Beyond ΛCDM Survey: Theoretical problems with ΛCDM

Ruth Durrer
Université de Genève
Départment de Physique Théorique and Center for Astroparticle Physics

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1 - What are the biggest deficits and challenges of the ΛCDM paradigm?

Nothing is wrong with ΛCDM	5.3%
Cold dark matter	21.1%
General relativity cannot be relied upon on large length scales	11.8%
There is no dark matter	6.6%
Inflation isn't predictive enough	18.4%
The cosmological constant problem	50.0%
The coincidence problem	15.8 %
It can't explain small-scale structure (e.g. dwarf galaxies)	28.9%
Baryonic effects are too difficult to model	18.4%
The model is fine-tuned	21.1%
Confirmation bias	21.1%
Big Bang singularity and high energy description of gravity	13.8 %
ΛCDM will remain the best-fit model to the data while it will not be understood theoretically	39.5%
Inflation is a general idea with no clear implementation in particle physics	19.1 %
Cosmic variance on ultra-large scales	7.9%
Effects of inhomogeneities and anisotropies	15.1%
There are no compelling alternatives	30.9%
Other (scaling relations in galaxies, MOND)	3.9%

2 - What will the future bring? Where do you think future efforts should be focused: Observational progress· · ·

• will slow due to difficult systematics	38.5%
• will slow due to reduced funding	29.6%
• will slow due to lack of theoretical progress	30.3%
• will slow due to computational challenges	9.9%
• will speed up!	17.8%
• Other	8.6%

3- What will the future bring? Where do you think future efforts should be focused: The most important results will come from$\cdots$

small experiments	33.6%
large experiments	58.6%
simulations	30.9%
theories	36.8%
particle physics	17.8%
Other (non-cosm. experiments like Casimir-effect, LHC	5.3%

4 - What will the future bring?
Next-generation experiments will· · ·

• confirm ΛCDM to higher precision	34.9%
• discover new things that can just be added to ΛCDM	38.2%
• discover new things that fundamentally change ΛCDM	31.6%
• discover something that completely overturns ΛCDM	12.5%
• Other	4.6%

5 - What will the future bring?
Dark energy will turn out to be$\cdots$

• related to dark matter	10.5%
• a cosmological constant	13.8%
• indistinguishable from a cosmological constant	48.7%
• a new scalar field	9.2%
• a modification to GR	18.4%
• something completely different	24.3%
• Other	4.6%
• $\Sigma =$	129.5%

6 - What will the future bring?
Our understanding of inflation will· · ·

• improve due to a primordial B-mode detection	38.8%
• improve due to a non-Gaussianity detection	13.8%
• improve due to a detection of non-zero spatial curvature	5.9%
• improve due to new/existing CMB/large-scale anomalies	9.9%
• improve due to philosophical developments	5.4%
• improve due to string theory	3.3%
• remain foggy	45.4%
• improve due to a detection of features in primordial power spectrum	7.9%
• get worse!	2.6%
• improve because it will be ruled out	9.2%
• Other (improved understanding of reheating)	5.3%

The cosmological constant problem will be solved by···

• a dark energy theory	21.7%
• a modified gravity theory	30.9%
• better understanding of particle physics	37.5%
• realising it's not a problem	28.3%
• Other (has already been solved, eternal inflation, quantum gravity)	10.5%

8 - What will the future bring?
The Higgs will turn out to be important in understanding· · ·

• inflation	19.1%
• dark matter	12.5%
• dark energy	9.9%
• none of the above	59.2%
• Other	5.9%

9 - What will the future bring? Current anomalies will· · ·

• remain, but can safely be ignored	18.4%
• remain and must be addressed	53.9%
• go away	20.4%
• overturn ΛCDM	15.8%
• Other	5.3%

10 - What will the future bring? New anomalies will be found$\cdots$

• but can safely be ignored	13.2%
• and must be addressed	67.8%
• and will overturn ΛCDM	17.1%
• Other	7.9%

11 - What will the future bring?
Baryonic physics· · ·

- will be completely understood through simulations 1.3%
- will be understood well enough through simulations to interpret observations correctly 30.9%
- will remain difficult to simulate, and is an important systematic effect 56.6%
- will remain difficult to simulate, but is a minor systematic effect 9.9%
- will remain difficult to simulate, and is disastrous for observations 7.2%
- Other (indirect cosmo/astro observations) 2.0%

12 - What will the future bring? Particle physics···

Cosmologists will discover something fundamental about neutrinos	44.7%
Particle physicists will discover something fundamental about neutrinos	33.6%
Neutrinos will remain mysterious	9.2%
Particle dark matter will be discovered experimentally	35.5%
Particle dark matter will be found not to work	17.8%
Particle physicists will explain the nature of inflaton	5.3%
Completely new particles will be discovered with important implications for cosmology	22.4%
Other	5.3%

13 - For cosmology, the most valuable/exciting observables over the next decade will probably be· · ·

CMB temperature	3.9%
CMB polarization	53.9%
CMB lensing	25.7%
CMB scattering (Thermal SZ/Rayleigh/spectral distortions)	20.4%
Supernovae	11.2%
Galaxy redshifts (spectroscopic)	32.9%
Galaxy redshifts (photometric)	16.4 %
High-redshift galaxies	25.0%
Other large-scale structure/matter distribution observables	27.0%
Peculiar velocities (Kinetic SZ)	18.4%
Weak lensing (shear/convergence)	41.4%
Strong lensing	12.5%
Local Hubble rate measurements	11.2%
21cm intensity mapping (EoR)	36.8%
21cm intensity mapping (late times)	22.4%
Matter distribution on ultra-large scales	21.7%
Laboratory tests of gravity	18.4%
Dark matter direct detection	38.8%
. . .	

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• ···	
• Neutrinos	24.3%
• Cosmic rays	4.6%
• Transients	5.3%
• Gravitational waves	44.7%
• Particle collisions (LHC)	20.4%
• Proper motions of stars	9.2%
• Variation of fundamental constants	4.6%
• Various cross-correlations	14.5%
• Local tests of gravity	14.5%
• Other (galaxy clusters)	2.6%

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summary

#	question	☺	☹
1	challenges of ΛCDM	Cosmological Constant	Nothing is wrong
2	Observational progress	slow: systematics	slow: lack of theory
3	most important	large experiments	particle physics
4	Experiments	+ ΛCDM	overturn ΛCDM
5	Dark energy	indistinguishable from Λ	new scalar field
6	Understanding inflation	remain foggy	string theory
7	Λ – Solution	particle physics	dark energy theory
8	The Higgs	none	dark energy
9	Anomalies	must be addressed	overturn ΛCDM
10	New anomalies	must be addressed	can safely be ignored
11	Baryonic physics	will remain difficult	...completely understood
12	Particle physics	cosmology: neutrinos	nature of inflaton
13	observables	CMB ploarization	CMB temperature

The Laws of Nature are not Democratic

and $\cdots$