Backreaction and FLRW consistency conditions

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FM, Syksy Räsänen [arXiv:1709.06022]

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FLRW consistency condition

Clarkson, Basset, Hui-Ching Lu [arxiv:0712.3457]

$$d(z) = \frac{1}{\sqrt{k}} \sin\left(\sqrt{k}\int_0^z \frac{d\tilde{z}}{h(\tilde{z})}\right) \quad \Rightarrow \quad \boxed{k = \frac{1 - h^2 d'^2}{d^2} \equiv k_H(z)}$$

$d(z) = H_0(1+z)D_A(z)$
$h(z) = H(z)/H_0$

Backreaction

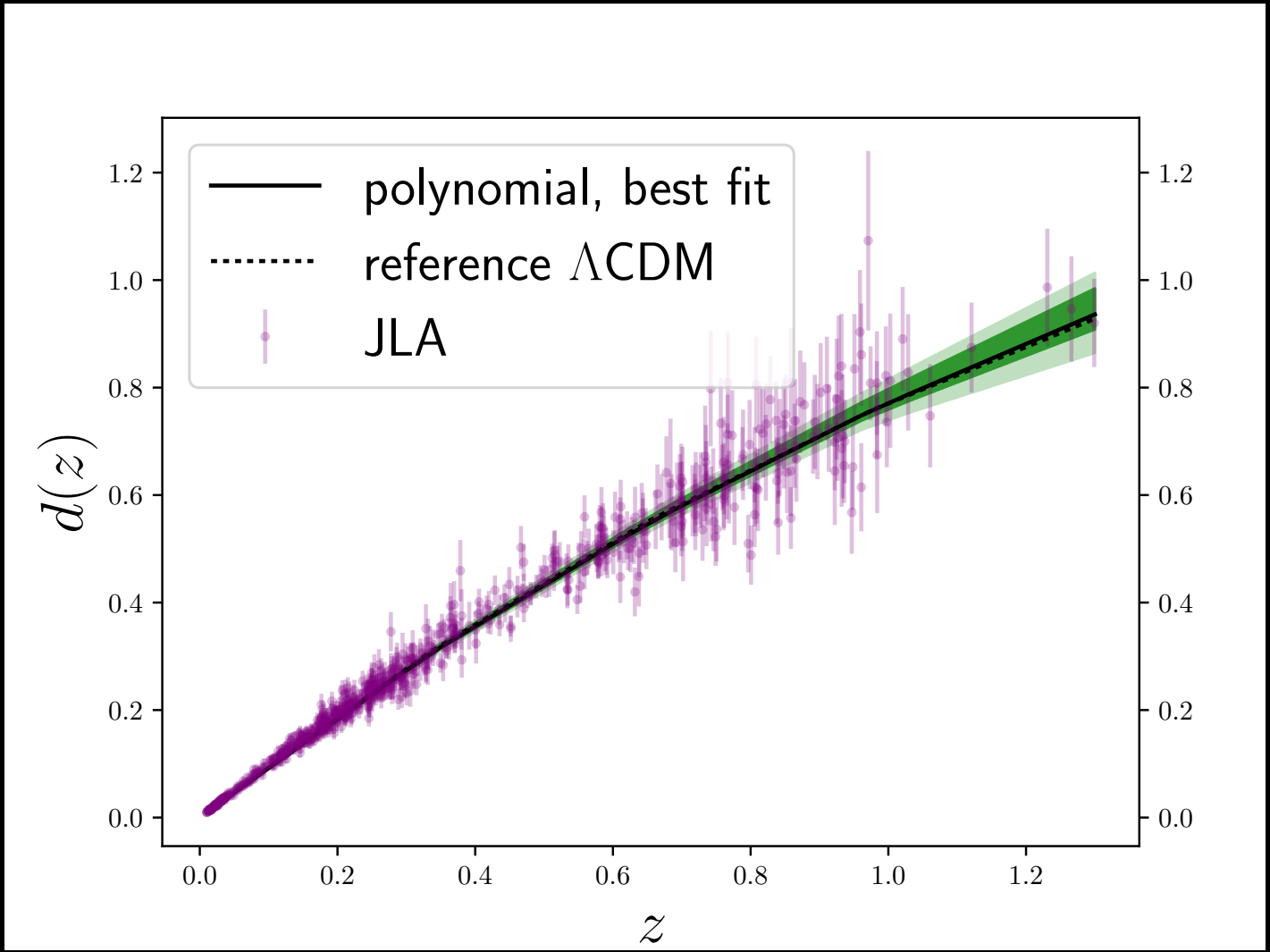
Sachs optical equation

$$h\frac{\mathrm{d}}{\mathrm{d}z}\left[(1+z)^2 h d'_A\right] = -\frac{3}{2}\Omega_{\mathrm{m}0}(1+z)^3 d_A$$

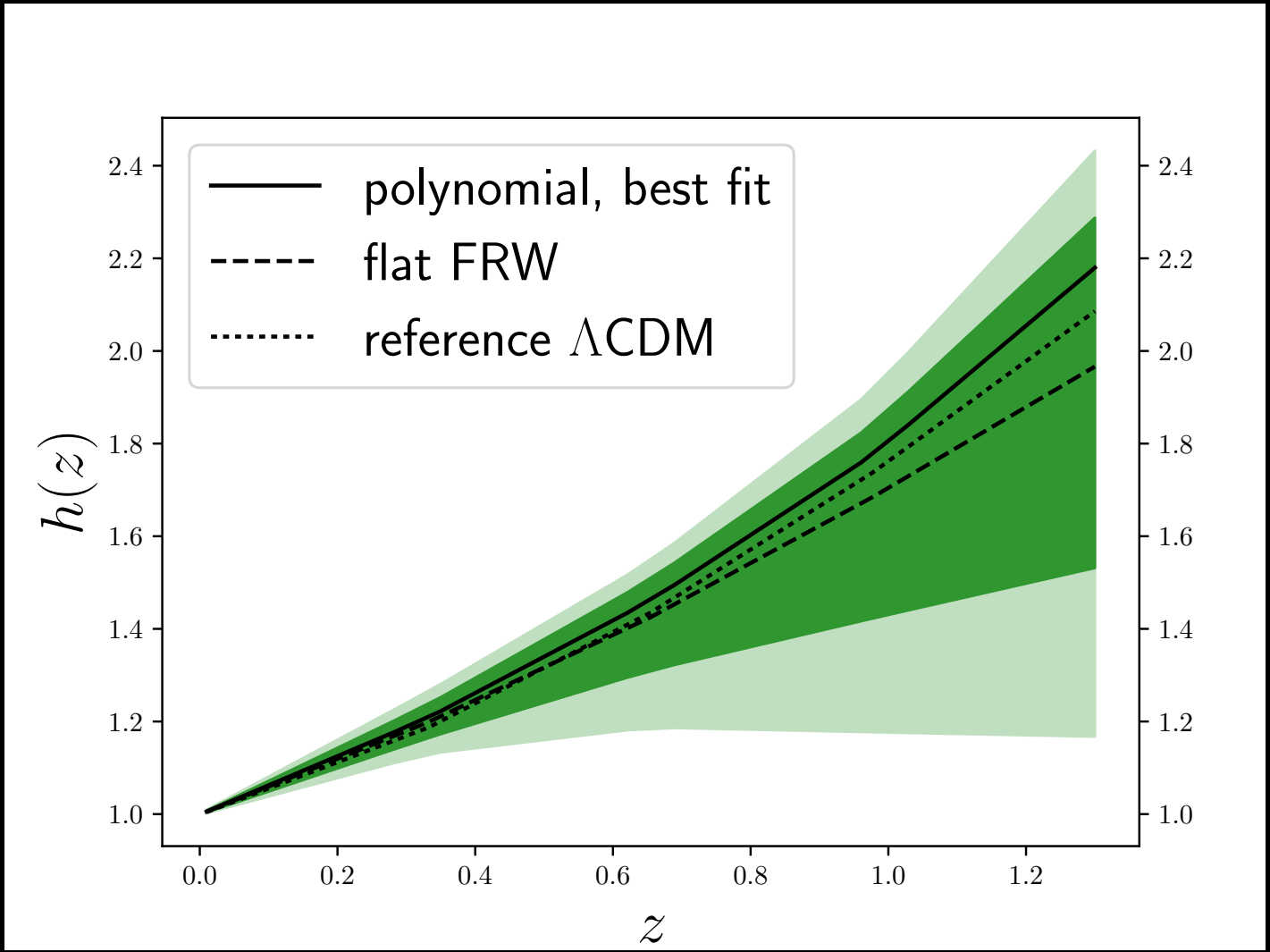
gives

$$\boxed{h(z)^2 = \frac{1}{(1+z)^4 (d'_A)^2}\left[1 - 3\Omega_{m0}\int_0^z d\tilde{z}(1+\tilde{z})^5 d_A(\tilde{z}) d'_A(\tilde{z})\right]}$$

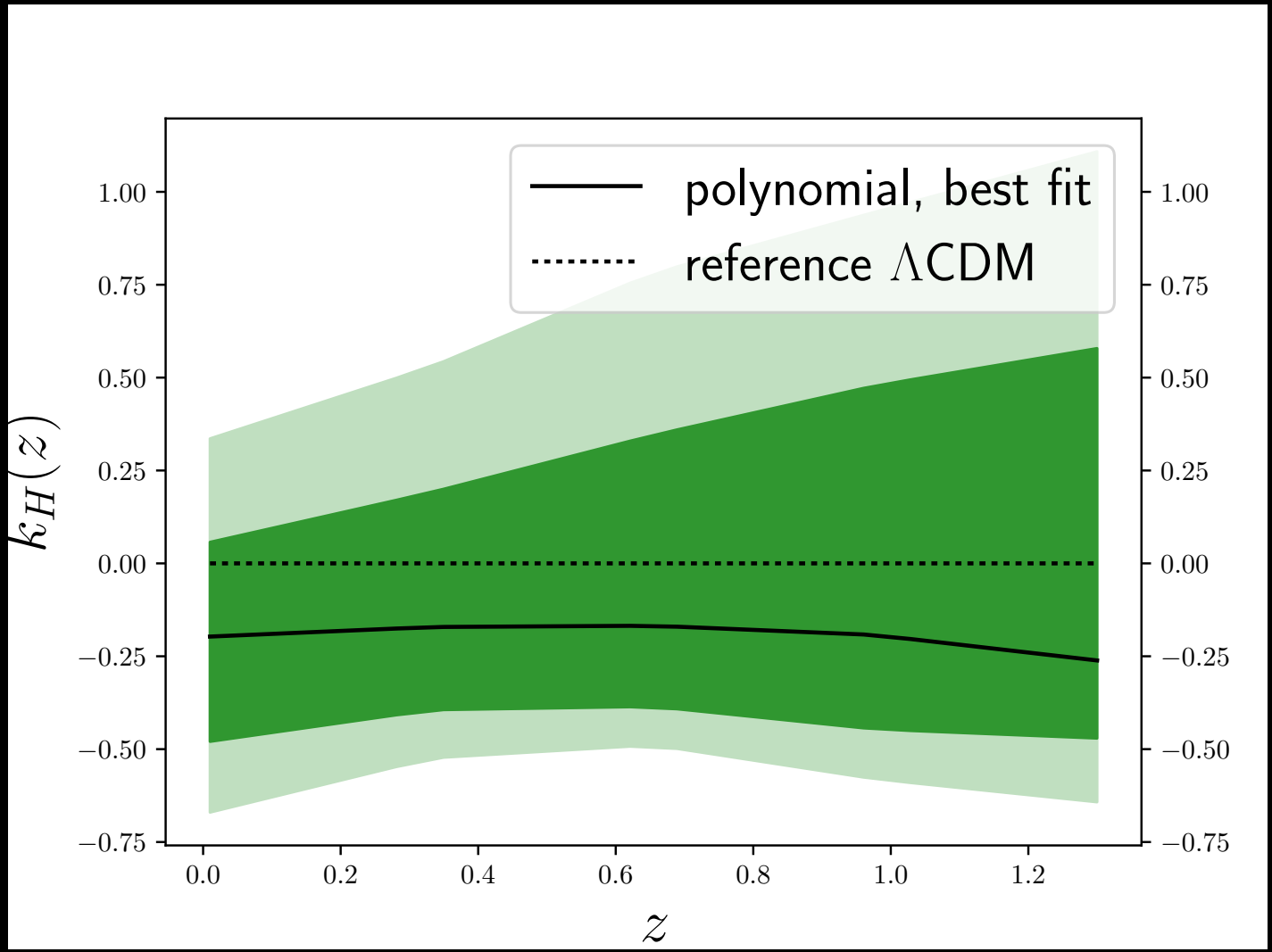
Distance


polynomial, best fit
reference ΛCDM
JLA
d(z)
z
0.0
0.2
0.4
0.6
0.8
1.0
1.2

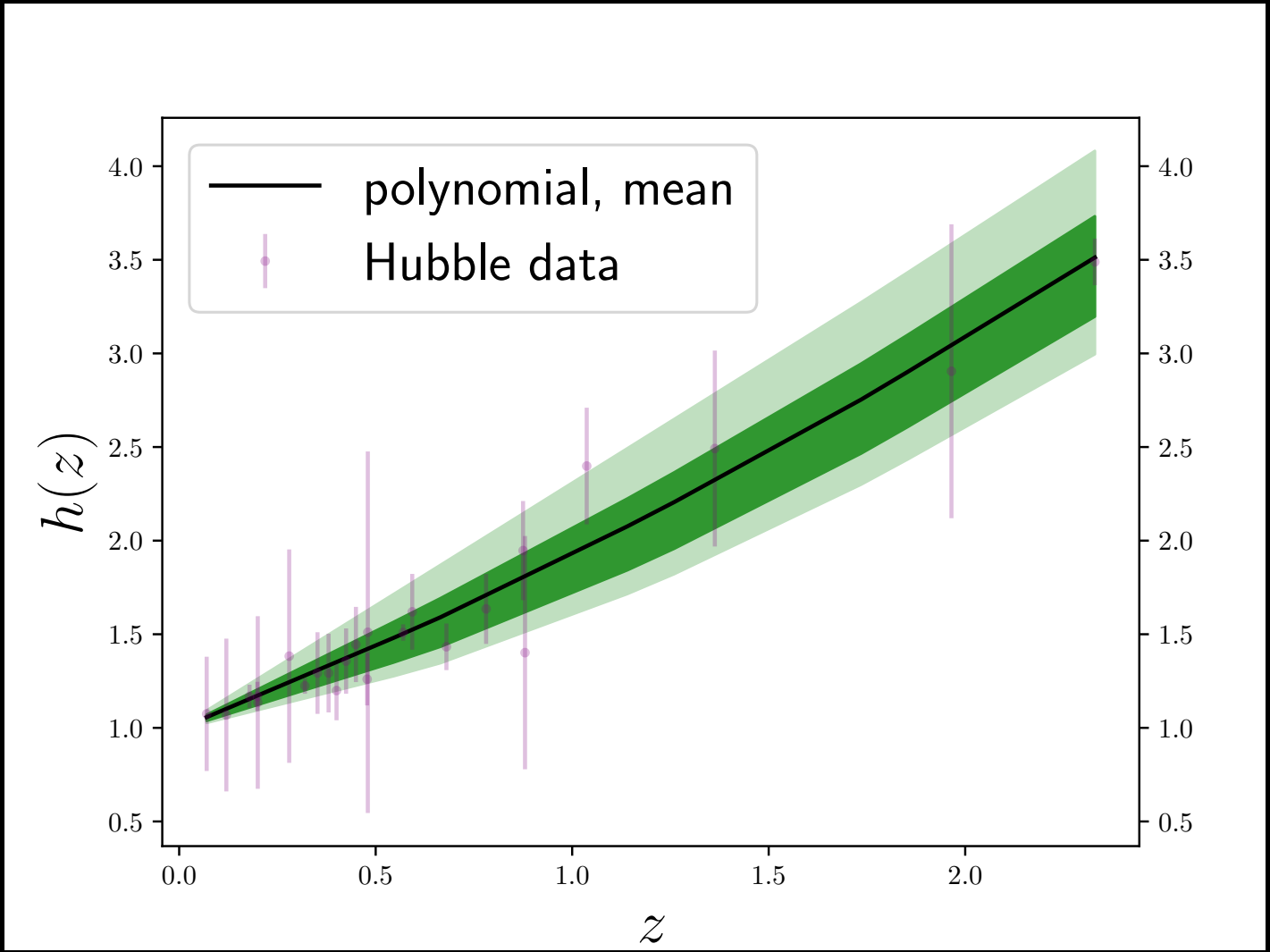
Backreaction expansion rate



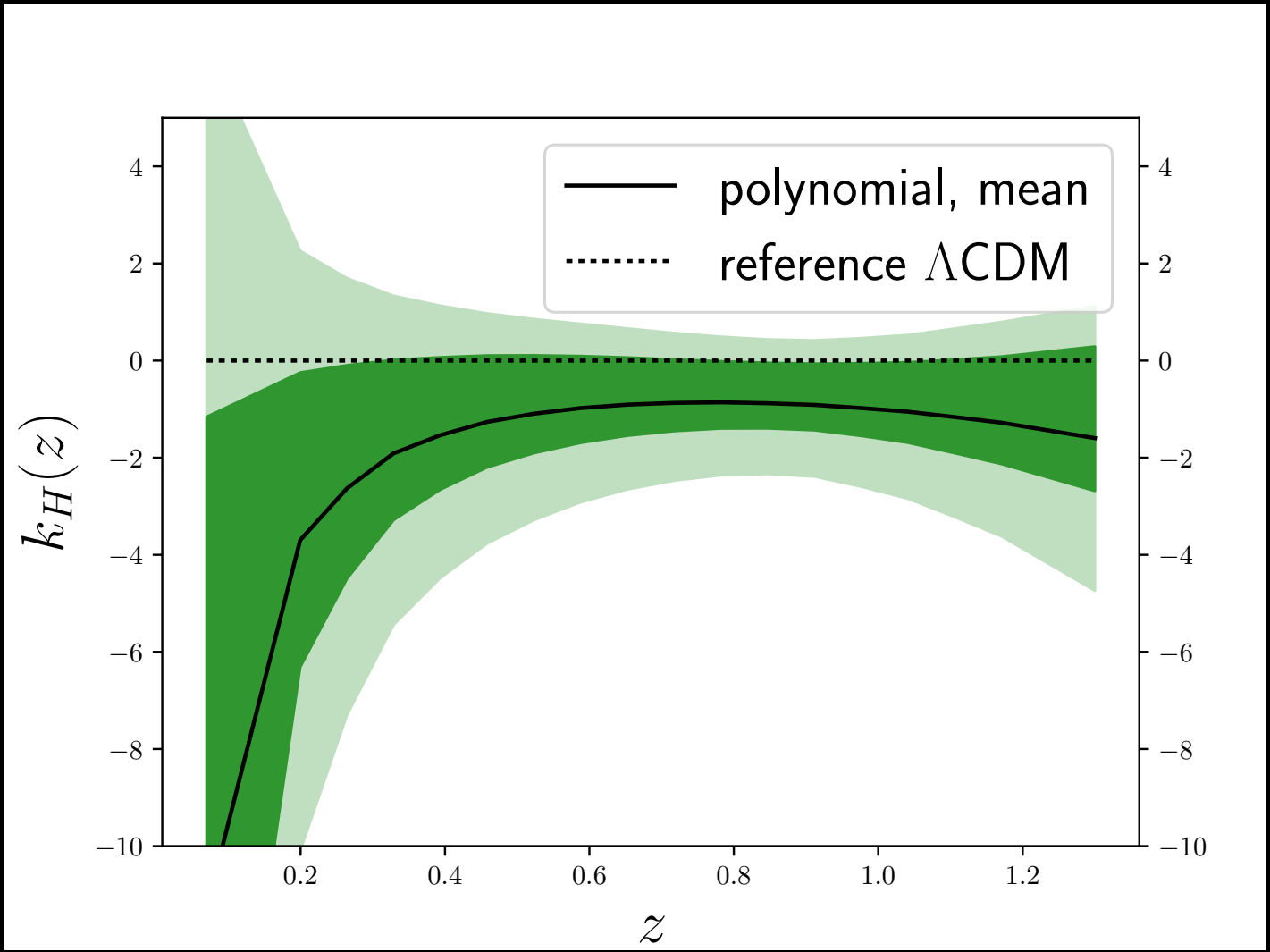
Backreaction prediction



Expansion rate from BC03 cosmic clocks + BAO



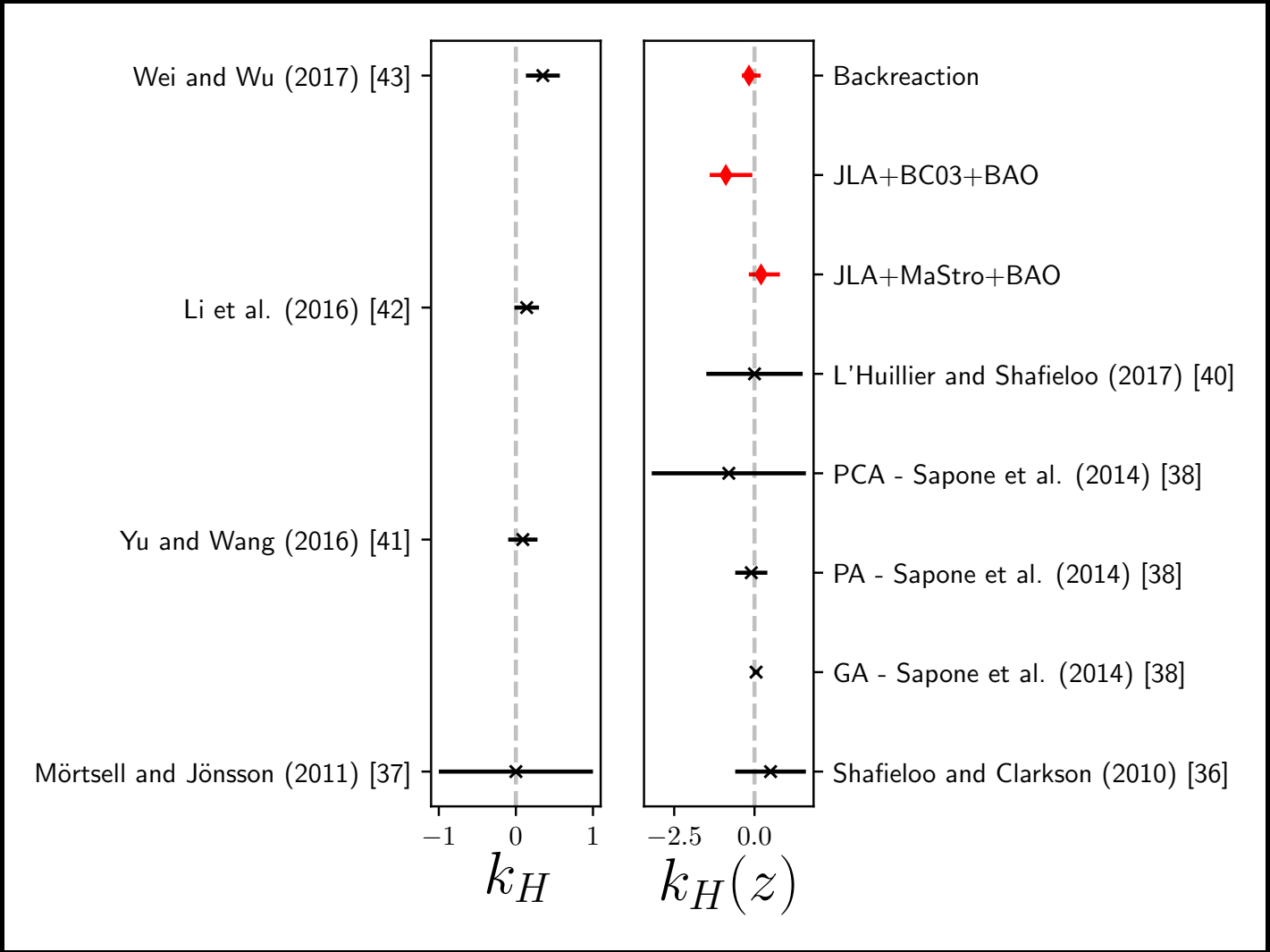
FLRW null test



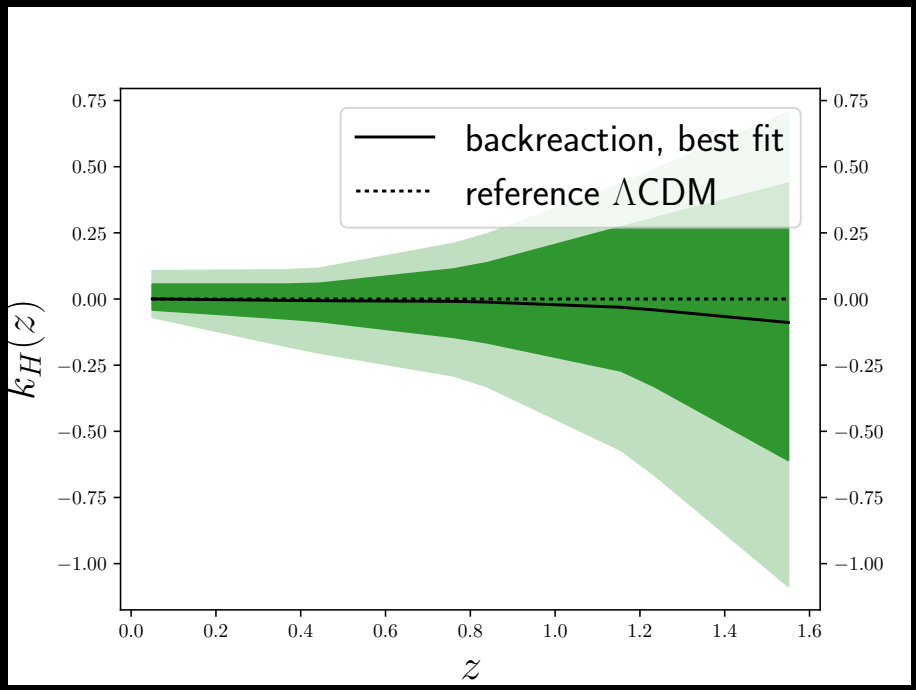
Hubble parameter today

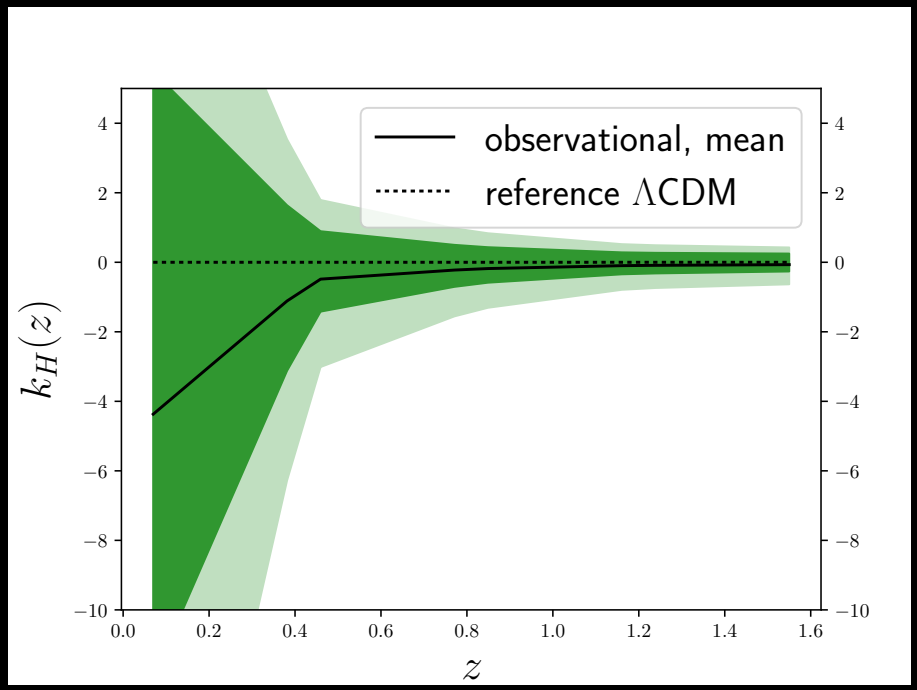
H_0 [km/Mpc/s]	BC03	BC03+BAO	MaStro	MaStro+BAO
polynomial	$66.8^{+6.1}_{-6.3}$	$64.2^{+5.2}_{-3.9}$	70.7^{+12}_{-13}	$67.7^{+4.9}_{-4.8}$
spline	$68.8^{+7.3}_{-7.1}$	$62.5^{+4.6}_{-4.6}$	69.0^{+15}_{-16}	$68.7^{+5}_{-5.3}$
ΛCDM	$68.4^{+6.2}_{-6.3}$	$61.7^{+4.5}_{-4.5}$	$79.6^{+6.7}_{-7.5}$	$67.7^{+5.3}_{-4.8}$

k_H constraints



Forecast LSST+Euclid





Conclusions

- Backreaction prediction (best 95% C.I.): $-0.7 < k_H < 0.4$.
- Geometric, model independent test (best 95% C.I.):
  - JLA+BC03+BAO: $-2.32 < k_H < 0.4$.
  - JLA+MaStro+BAO: $-0.86 < k_H < 1.13$.
- Non-trivial degeneracies in parameter space.
- LSST+Euclid forecast, improvement on $k_H(z)$ by factor 6 (backreaction) and 3 (observational).
- Further consistency conditions: $k_p(z)$ (parallax), $k_S(z_l, z_s)$ (distances sum rule).