Intrinsic alignments roadmap

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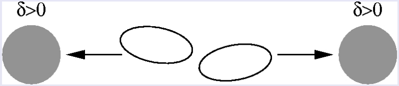
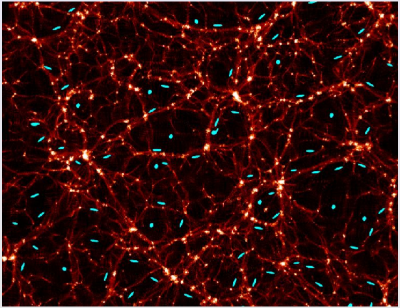
Galaxy ellipticity correlations

2pt correlation: $$\underbrace{\langle \epsilon_i \epsilon_j \rangle}_{\text{observed}} = \underbrace{\langle \gamma_i \gamma_j \rangle}_{\text{GG}} + \underbrace{\langle \epsilon_i^s \epsilon_j^s \rangle}_{\text{II}} + \underbrace{\langle \gamma_i \epsilon_j^s \rangle + \langle \epsilon_i^s \gamma_j \rangle}_{\text{GI}}$$





Standard picture:

tidal gravitational field generates torques & shear forces

$\rightarrow$ angular momenta & shapes of forming haloes become correlated

$\rightarrow$ galaxy ellipticities become correlated

Galaxy ellipticity correlations

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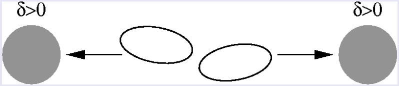

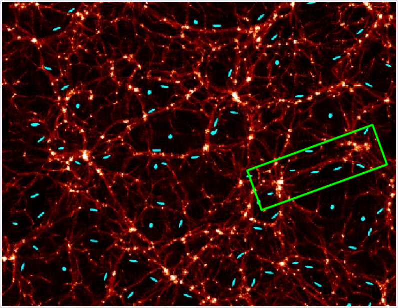

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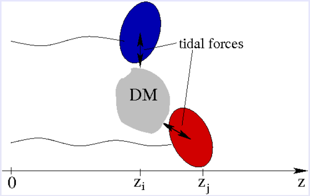
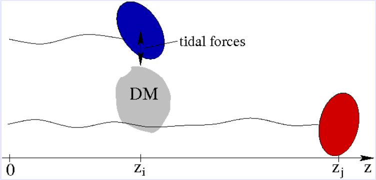
Redshift dependence

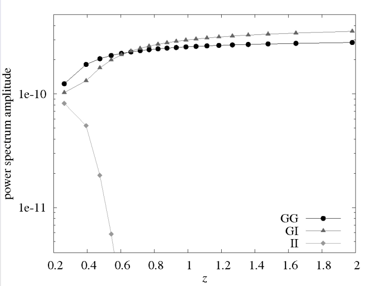




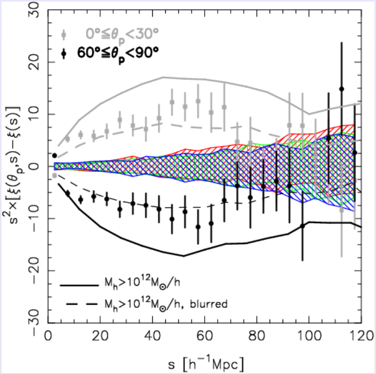
2pt correlation: $\langle \epsilon_i \epsilon_j \rangle = \underbrace{\langle \gamma_i \gamma_j \rangle}_{GG} + \underbrace{\langle \epsilon^s_i \epsilon^s_j \rangle}_{II} + \underbrace{\langle \gamma_i \epsilon^s_j \rangle + \langle \epsilon^s_i \gamma_j \rangle}_{GI}$

Redshift scaling of GG, GI, and II

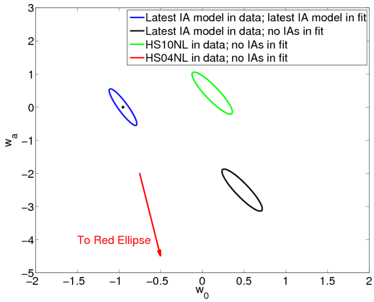
GG	lensing signal
II	intrinsic ellipticity correlations
GI	gravitational shear-intrinsic ellipticity correlations



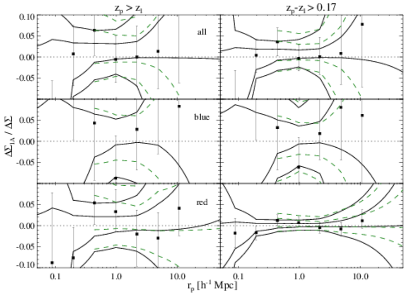
If IA are not dealt with...



Li et al. (2013)



Kirk et al. (2012) — *Blazek et al. (2012)*



- no competitive cosmology from cosmic shear
- risk of bias in galaxy-galaxy lensing
- subtle biases in clustering?

Intrinsic alignment self-calibration

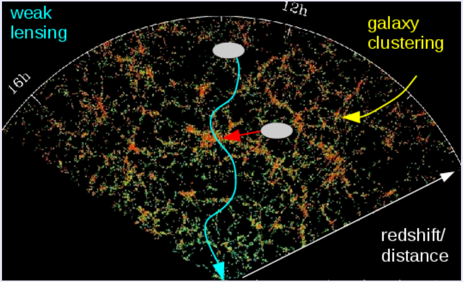
Ansatz: Use additional correlations available from weak lensing surveys

$$C^{(ij)}_{\epsilon\epsilon} = C^{(ij)}_{\rm GG} + C^{(ij)}_{\rm IG} + C^{(ji)}_{\rm IG} + C^{(ij)}_{\rm II}$$

$$C^{(ij)}_{n\epsilon} = C^{(ij)}_{\rm gG} + C^{(ij)}_{\rm gI} + C^{(ij)}_{\rm mG} + C^{(ij)}_{\rm mI}$$

$$C^{(ij)}_{nn} = C^{(ij)}_{\rm gg} + C^{(ij)}_{\rm gm} + C^{(ji)}_{\rm gm} + C^{(ij)}_{\rm mm}$$

G: gravitational shear
I: intrinsic shear
g: intrinsic number densities
m: magnification effects



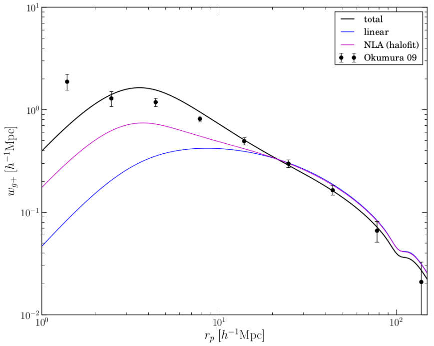
Goal:
Calibrate GI signal via cross-correlation with galaxy clustering

Procedure: *(Bernstein 2009, Joachimi & Bridle 2010)*

- include galaxy number density correlations
- introduce model or parametrisation for IA and galaxy bias
- marginalise over all IA and galaxy bias parameters

Analytical models

Tidal shear model



Blazek et al., in prep.

Next-to-leading-order perturbation theory:

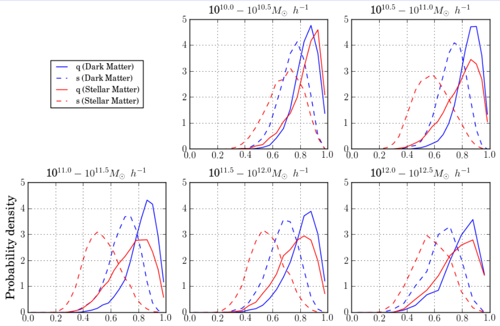
- weighted shear field
- non-linear biasing
- smoothing at halo scales

→ consistent alternative to NLA model

- analogous PT model for spin alignments underway *(Schäfer et al.)*
- full halo model that jointly predicts IA and clustering signals ready and currently applied to SDSS data sets *(Cacciato et al., in prep.)*

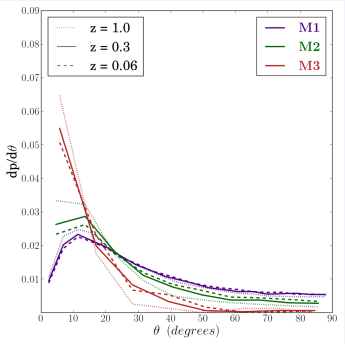
Simulations & semi-analytics

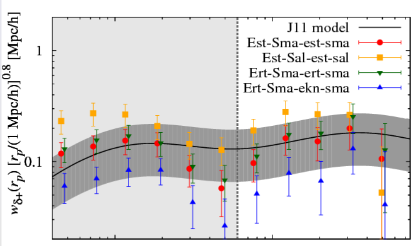
Dark & stellar matter shapes



Tenneti et al. (2014)

DM-gas alignment



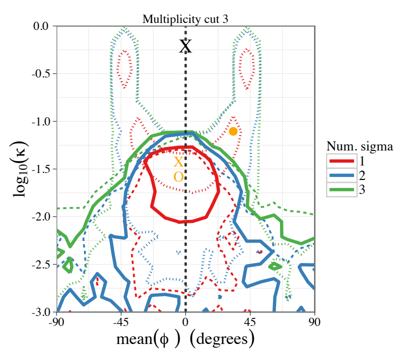


- create semi-analytic models of galaxy shapes
- obtain analytics from high-res. DM and gas simulations

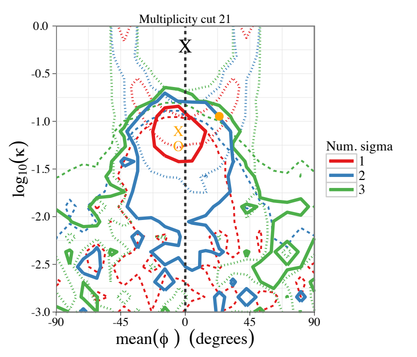
Joachimi et al. (2013)

IA observational constraints – small scales

low mass GAMA groups



massive GAMA groups



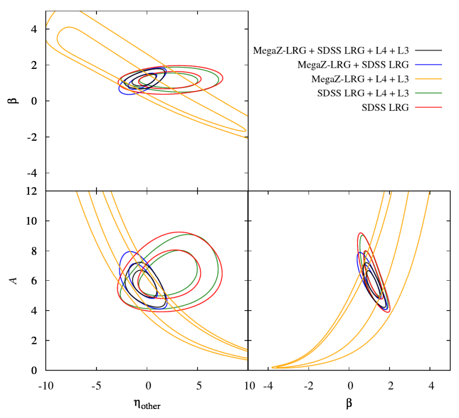
$\kappa = 0$: no alignment

Schneider et al. (2013)

- no satellite alignment detection in large sample of low-redshift clusters *(Sifon et al., in prep.)*

$\rightarrow$ possible hint at non-monotonic mass dependence?

IA observational constraints – large scales



SDSS early-type samples

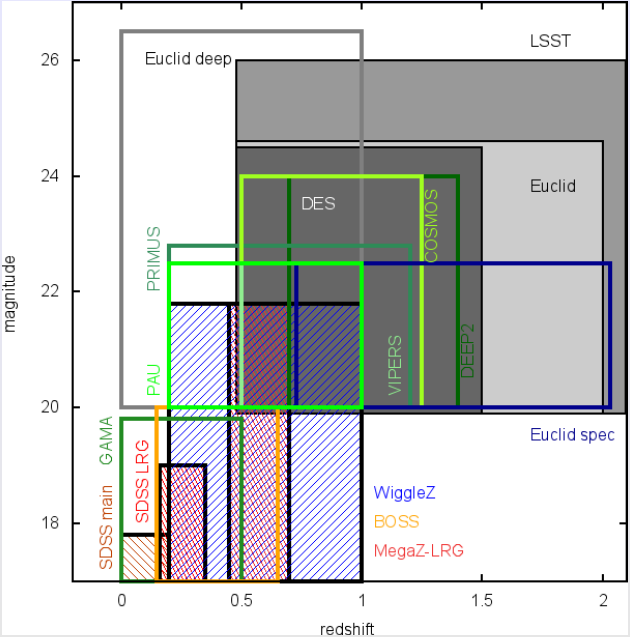
A: IA amplitude
$\eta_{\rm other}$: redshift scaling
β: luminosity scaling

simple model based on tidal shear alignment

1σ and 2σ marginal confidence levels *(Joachimi et al. 2011)*

- currently no clear detections for disc galaxies *(Mandelbaum et al. 2011)*
- strong signal for BOSS LOZ galaxies to be published soon *(CMU group)*
- constraints from GAMA, VIPERS, DEEP2 + CFHT imaging this year

IA calibration samples

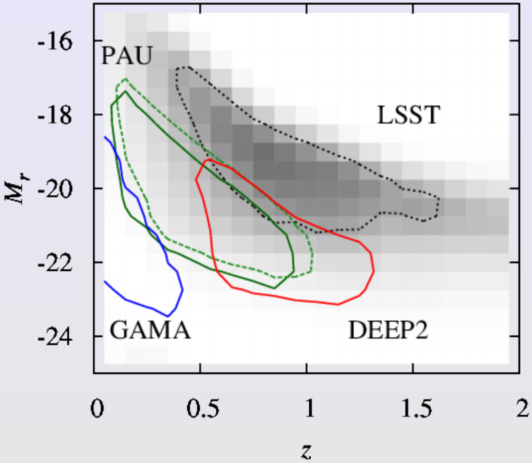


hatched: existing
open: planned
grey: to be calibrated

reddish: red samples
blueish: blue samples
greenish: both

IA calibration samples

absolute magnitude & redshift

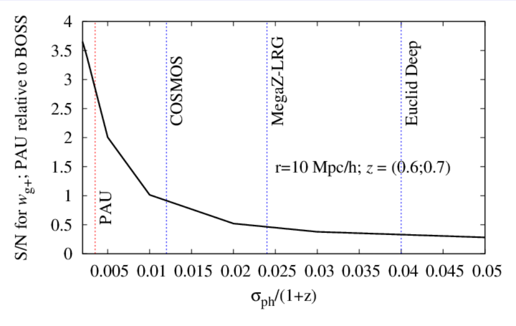


actual GAMA and DEEP2 samples

otherwise Millennium simulation + Durham semi-analytics

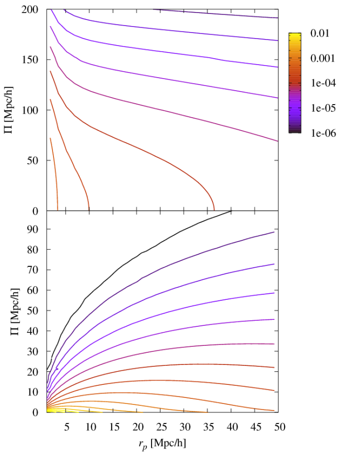
Effect of photometric redshift scatter

Signal dilution due to photoz scatter



for an early-type galaxy sample;
assuming Gaussian photoz scatter

3D IA signal



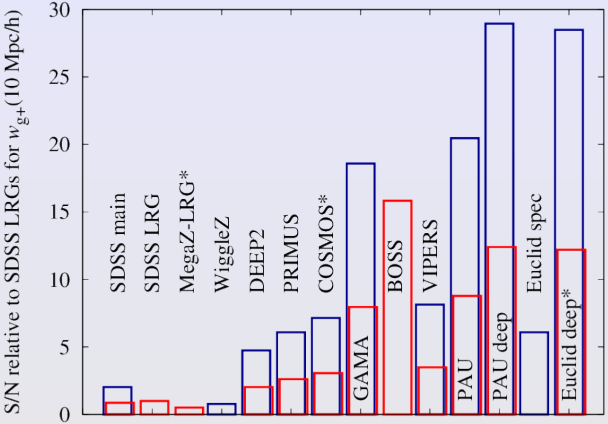
$\sigma_{\rm ph} = 0.02$ *(Joachimi et al. 2011)*

Further effects:

- increasing contamination by gg-lensing which needs to be subtracted
- increasing chance of catastrophic redshift failures

Expected significance of IA measurements

Forecast for IA S/N using $w_{g+}(10\,\mathrm{Mpc}/h)$



*: additional contamination by gg-lensing

assuming weak signals i.e. negligible cosmic variance

$\rightarrow$ driving survey parameter is galaxy number density

Conclusions

The roadmap for IA calibration:

- Aim for deep physical understanding of IA effects $\rightarrow$
  a) improved constraints on cosmology
  b) novel insights into galaxy formation and evolution
- Analyse high-resolution dark matter & gas simulations to study highly non-linear regime
- Use halo model & semi-analytic prescriptions to create comprehensive models that are fit to calibration data and employed in cosmological analyses
- Develop model-independent mitigation for validation of approach

Requirements on IA calibration survey:

1. Maximum overlap with lensing quality deep imaging
2. Depth & redshift range close to survey to be calibrated
3. Quasi-spectroscopic redshift information with dense sampling
4. Contiguous patches that allow sampling out to $\sim$ 20 Mpc/h scales (min. patch size $\sim 25\,\mathrm{deg}^2$)