

# ModIC 2024 - IFPU Focus Week Workshop

## Summary and Future Plans

### Cosmological Concordance Model – State-of-the-Art:

- Despite its success,  $\Lambda$ CDM is a parametric model (and has some problems)
  - The Hubble tension could be pointing to new physics before/at recombination  $\rightarrow$  reduction of the sound horizon  $r_s$  to increase  $H$
  - Possible deviations from a power law primordial power spectrum?
- Model-independent implications (as long as the late-time dynamics is unchanged) of  $r_s$  reduction  $\rightarrow$  smaller age of the universe, larger DM physical density, larger  $S_8$
- “Tantalizing suggestions” of dynamical DE from DESI (+SNIa)

**It is not possible to resolve all problems with minimal modification of  $\Lambda$ CDM. This is why  $\Lambda$ CDM has survived so far. Are we seeing hints to a breakdown in the cosmological principle/GR, or signs of DM/DE?**

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### Theory and Phenomenological Modeling – What now:

- How to deal with the age of the universe tension?
- How to reduce the sound horizon while compensating the impact of a larger DM density? → late-time modifications of  $\Lambda$ CDM?
- Priors matter. Should we explore negative neutrino masses or other choice?
- Facing the Hubble tension:
  - Model-independent approach to the early universe → PCA, binning, ... (need to go beyond “background-only” approach)
- Is DE thawing? Freezing? In “an impossible place”?
  - Model-independent approach to the late universe → GP, crossing statistics, ...

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### Data Analysis and Forecast – What now:

- Early-time cosmology
  - How can we exploit synergies GWB-LSS to test imprints of  $r_s$  reduction or deviations from power law PPS (e.g. primordial oscillations)?
- Late-time cosmology (beyond multi-class thanks to N-body sims)
  - How can we calibrate the redshift distribution of GW events via GWxIM?
  - How can we use GWxIM to investigate DE?
- How can we test the cosmological principle with GWs (beyond the dipole)?
- Beyond (prior-informed) Fisher Matrix approach for GWs → Hierarchical Bayesian analyses
- Can we exploit non-parametric tools to extract GRB properties (e.g.  $z$ , jet inclination angle)?
- Can we exploit model-independent statistical tools to deal with systematics?

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From a statistical point of view, it is highly possible that **there are systematics** in some of current data, yet it is likely that **we need new physics too**.  
New independent measurements and observations will clear things up.

### **Roadmap:**

1. DATA: Multi-probe consistent approaches (new (mock) data?)
2. PHEN. MODELING: Non-parametric approaches (new methods?)
3. LINK TO THEORY: A unified (early - late time) framework? (new model?)

**It is crucial to strengthen links between GW-MM and COSMO-LSS communities**

**How can we build upon Rodrigo+Ulyana+Andrea's work to pursue this roadmap?**

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