

Title: Wrap Up

Speakers: Niayesh Afshordi

Collection: Cosmological Frontiers in Fundamental Physics 2019

Date: September 06, 2019 - 2:45 PM

URL: <http://pirsa.org/19090114>

# Wrap Up!

## COSMOLOGICAL FRONTIERS IN FUNDAMENTAL PHYSICS 2019

Conference Date: Tuesday, September 3, 2019 (All day) to Friday, September 6, 2019 (All day)

Scientific Areas: Astrophysics

Cosmology

Particle Physics

Strong Gravity

The workshops focuses on novel frontiers in observational cosmology and astrophysics and how they shed light fundamental questions in understanding the universe.

Registration for this event is now closed.

Sponsorship for this event has provided by:



European Research Council  
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***Eclectic!***

NY Times

***Not your Grandfather's  
cosmology conference!***

Globe and Mail

***A welcome Break  
from Brexit!***

Guardian



# Countdown to next meeting

## Cosmological Frontiers in Fundamental Physics 2020 - Triangular Conference, APC-Perimeter-Solvay

25-30 May 2020  
Bâtiment Sophie Germain  
Europe/Paris timezone

[Overview](#)

[Timetable](#)

[Participant List](#)

### Scientific Areas:

Astrophysics

Cosmology

Particle Physics

Strong Gravity

### Duration of the Meeting

Arrival day: 25 may 2020

Meeting: 26-29 May 2020

Departure Day: 30 May 2020

The workshop is explorative in nature. It focuses on novel frontiers for the theoretical understanding of gravity and other interactions and their interface with observational cosmology and astrophysics. The goal is to understand how observations can shed light to the fundamental questions in understanding the universe.



PERIMETER INSTITUTE RECORDED SEMINAR ARCHIVE

- All the talks are (or will become available) online at: <http://pirsa.org/C19037>
- Also Adam Riess's colloquium is at: <http://pirsa.org/19090086/>

# A very productive meeting!

## Speakers

## Participants

## Schedule

## Abstracts

## Travel

## Accommodations

- Damiano Anselmi, University of Pisa
- James Bardeen, University of Washington
- Brando Bellazzini, Institute de Physique Theorique of CEA
- Latham Boyle, Perimeter Institute
- **Avery Broderick, Perimeter Institute**
- George Efstathiou, University of Cambridge
- Bob Holdom, University of Toronto
- Mariangela Lisanti, Princeton University
- Moritz Munchmeyer, Perimeter Institute
- **Samaya Nissanke, University of Amsterdam**
- Francesco Nitti, Astroparticle and Cosmology Laboratory
- Masamune Oguri, Kavli Institute
- Ue-Li Pen, Canadian Institute for Theoretical Astrophysics
- Maxim Pospelov, Perimeter Institute & University of Victoria
- Adam Riess, Space Telescope Science Institute
- Neelima Sehgal, Stony Brook University
- **Kendrick Smith, Perimeter Institute**
- Gerard 't Hooft, Utrecht University
- Chris Tully, Princeton University



**WINNERS OF THE 2020 BREAKTHROUGH PRIZE IN LIFE  
SCIENCES, FUNDAMENTAL PHYSICS AND MATHEMATICS  
ANNOUNCED**

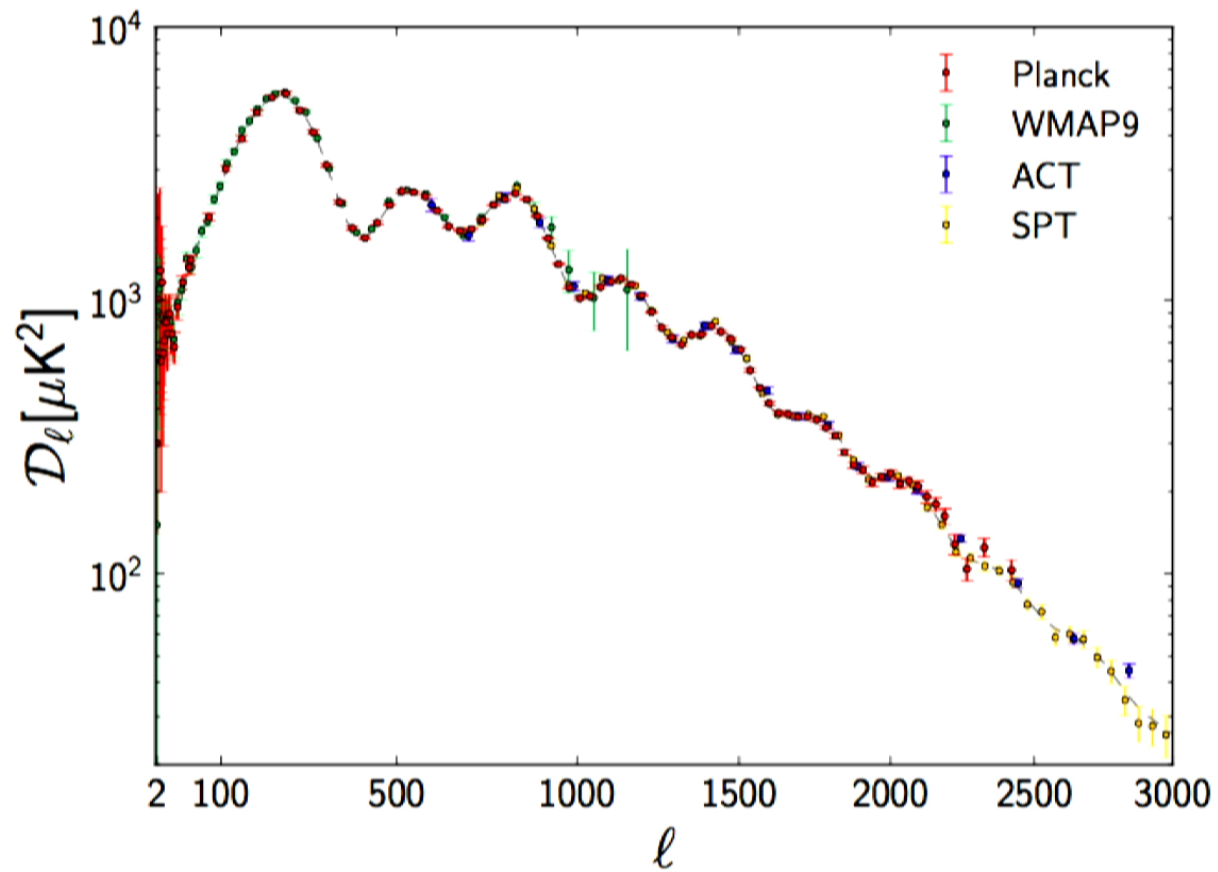
***New Observations***

***New Tensions***

***New Tools***

***New Ideas***

# Efstathiou's talk

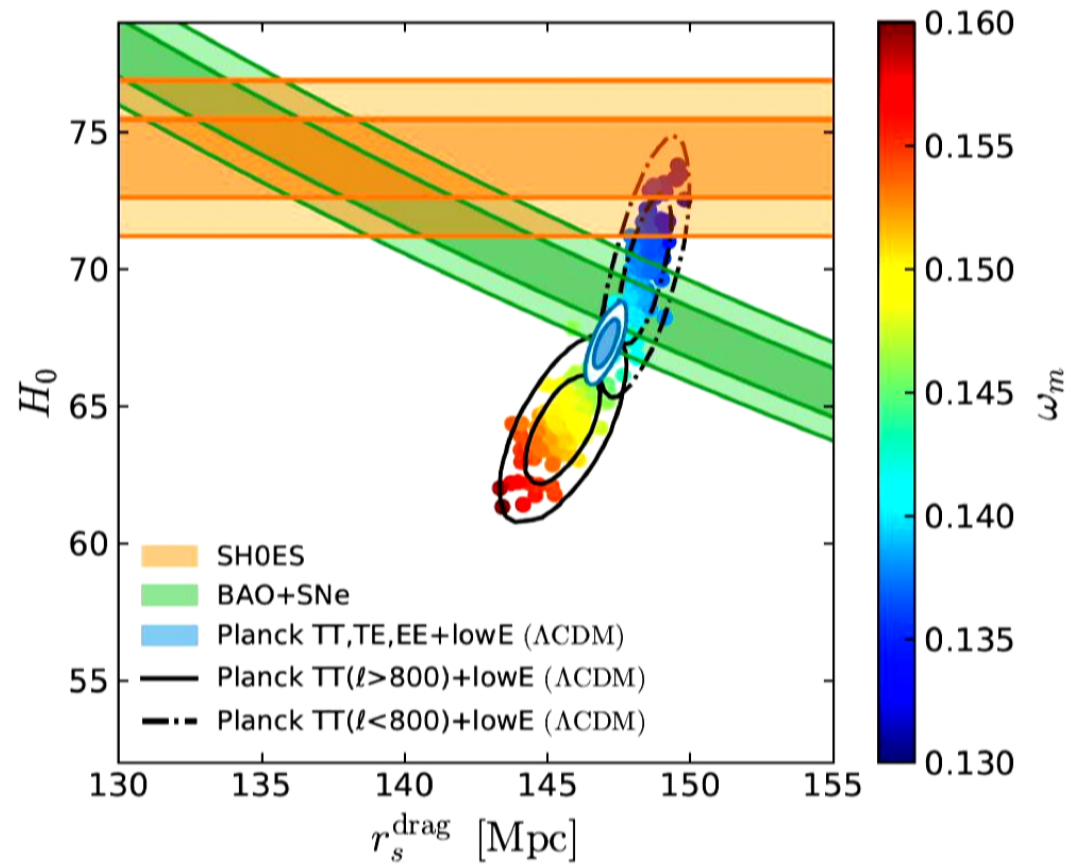


## The Hubble Hunter's Guide

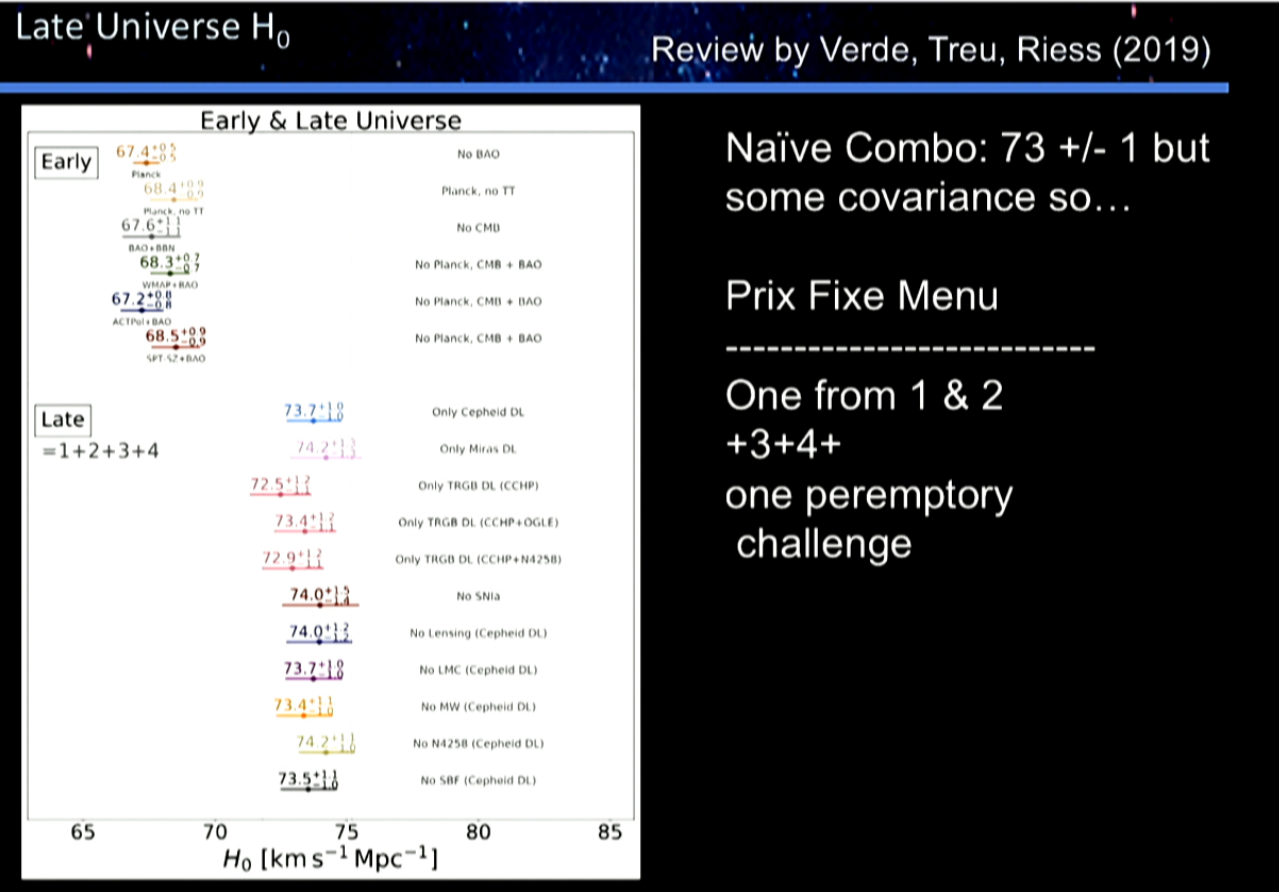
Lloyd Knox, Marius Millea

(Submitted on 10 Aug 2019)

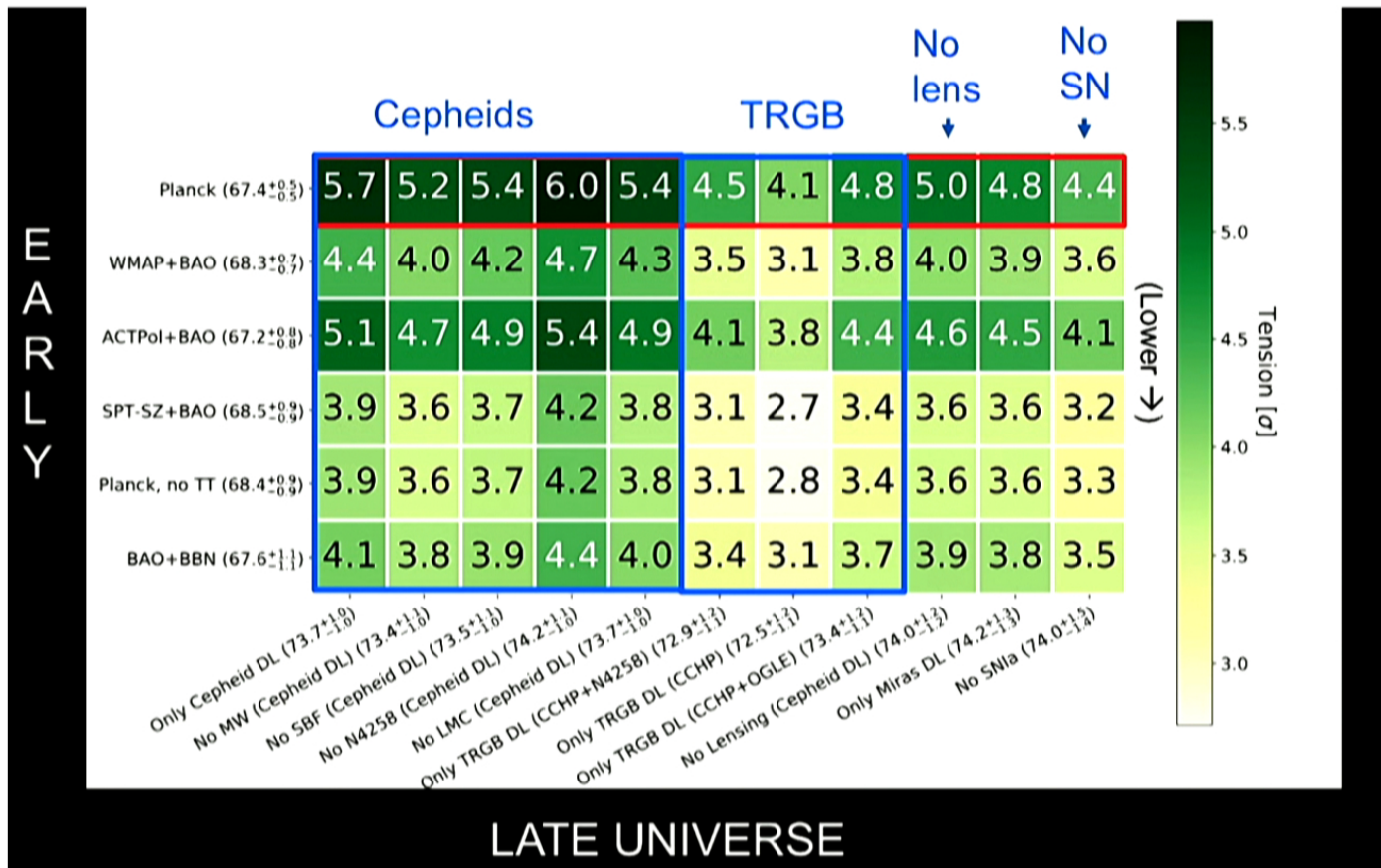
# But:



# And Of course (Riess' talk)



# 3-6 $\sigma$ tension

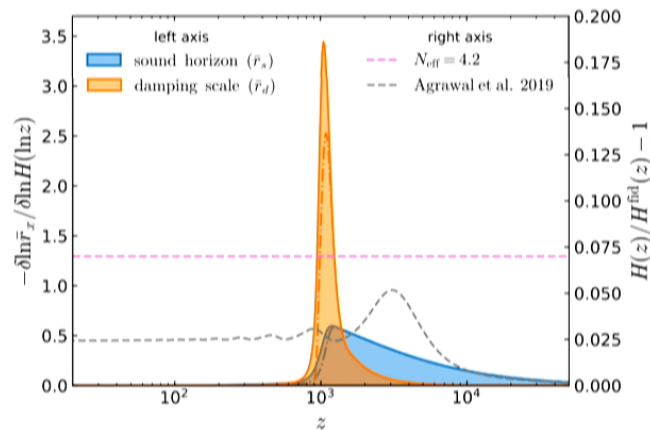




# New Physics?

## Catastrophic Multiple Failures!

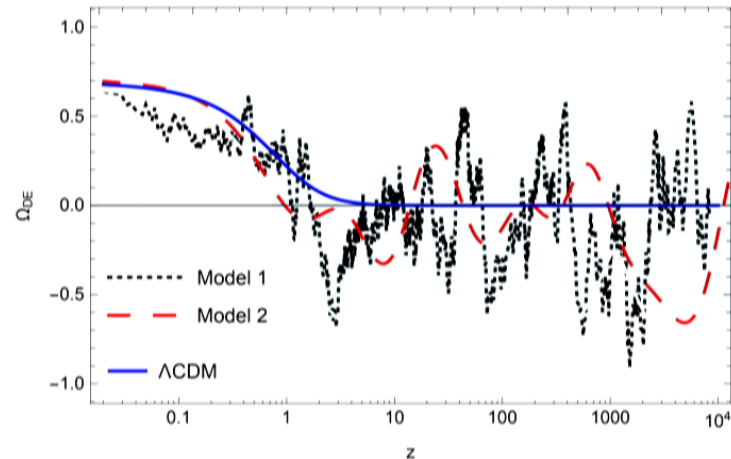
- Weight of History!
- Dynamical/Fluctuating/Interacting Dark Energy/Modified gravity



### The Hubble Hunter's Guide

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### Cosmological Tests of Everpresent $\Lambda$

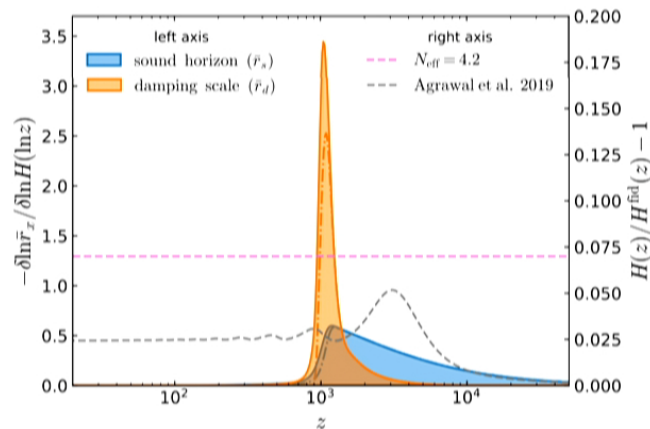
Nosiphiwo Zwane, Niayesh Afshordi, Rafael D. Sorkin

(Submitted on 18 Mar 2017 (v1), last revised 22 May 2018 (this version, v4))

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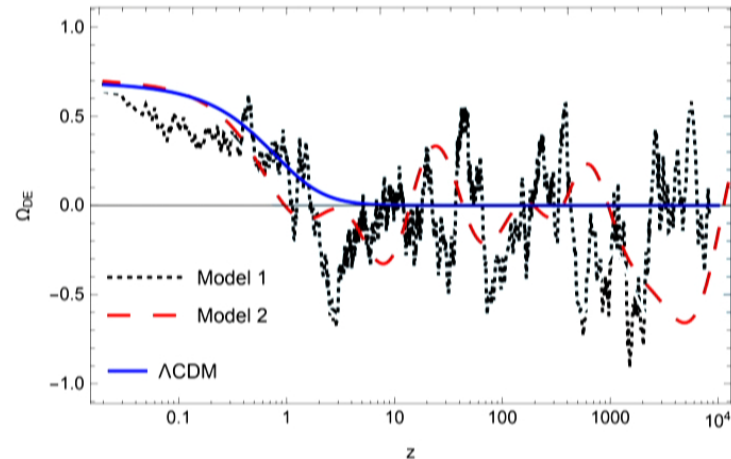
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**David Spergel** Niayesh Afshordi: A double bet: I will be a good meal in NY or Toronto (not Princeton or Waterloo) on (1)  $H_0$  discrepancy being due to physics not systematics and (2) the reality of firewalls. Either of us will buy the other dinner if we concede on either point.

Like · Reply · 3 mins

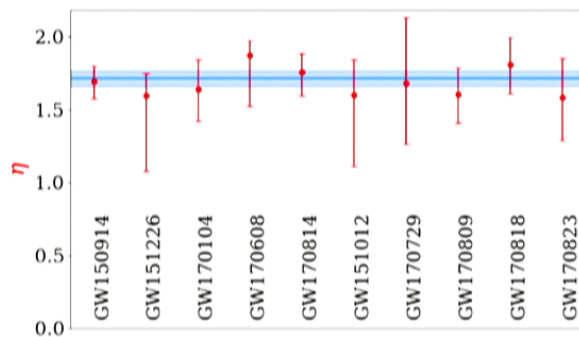


**Niayesh Afshordi** David Spergel Fair enough! You're on 😊

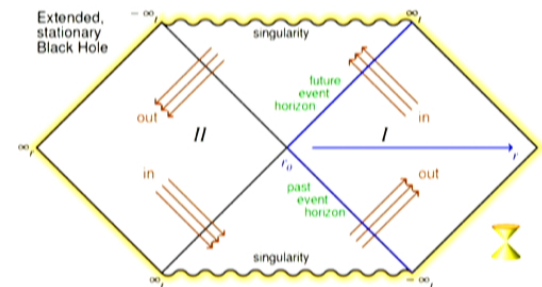
Like · Reply · Just now

# Firewalls?! (talks by Broderick, t'Hooft, Bardeen, Holdom, Mottola)

- But how does information get out?
- Novel Physics at horizon? Inside?
- p-value for echoes?
- Systematic search? Right model?

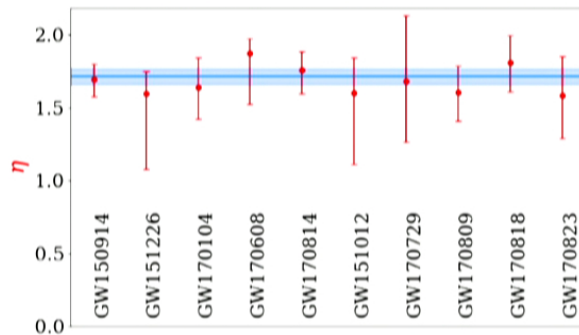


- $\eta = 1.7$  means that  $\delta r \approx 10^{-28} \ell_{\text{Pl}} \approx 10^{12} \times (\text{proper Planck length})$

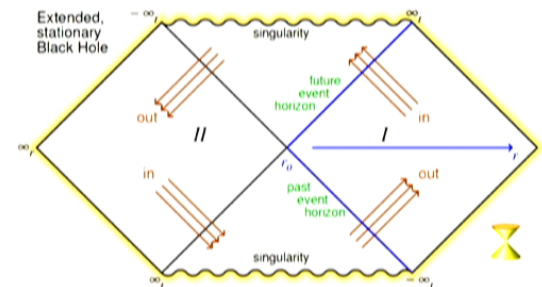
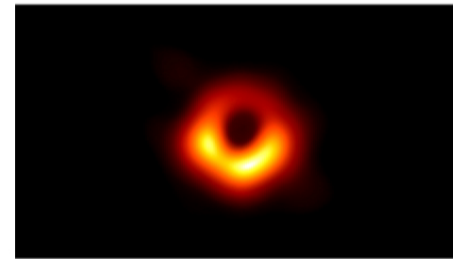


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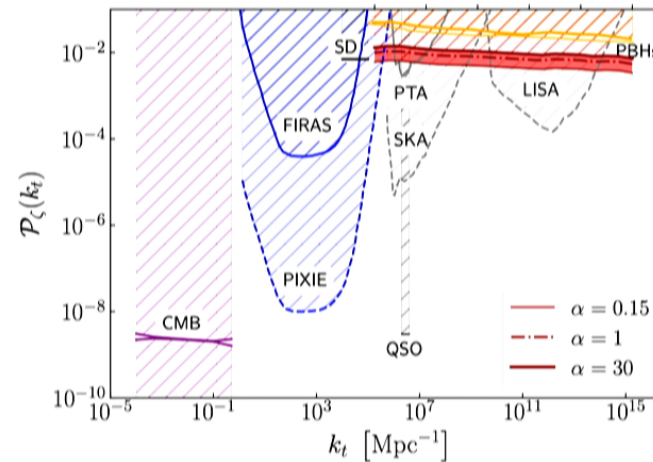
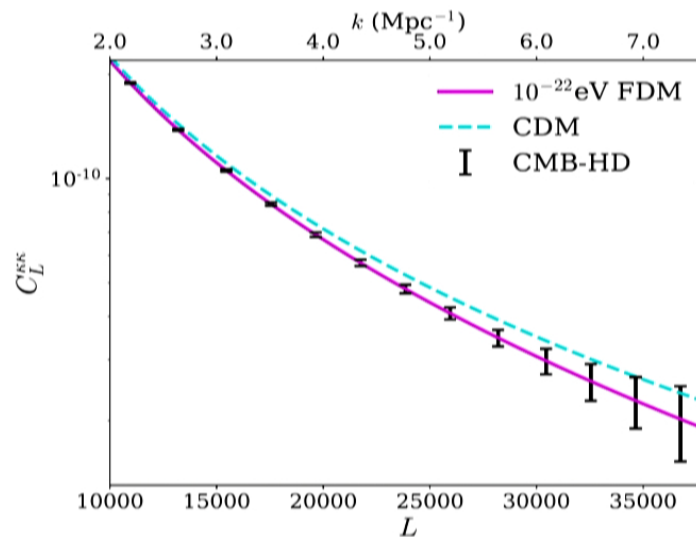


# Future of CXB (talks by Sehgal, Munchmeyer, Tully)

- — — > CMB-S4 — > CMB-HD — — — — > CNB-HD!!
- CDM on small scales from CMB lensing? Baryons/stars?
- Inflationary B-modes? Is there a target for  $r$ ?
- Power of X-correlation: Euclid, LSST, WFIRST, Sphere-X
- Kinetic SZ — > ultra large-scales,  $f_{\text{NL}}$ , gasrophysics
- Lithium Problem, Hubble tension, Early Dark Energy from CNB probes of BBN? mini-Boone, mass-varying  $\nu$ 's

# CDM crisis on small scales? (Sehgal)

- Too big to fail?
- Missing satellites?

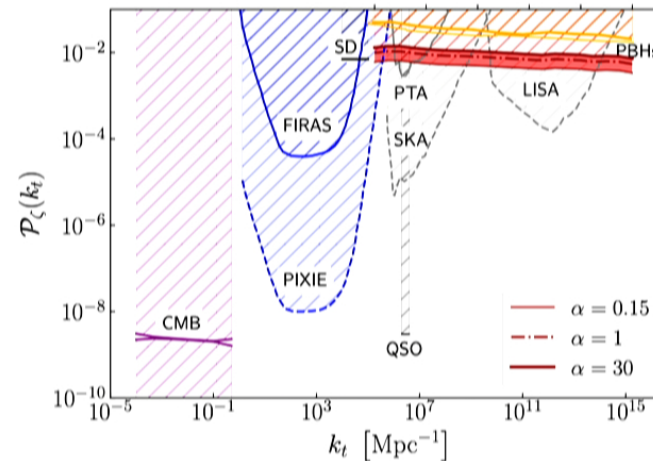
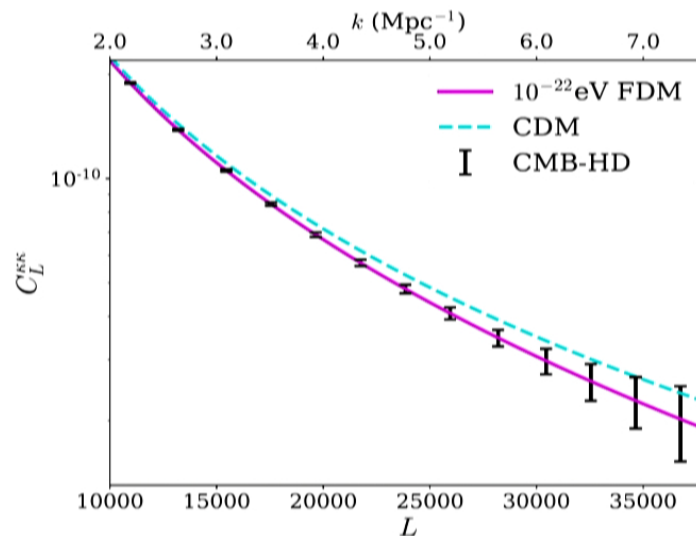


From Primordial Black Holes Abundance to Primordial Curvature Power Spectrum (and back)

Alba Kalaja, Nicola Bellomo, Nicola Bartolo, Daniele Bertacca, Sabino Matarrese, Ilia Musco, Alvise Raccanelli, Licia Verde  
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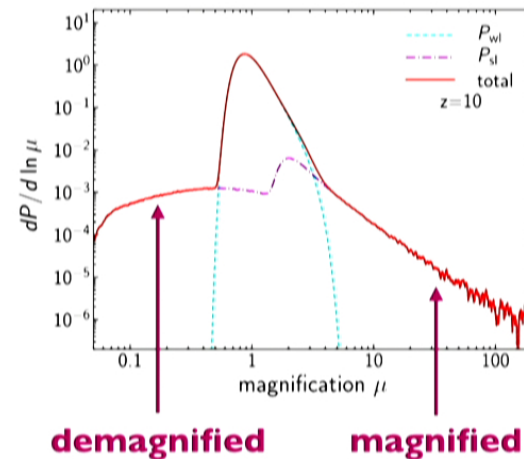
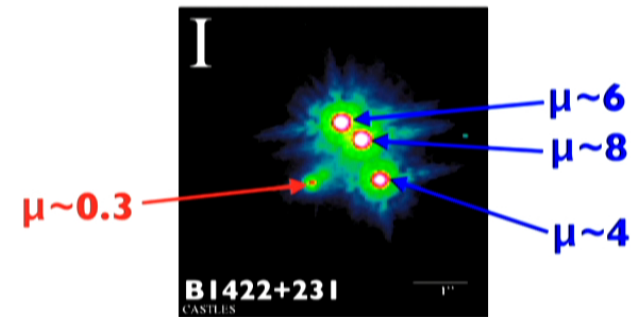
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**What about Latham's CPT neutrino Dark Matter?**  
**Will we ever detect Dark Matter? Axions?**



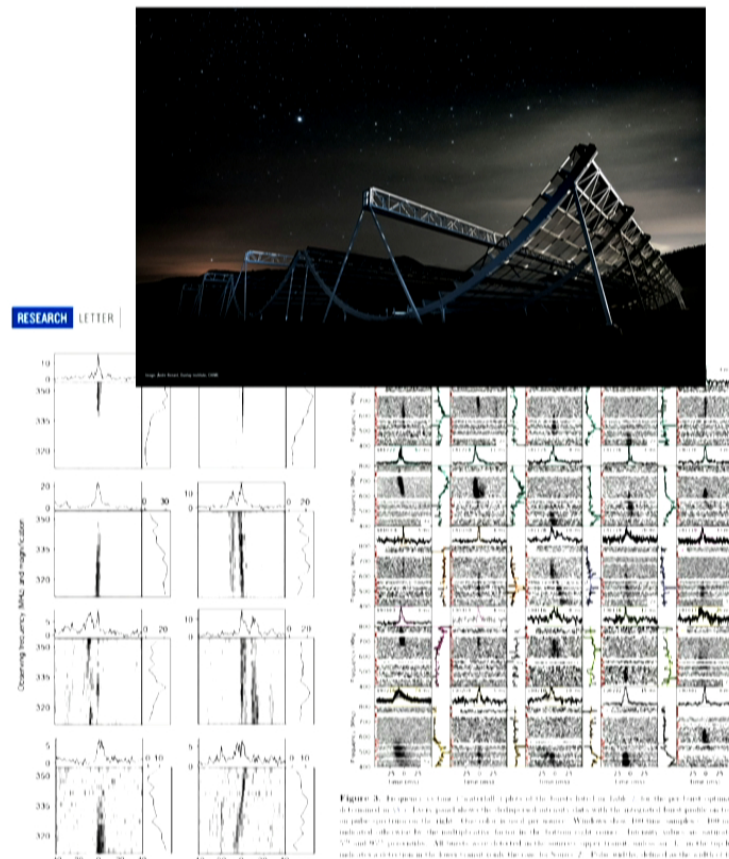
# Strong Lensing (talk by Oguri)

- Strong Lensing and small-scale crisis (Dalal & Kochanek 1913, Hezaveh ...)
- Strong Lensing of LIGO events!
- Microlensing/strong lensing with FRBs



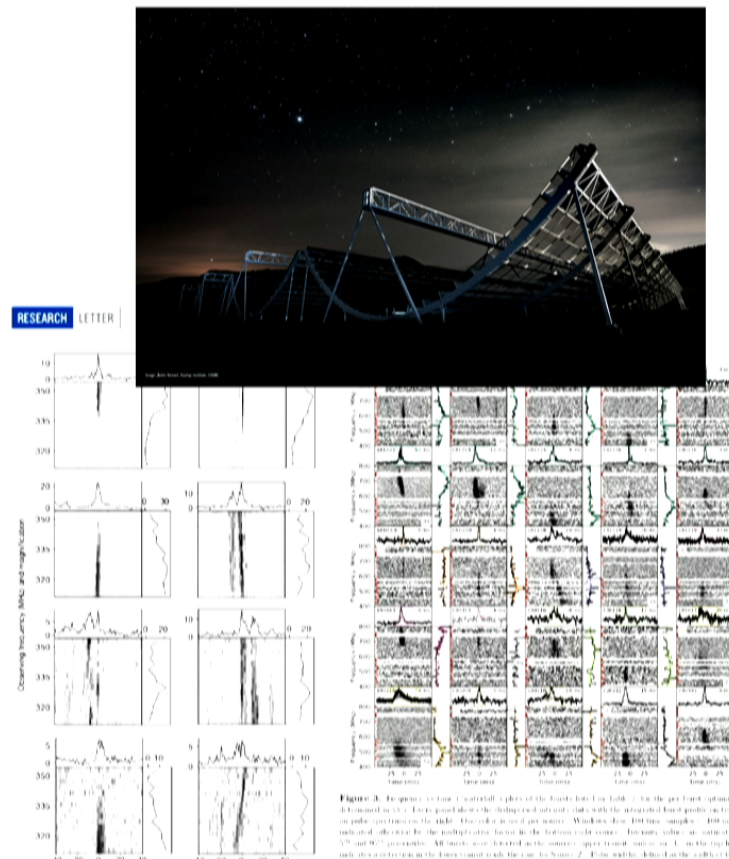
# Fast Radio Bursts (talks by Smith & Pen)

- What are they?
- Promising probes of fundamental physics?
- Promising probes of cosmology? standard yardstick, 1M FRBs!



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# 21 cm cosmology, EDGES?!

## (Pospelov)

- Dark Photons? Maybe not! Ask Bob Holdom 😊

### EDGES result: cosmic 21 cm

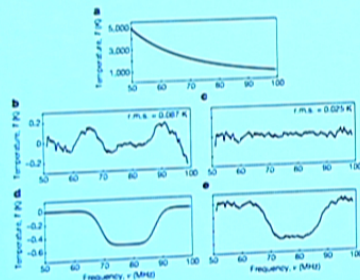
#### LETTER

doi:10.1038/nature25792

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

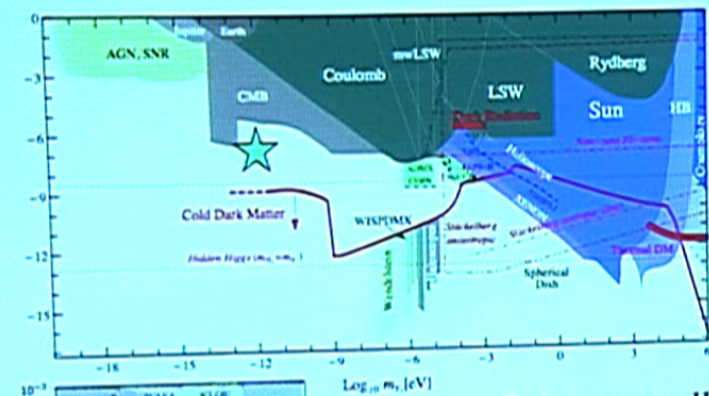
Judd D. Bowman<sup>1</sup>, Alan E. E. Rogers<sup>2</sup>, Raul A. Monsalve<sup>1,3,4</sup>, Thomas J. Mozdzen<sup>1</sup> & Nivedita Mahesh<sup>1</sup>

- *This is as big a deal in cosmology as it gets*



**Figure 1 | Summary of detection.** a, Measured spectrum for the reference dataset after filtering for data quality and radio-frequency interference. The spectrum is dominated by Galactic synchrotron emission. b, c, Residuals after fitting and removing only the foreground model (b) or the foreground and 21-cm models (c). d, Recovered model profile of the 21-cm absorption, with a signal-to-noise ratio of 37, amplitude of 0.53 K, centre frequency of 78.1 MHz and width of 18.7 MHz. e, Sum of the 21-cm model (d) and its residuals (c).

### Constraints on dark photon





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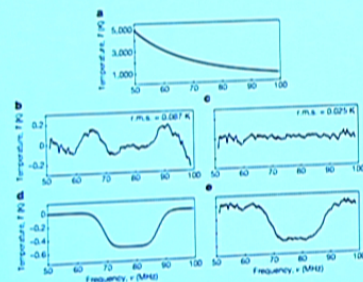
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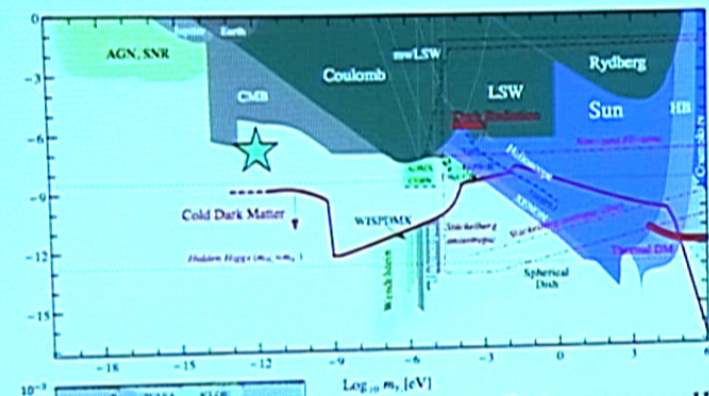
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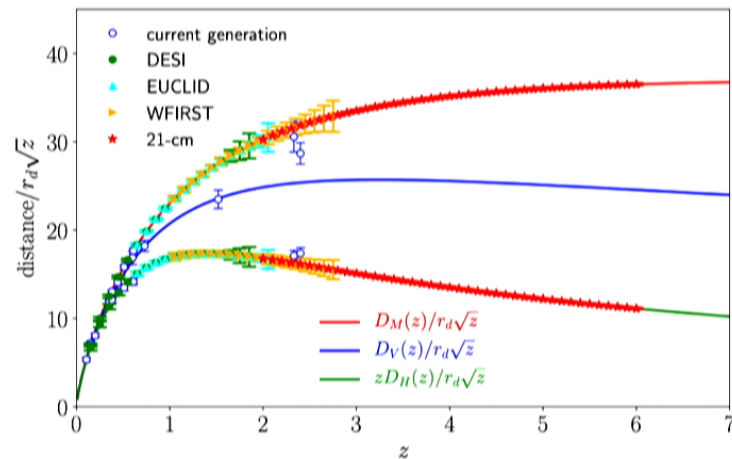


# 21 cm cosmology, the future

- This is only the beginning!

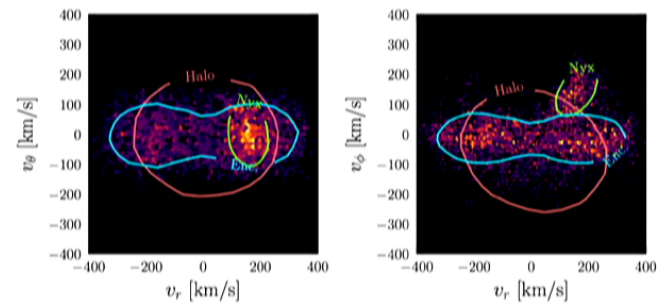
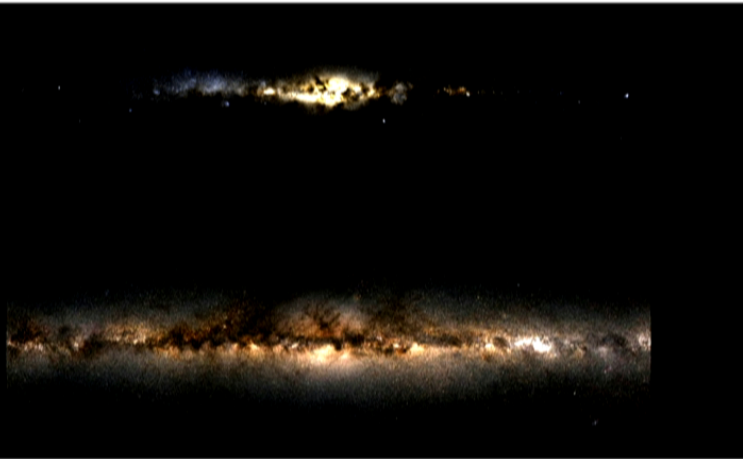
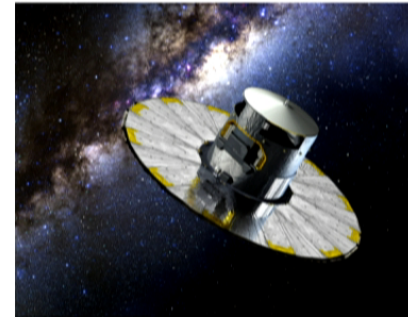
## Inflation and Early Dark Energy with a Stage II Hydrogen Intensity Mapping Experiment

Cosmic Visions 21 cm Collaboration



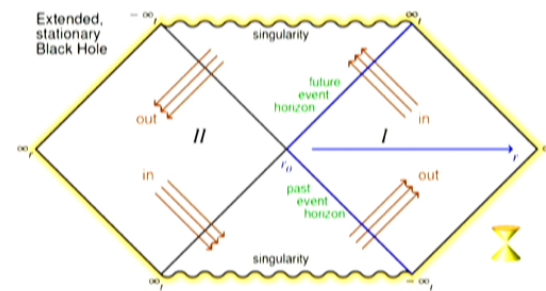
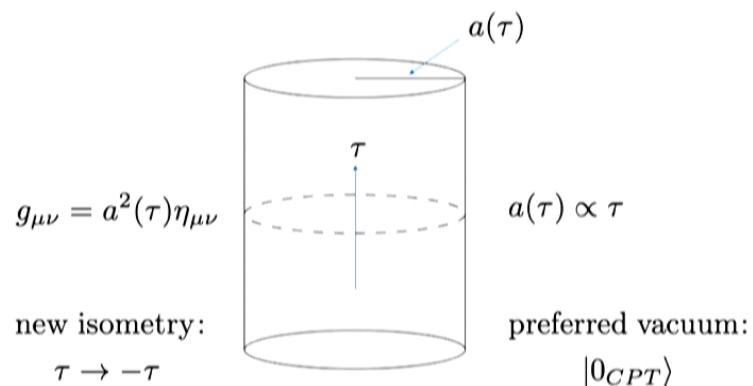
# Gaia (talk by Lisanti)

- Billions of stars (1% of Milky Way)
- Dark Matter or Galaxy Formation?
- Amazing progress in Galaxy Formation



# CPT-symmetry of Big Bang and Black Holes (talks by Boyle & t'Hooft)

- Predictions? Echoes?
- Scalar-Perturbations from Big Bang?
- Do we need inflation?





# Outstanding Issues! (talks by Anslemi, Nitti, Bellazzini)

- Is micro-causality necessary? What does predictivity mean in Quantum Theories? Is causality important?
- $R^2$  gravity? Starobinsky inflation; The only concrete renormalizable theory of Quantum Gravity?! Hamiltonian for Fakeons? Black Holes? Big Bang?
- Positivity constraint? Do we care about locality for gravity? Do we care about scattering amplitudes if we don't live in (3d or 4d) Minkowski
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# Thanks to:



**STEPHANIE MOHL**

Conference Program Lead



**MARGARET MINSTER**

Audio Visual Technician



**MARY LALONDE**

Audio Visual Technician



**JOSH DAWS**

Audio Visual Technician/Media Producer



**DAVID FAIRTHORNE**

Audio Visual Services Lead

# Thank you and have a safe trip!

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