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Peuclid

Recent results on cosmic shear

Nicolas Martinet (postdoc @LAM) Colloque Dark Energy 2020 Paris, October 15th



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68.3% Dark

Eneray

26.8% Dark Matter

4.9% Ordinary

Matter

Recent results on cosmic shear

KiDS-450 1.2 CFHTLenS (MID J16) WMAP9+ACT+SPT Planck15 1.0 08 0.8 0.6 0.16 0.24 0.32 0.40 $\Omega_{\rm m}$

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KiDS-450 constraints (Hildebrandt et al. 2017)



Dreams



Beyond ACDM: Neutrinos (Joudaki et al. 2017)



Massive neutrinos cannot solve the tension

Beyond ACDM: Dark Energy (Joudaki et al. 2017)



• Evolving DE can solve the tension

Systematics



Weak lensing systematics







DES-Y1, impact of shear measurement (Troxel et a_{10} 2018)

Weak lensing systematics: intrinsic alignments

set to zero

 Model from Hirata & Seljak 2004, Bridle & King 2007, Joachimi et al. 2011

$$\begin{split} \left\langle \hat{\xi}_{\pm} \right\rangle &= \xi_{\pm} + \xi_{\pm}^{\mathrm{II}} + \xi_{\pm}^{\mathrm{GI}} \,, \\ P_{\mathrm{II}}(k,z) &= F^2(z) P_{\delta}(k,z) \\ P_{\mathrm{GI}}(k,z) &= F(z) P_{\delta}(k,z) \,, \end{split}$$

$$F(z) = -A_{\rm IA}C_1\rho_{\rm crit}\frac{\Omega_{\rm m}}{D_+(z)} \left(\frac{1+z}{1+z_0}\right)^{\eta} \left(\frac{\bar{L}}{L_0}\right)^{\beta}$$

Amplitude of IA = new free parameter



Weak lensing systematics: baryons



 Amplitude of the halo mass concentration (B) as a free parameter

Impact of baryons on the matter power spectrum (Chisari et al. 2019)

Colleagues

Stage III cosmic shear surveys

	KiDS+VIKING	HSC	DES
Mirror [m]	2.6 + 3.9	8.2	4.0
Focus (optical)	Cassegrain+Prime	Prime	Prime
FOV [deg ²]	1.0	1.8	3.0
Area [deg ²]	1350	1400	5000
Filters	u gri+ZY JHKs	grizy	griz(y)
Seeing [arcsec]	0.7	0.6	0.9
Source density [gal/arcmin ²]	~9	~22	~7
Depth	<i>r</i> ~24	i~24.5	<i>r</i> ~23.5

Courtesy Hendrik Hildebrandt

Comparison between current cosmic shear surveys (Hildebrandt et al. 2020)



Re-analysis of DES with KiDS setup (Joudaki et al. 2020)

- Only difference left:
- DES n(z) based on COSMOS photoz calibration
- KiDS n(z) based on spectroscopic calibration



Re-analysis of DES with KiDS setup (Joudaki et al. 2020)

- Re-calibrate DES n(z) from KiDS spec-z sample
- Increases mean redshift of every tomographic bin
- Lower S₈ values

Tom.	COSMOS-2015	Spec-z (DIR)
bin	$\langle z \rangle$	$\langle z \rangle$
1	0.389 ± 0.016	0.403 ± 0.008
2	0.507 ± 0.013	0.560 ± 0.014
3	0.753 ± 0.011	0.773 ± 0.011
4	0.949 ± 0.022	0.984 ± 0.009



Impact of the redshift distribution (Joudaki et al. 2020)

- Same n(z) calibration -> perfect agreement between KiDS and DES
- Combination -> 2.5σ tension with Planck



What else?

KiDS-1000: 3 x 2pt (Heymans et al. 2020)



Beyond 2-pt: the non-Gaussian information



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Estimator: mass map statistics



Weak-lensing peaks in KiDS-450 (Martinet et al. 2018)



- Peaks = clusters + chance alignment + noise
- Peaks + shear 2PCF improve constraints on S8 by 20%
- See also results from CFHTLenS (Liu et al. 2015) and DES (Kacprzak et al. 2016)



- Constraints on S8 improved by 25%
- Tomography works better for 2PCF than peaks (because of cross-correlations)

Improving tomography (Martinet et al. 2020)



Improving tomography (Martinet et al. 2020)



Improving tomography (Martinet et al. 2020)



- Tomography with crossterms improves the constraints by 50%
- Combination with 2PCF now as good with tomography as without
- Useful for the S8 tension
- Lensing pdf (1D Map) better than any other estimator

and probing DE (Martinet et al. 2020)



- Forecasts for 100 deg² of Euclid with a 5-slice tomography
- Constraints from 1D Map + shear 2PCF improved by ~70% compared to 2PCF alone
- Huge potential for DE

Euclid forecasts with neutrinos (Ajani et al. 2020)



Combining higher order statistics (HOWLS)

- Euclid collaborative project
- Comparison of all known HOS estimators on a common set of mass maps





New results to come soon (step 3):
w₀ forecasts, more estimators, systematics

Deep learning on KiDS-450 (Fluri et al. 2019)



- Based on mass maps
- Outperforms shear 2PCF
- Still needs some refinements on systematics compared to more traditional methods, but very promising!



Conclusion

- Exciting time for cosmic shear!
- Ongoing stage III surveys
 - KiDS, DES, HSC
 - S8 measurement in tension with CMB high-z probe
 - Possibility for new physics (DE ?)
 - Mostly based on 2pt estimators (less noisy, better understood)
- Future stage IV surveys
 - Euclid (2022+), LSST (2021+), WFIRST
 - Strong constraints on w₀ expected
 - Beyond cosmic shear 2pt statistics are flourishing...
 - ...and extremely promissing!
- Focus meeting @ IAU General Assembly 2021: « Consensus Cosmic Shear in the 2020s » (co-chairs Martinet & Wright)

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