Cosmological Information Contents on Light Cone

based on Yoo, Mitsou, Grimm, Durrer, Refregier 2019 JCAP

Jaiyul Yoo

Center for Theoretical Astrophysics and Cosmology

Institutes for Computational Science, University of Zürich

4 February 2020

Universität Zürich[UZH]

Cosmological Information

- how much cosmological information available?
  - surveys: galaxy, weak lensing, cmb, supernova, etc
  - complications: systematic errors, statistical fluctuations, observational bias, etc
  - fundamental limitation: *cosmic variance*

- standard picture in literature (*not accurate*)
  - survey volume: hypersurface of simultaneity
  - cubic box, counting independent Fourier modes
  - good approximations

not bad, but inaccurate for precision cosmology!

Inaccuracies in Standard Picture

- **survey volume:** ***not cubic box!***
  - **hypersurface of simultaneity vs. past light cone volume**
  - **time evolution: radial correlation,** ***ignored***

- **all observables:** ***correlated*** **&** ***CV limited!***
  - **direct observables: flux, angle, redshifts, shape,… affected by** ***inhomogeneities*** **and** ***correlated***
  - **galaxy number density, weak lensing shear, and so on**
  - **luminosity distance: not bg $\bar{D}_L(z)$, but with** ***fluctuations***
  - **maximum or limited cosmological information available**

Inaccuracies in Standard Picture

- **host galaxy fluctuations: *biased!***
  - **galaxy bias: sample only over-dense regions**
  - **luminosity distance: *non-zero* in a void, but no obs.**
  - **all cosmological observables: *biased!***

- **correlation along light cone: *ignored!***
  - **inverse covariance is needed**
  - **angular correlation C_l & inverse covariance is C_l^{-1}**
  - **3D correlation $P(k)$ & inverse covariance is *not* $P(k)^{-1}$**
  - ***no* radial correlation is considered**

Yoo, Mitsou, Grimm, Durrer, Refregier 2019 JCAP

Type-Ia Supernova Surveys

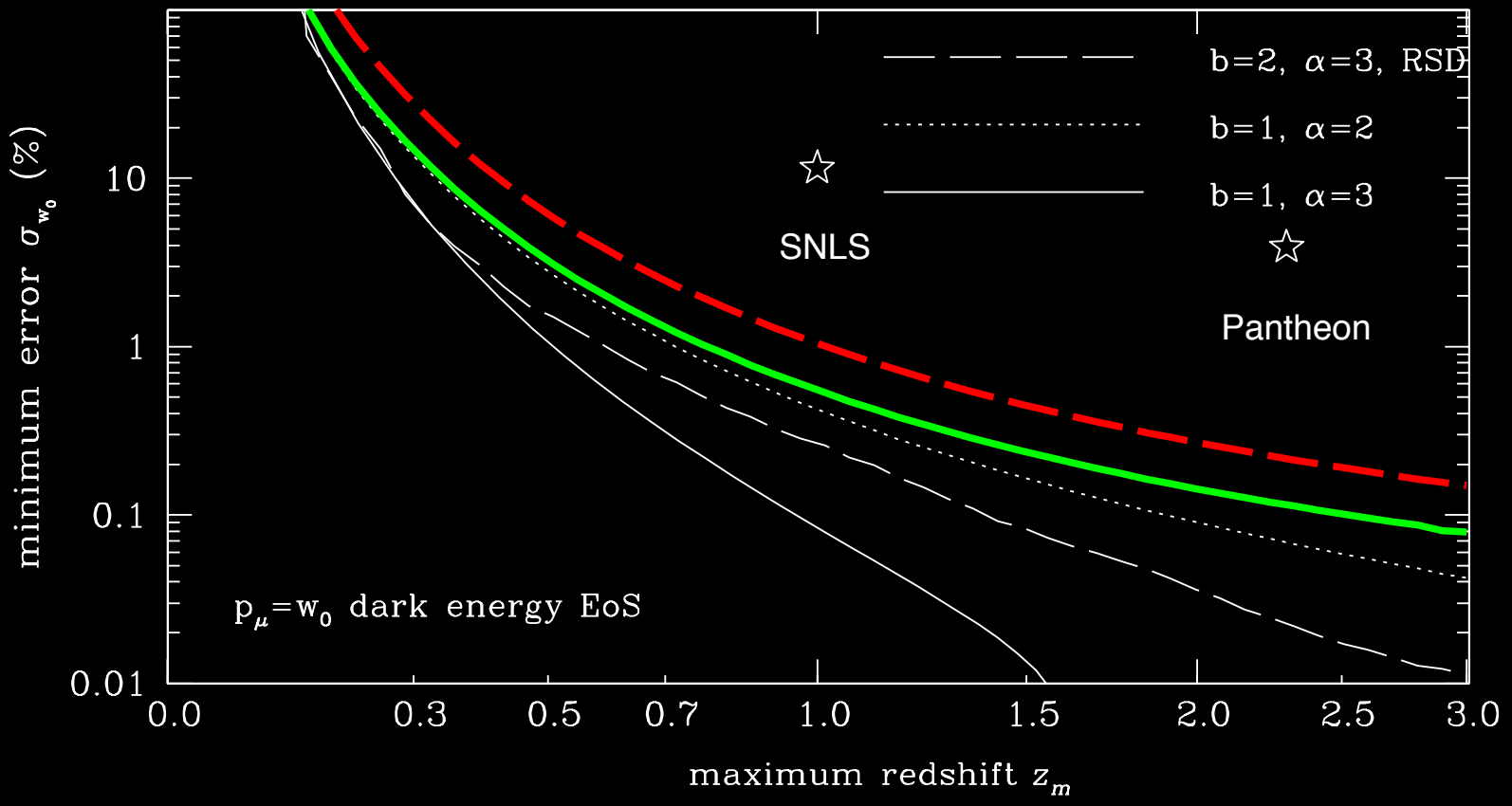
- **idealized supernova observations:**
  - ***no*** **systematic errors**
  - **infinite number of observations (*no* stat. error)**
  - **all sky, all SN measurements up to maximum redshift**

- **cosmic variance:**
  - **information is *not infinite!***
  - **observed flux, angular position, redshift: *correlated***
  - **correctly account for host galaxy fluctuations & radial correlation**

Yoo 2020 PRD (arXiv:1911.07869)

Maximum Information

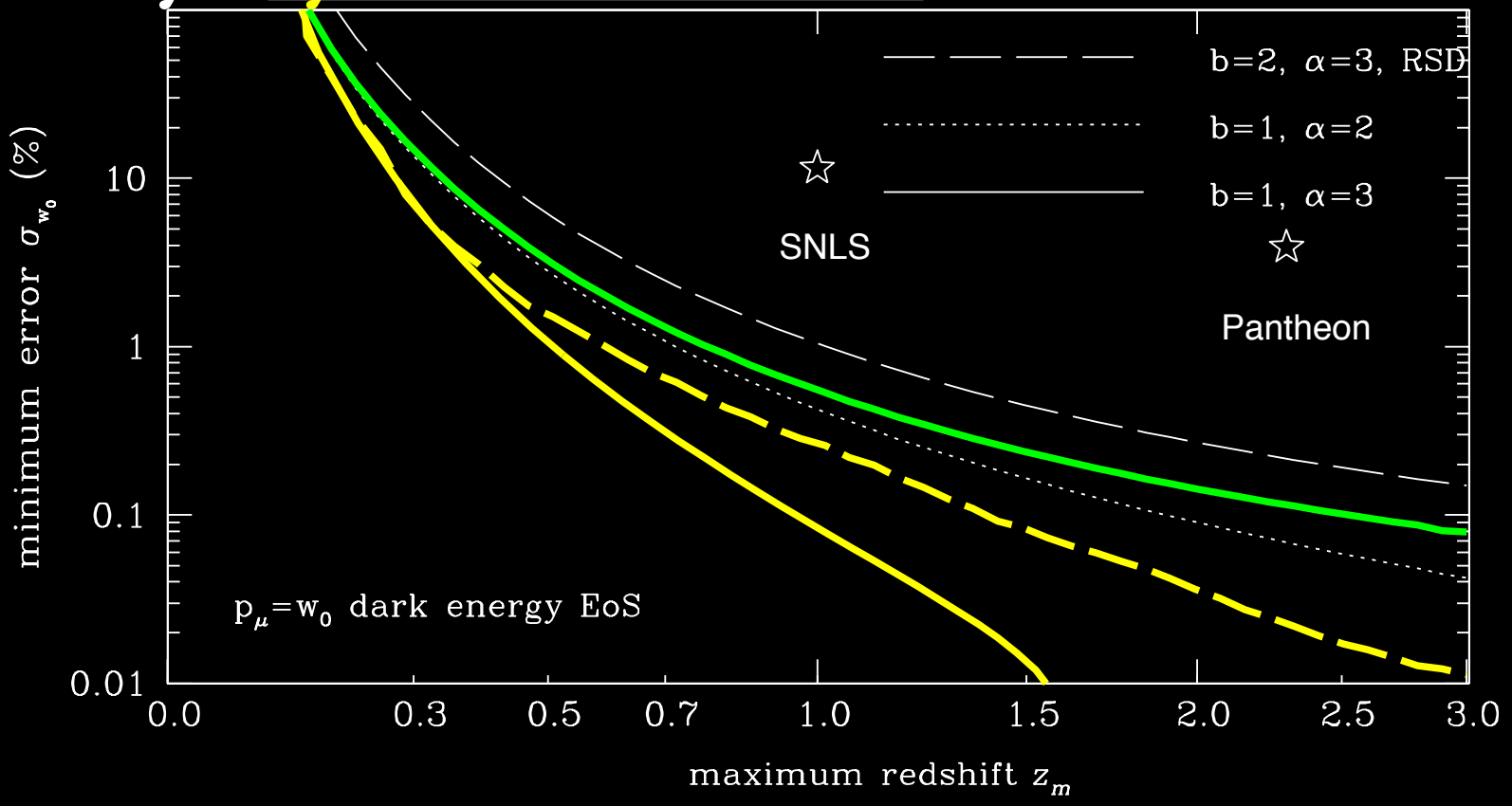
- ***two*** **cosmological parameters in LCDM:** (Ω_m, w_0)
  - **fiducial (solid): unbiased host like dark matter**
  - **more biased host (dashed): sample biased region**
  - **large cosmic variance at low redshift**



- **b: galaxy bias**
- **α: evolution factor (3: dark matter)**

Systematic Errors in Literature

- **over-estimation of cosmological information:**
  - **without *radial correlation* (solid)**
  - **without *host galaxy correlation* (dashed)**
  - **current surveys: systematics limited**



- **b: galaxy bias**
- **α: evolution factor (3: dark matter)**

Conclusion

- **proper** quantification:
  - *radial* correlation & *host galaxy* fluctuation
  - *over-estimation* of cosmological constraining power
  - some priors used, uncertainty in host environment

- *go beyond* cosmic variance:
  - correlation as *a signal*, rather than *a noise!*
  - **more information**: cross-correlation with other *cosmological probes* (or multi-tracer method)

Cosmological Information on Light Cone

based on Yoo, Mitsou, Grimm, Durrer, Refregier 2019 JCAP

Jaiyul Yoo

Center for Theoretical Astrophysics and Cosmology

Institutes for Computational Science, University of Zürich

4 February 2020

Universität Zürich[UZH]