Fermilab U.S. DEPARTMENT OF ENERGY | Office of Science

Cluster Cosmology

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SIST 5 minutes, 5 slides
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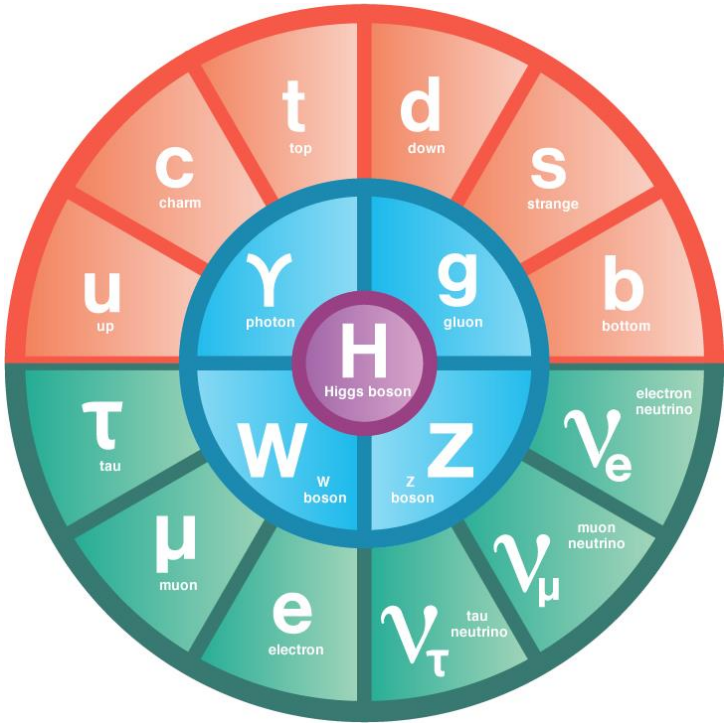
DARK ENERGY SURVEY

ΛCDM

- Standard model of cosmology



Description	Symbol	Value
Physical baryon density parameter[a]	$\Omega_b h^2$	0.022 30 ± 0.000 14
Physical dark matter density parameter[a]	$\Omega_c h^2$	0.1188 ± 0.0010
Age of the universe	t_0	13.799 ± 0.021 × 10^9 years
Scalar spectral index	n_s	0.9667 ± 0.0040
Curvature fluctuation amplitude, k_0 = 0.002 Mpc^{-1}	Δ^2_R	$2.441\ ^{+0.088}_{-0.092} \times 10^{-9}$[88]
Reionization optical depth	τ	0.066 ± 0.012

Total density parameter[b]	Ω_{tot}	1
Equation of state of dark energy	w	−1
Tensor/scalar ratio	r	0
Running of spectral index	$dn_s/d\ln k$	0
Sum of three neutrino masses	$\sum m_\nu$	0.06 eV/c^2[c][84]:40
Effective number of relativistic degrees of freedom	N_{eff}	3.046[d][84]:47
Hubble constant	H_0	67.74 ± 0.46 km s^{-1} Mpc^{-1}
Baryon density parameter[b]	Ω_b	0.0486 ± 0.0010[e]
Dark matter density parameter[b]	Ω_c	0.2589 ± 0.0057[f]
Matter density parameter[b]	Ω_m	0.3089 ± 0.0062
Dark energy density parameter[b]	Ω_Λ	0.6911 ± 0.0062
Critical density	ρ_{crit}	(8.62 ± 0.12) × 10^{-27} kg/m^3[g]
The present root-mean-square matter fluctuation averaged over a sphere of radius $8h^{-1}$ Mpc	σ_8	0.8159 ± 0.0086
Redshift at decoupling	z_*	1 089.90 ± 0.23
Age at decoupling	t_*	377 700 ± 3200 years[88]
Redshift of reionization (with uniform prior)	z_{re}	$8.5\ ^{+1.0}_{-1.1}$[89]

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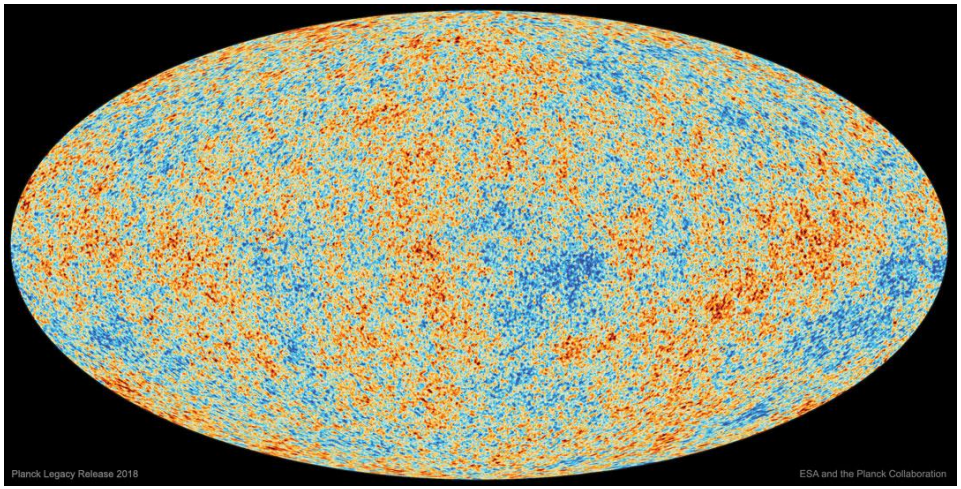
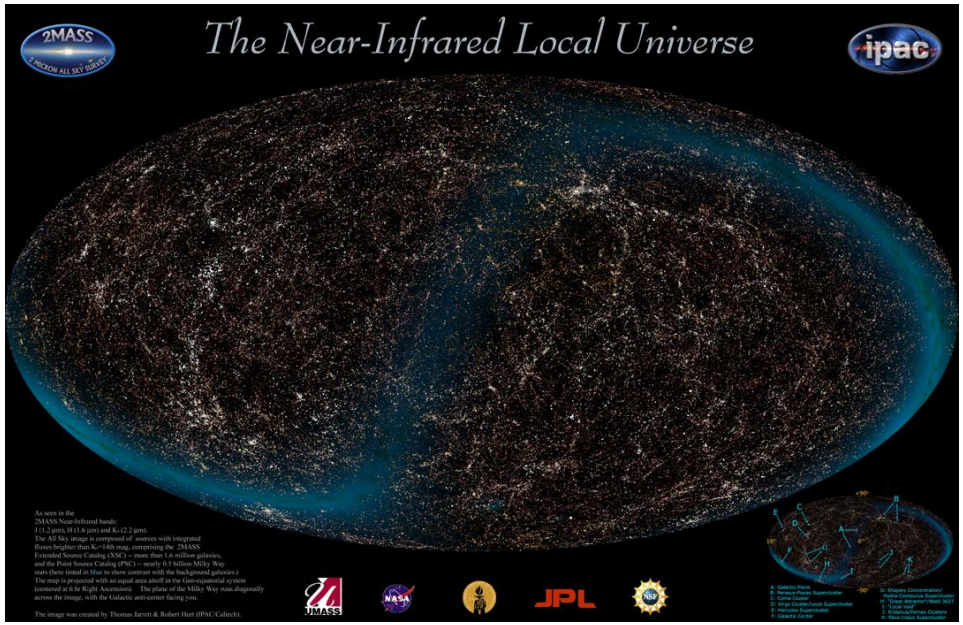
CMB



(Picture from Planck collaboration)

(Picture 2MASS Large Scale Survey)



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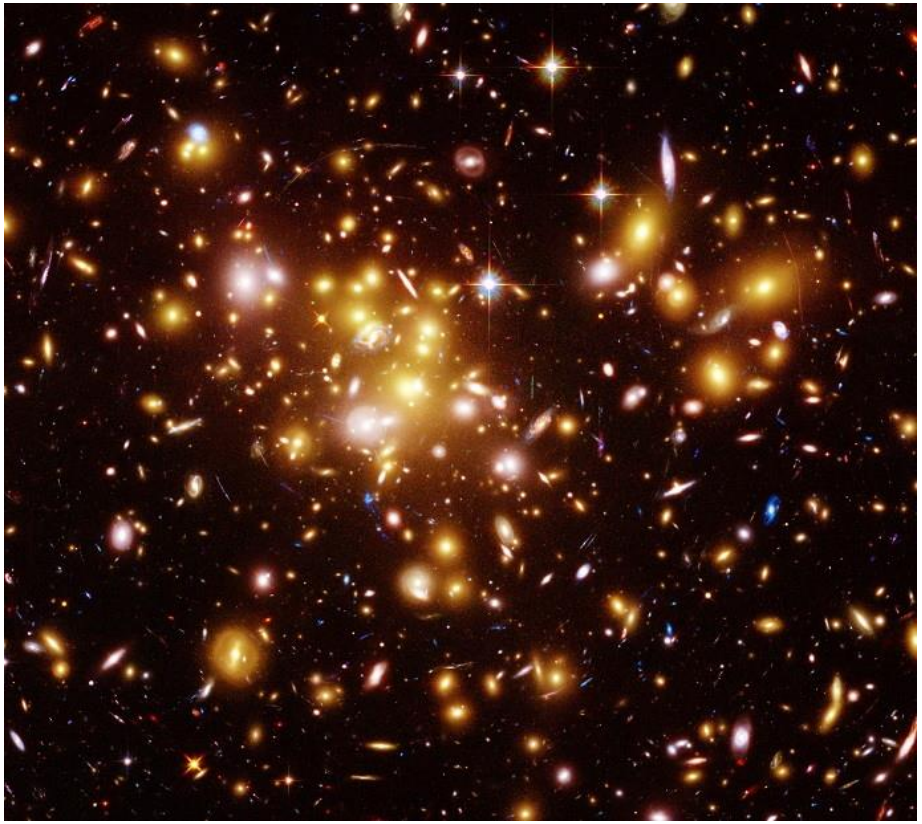
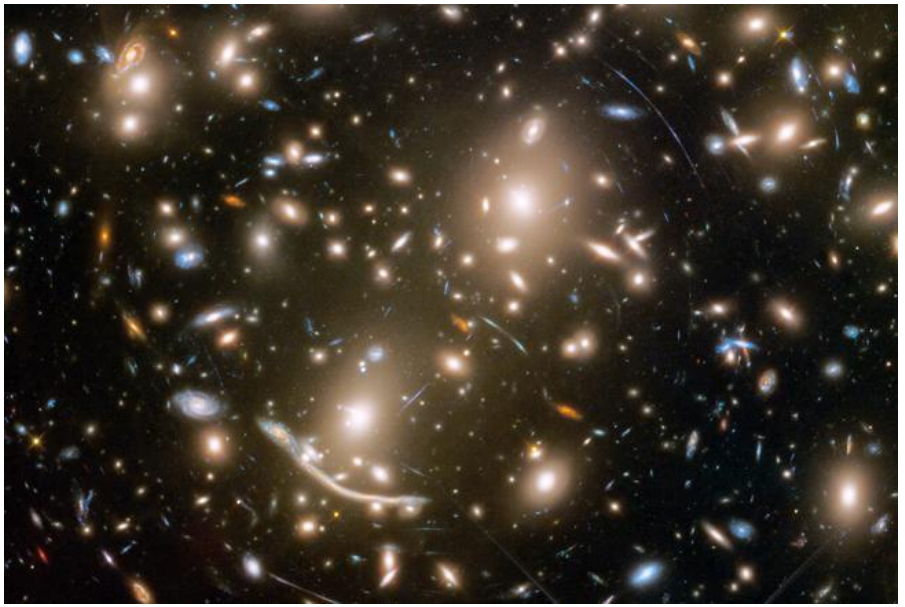
Galaxy clusters and weak lensing

- Structures with the largest scale in the Universe
- Their mass can be found using weak lensing





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Matter density parameter[b]	Ω_m	0.3089 ±0.0062

- In 2020, the DES cluster group measured $\Omega_m = 0.2$.

References

- Abbott, T. M. C., and others. "Dark Energy Survey Year 1 Results: Cosmological constraints from cluster abundances and weak lensing".*Phys. Rev. D* 102, no.2 (2020): 023509.
- Frieman, Joshua, Michael, Turner, and Dragan, Huterer. "Dark Energy and the Accelerating Universe".*Ann. Rev. Astron. Astrophys.* 46 (2008): 385–432.
- Costanzi, Matteo, Francisco, Villaescusa-Navarro, Matteo, Viel, Jun-Qing, Xia, Stefano, Borgani, Emanuele, Castorina, and Emiliano, Sefusatti. "Cosmology with massive neutrinos III: the halo mass function and an application to galaxy clusters".*JCAP* 12 (2013): 012.

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