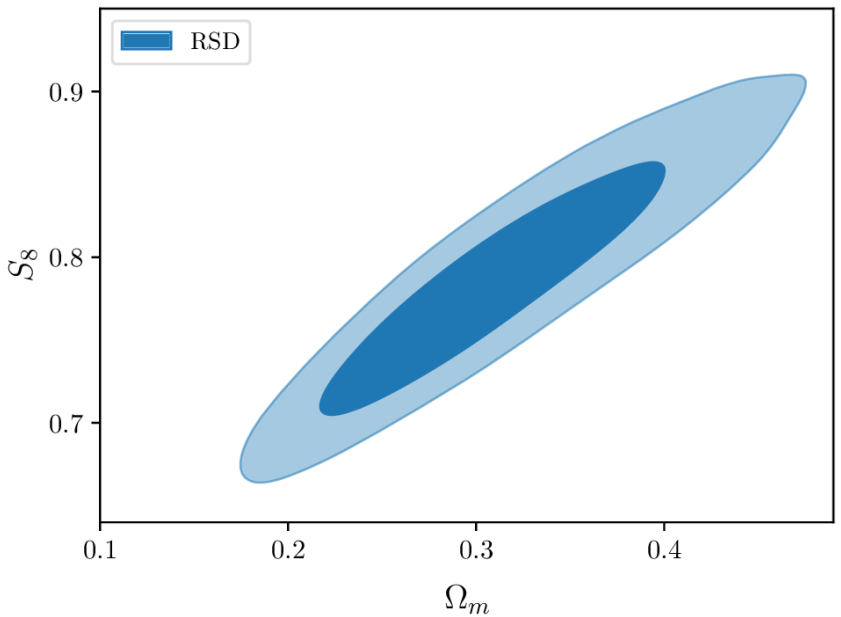
- use only "local" data (i.e. $z << 1000$)
- work in the ΛCDM framework.
- RSD
- SNIa diagram Pantheon+
- WL from DES 3yr

  Blanchard et al. (2024) OJAp **7E**, 32B arXiv:2205.05017

RSD from surveys

Survey	z	$f\sigma_8$	**Refs**
2MFT	0.001	0.51+/-0.085	[19]
6dFGS	0.067	0.423+/-0.055	[20]
SDSS DR13	0.1	0.48+/-0.16	[21]
2dFGRS	0.17	0.51+/-0.06	[22]
GAMA	0.18	0.36 +/- 0.09	[23]
WiggleZ	0.22	0.42+/-0.07	[24]
SDSS LRG60	0.25	0.35+/- 0.06	[25]
BOSS LOW Z	0.32	0.48+/-0.1	[26]
GAMA	0.36	0.44+/- 0.06	[23]
SDSS LRG 200	0.37	0.46+/- 0.04	[25]
WiggleZ	0.41	0.45+/-0.04	[24]
CMASS BOSS	0.57	0.453+/-0.02	[27]
WiggleZ	0.6	0.43+/-0.04	[24]
VIPERS	0.6	0.48+/-0.12	[28]
SDSS IV	0.69	0.447+/-0.039	[29]
VIPERS	0.76	0.44+/-0.04	[30]
SDSS IV	0.77	0.432+/-0.038	[31]
WiggleZ	0.78	0.38+/-0.04	[24]
SDSS IV	0.85	0.52+/-0.10	[32]
VIPERS	0.86	0.48+/-0.10	[28]
SDSS IV	0.978	0.379+/-0.176	[31]
SDSS IV	1.23	0.385+/-0.1	[31]
Fastsound	1.4	0.494+/-0.123	[33]
SDSS IV	1.52	0.426 +/-0.077	[34]
SDSS IV	1.944	0.364+/-0.106	[31]

RSD from surveys: constraints

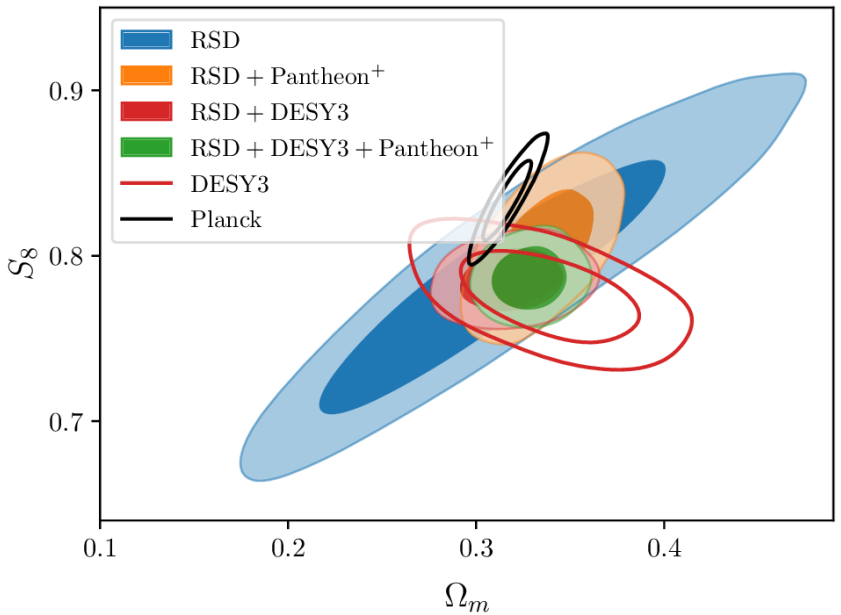


Not surprisingly strong degeneracy

Need to combine with other $low - z$ data

RSD from surveys + DES3yr +Pantheon+ compared with Planck

(no lensing)



$$\Omega_M = 0.3326 \pm 0.013$$

Blanchard et al. (2024) OJAp **7E**, 32B arXiv:2205.05017

A (new) stress test for extensions...

With *low-z* measurements of Ω_M :

$$\Omega_M = 0.3326 \pm 0.013 \ (\mathrm{RSD{+}DESY3{+}Pantheon{+}})$$

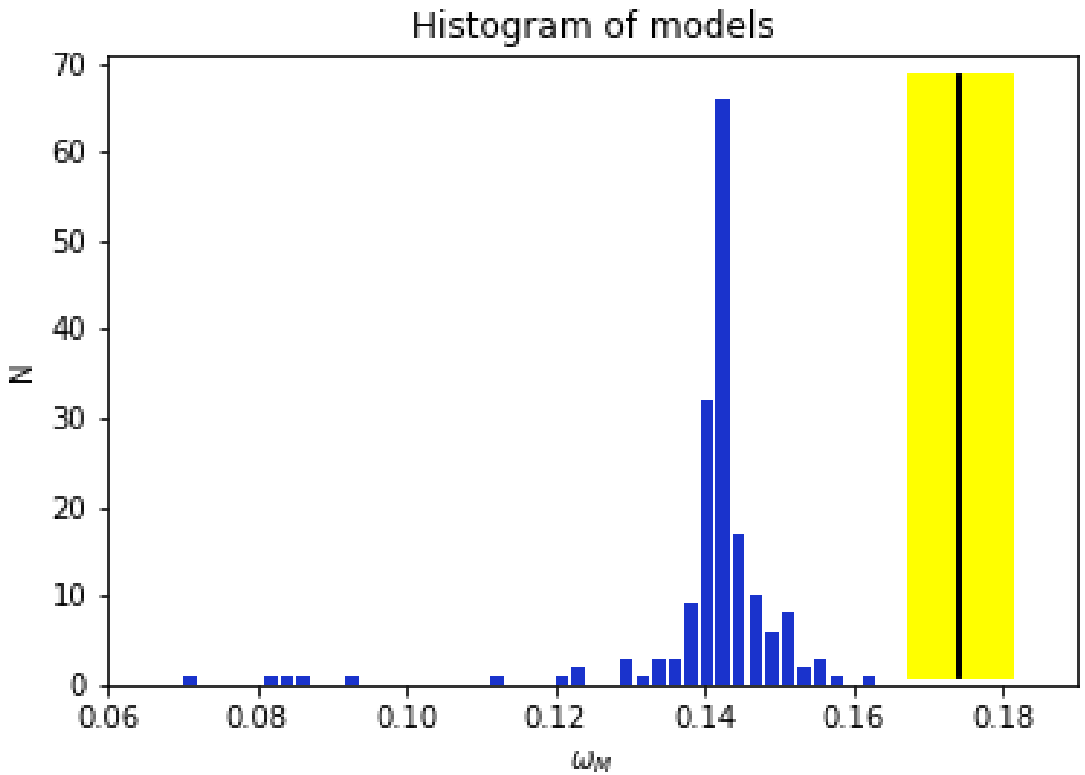
SNIa : Pantheon+ $\Omega_M = 0.334 \pm 0.018$
SNIa : DES5yr $\Omega_M = 0.352 \pm 0.017$
SNIa : Amalgame $\Omega_M = 0.328 \pm 0.024$
SNIa : Unity $\Omega_M = 0.356 \pm 0.027$
BAO : DESI $\Omega_M = 0.295 \pm 0.015$
Combined $\Omega_M = 0.322 \pm 0.008$
using SH0ES: $H_0 = 73.3 \pm 1.04$ km/s/Mpc, we can infer :

$$\omega_M = 0.17 \pm 0.005$$

compared to Planck L&L : 5.7σ away!

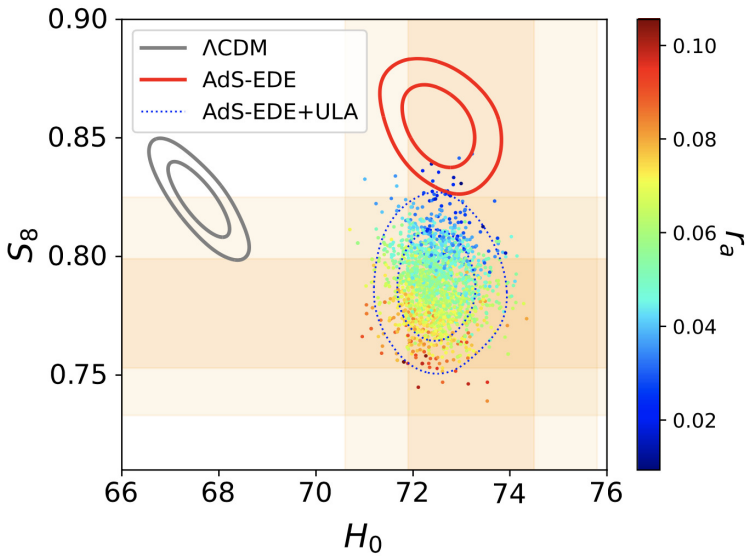
A (new) stress test for extensions...

Let's take the $\sim$ 200 models summarized in Di Valentino et al. (2021) In the realm of the Hubble tension – a review of solutions



A (new) stress test for extensions...

arXiv:2107.13391v2: EDE+ ultralight axion



However ω_m value $> 2.6\sigma$ away.

Conclusions

- ΛCDM is a 40-years old theory that matches remarkably well data at cosmological scales.
- Planck provides a tight constraint on ω_M independent of the late time universe.
- Ω_M is tightly constrained from local data: $\Omega_M = 0.316 \pm 0.0094$.
- The SH0ES H_0 leads to $\omega_M = 0.17 \pm 0.005$, in 5.7 σ tension.
- Very hard to solve on the theoretical side?

Thank You