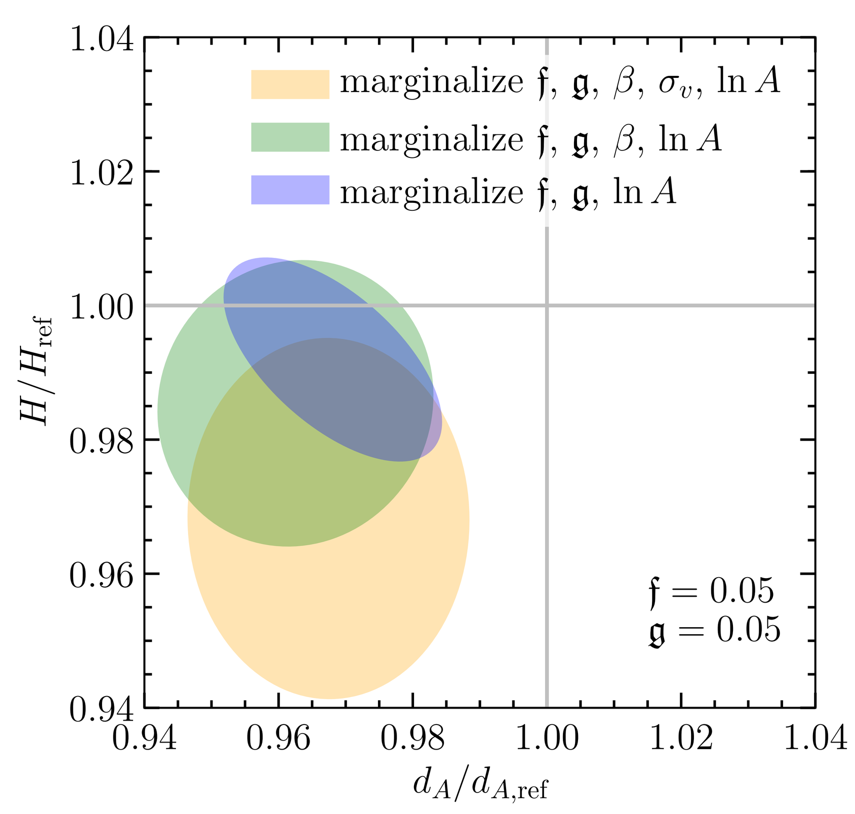
Distance Measurement with Interlopers in Emission Line Surveys

Henry S. Grasshorn Gebhardt, Donghui Jeong
Department of Astronomy and Astrophysics, The Pennsylvania State University

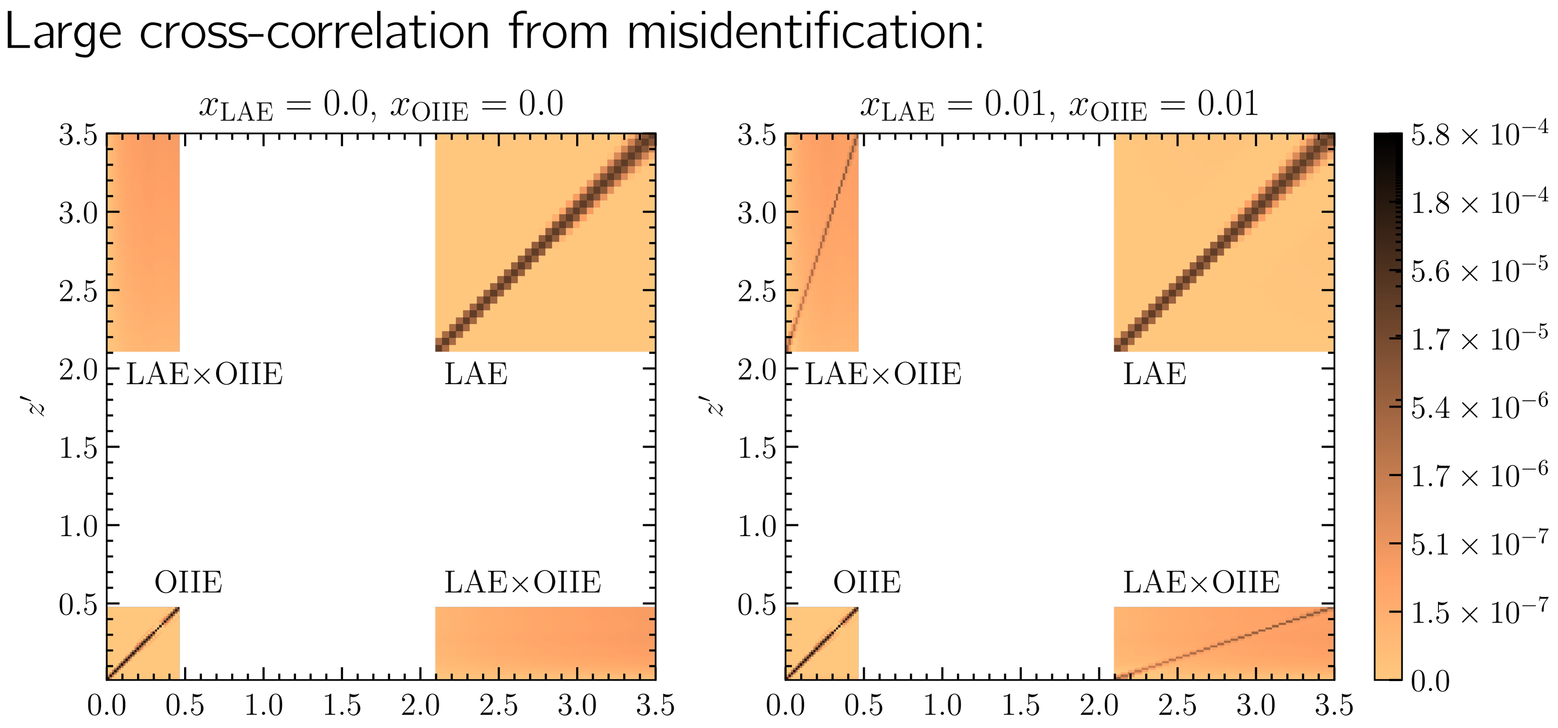
Introduction: Interloper Bias

HETDEX is a *blind* spectroscopic survey with the aim to detect ∼800 000 Lyman-α emitting galaxies (LAEs) at redshift $1.9 < z < 3.5$. In the same field of view, we expect to find ∼1 600 000 [O II] λ3727 emitting galaxies (OIIEs) at redshift $0 < z < 0.5$.
Due to imperfect line identification, the foreground OIIEs may be misidentified as LAEs. Thus, the distance measurement from BAO will be biased:



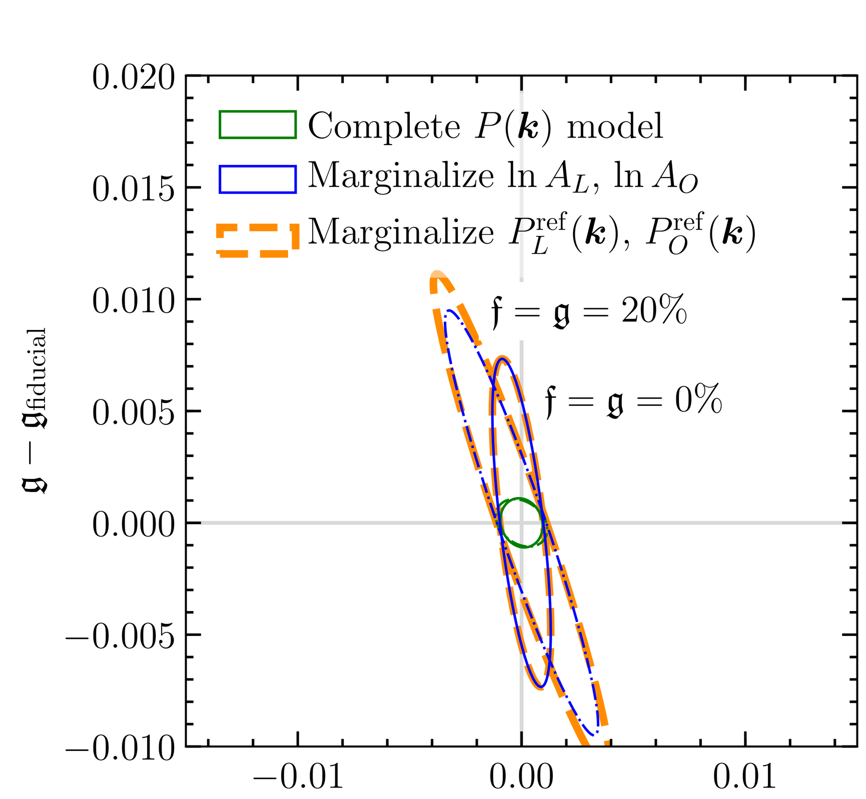
Cross-correlation Diagnostic

- Large physical separation between OIIEs and LAEs
  ⇒ cross-correlation vanishes
- Small cross-correlation from lensing
- Large cross-correlation from misidentification:



The shading shows the magnitude of calculated angular power spectrum $C_\ell(z, z')$ without (left) and with (right) interlopers.

Constraining interloper fractions



With the misidentification probabilities $x_{\rm LAE}$ and $x_{\rm OIIE}$ we define the interloper fractions

$$\mathfrak{f} \equiv \frac{x_{\rm OIIE} N_{\rm OIIE}}{N_{\rm LAE}^{\rm obs}} \quad (1)$$

$$\mathfrak{g} \equiv \frac{x_{\rm LAE} N_{\rm LAE}}{N_{\rm OIIE}^{\rm obs}}. \quad (2)$$

The information about the interlopers is in the cross-correlation: Having complete shape information, but not the amplitudes A_L and A_O ("L" is for LAE, "O" for OIIE), gives nearly as good a constraint on $\mathfrak{f}$ and $\mathfrak{g}$ as having no power spectrum shape information at all.

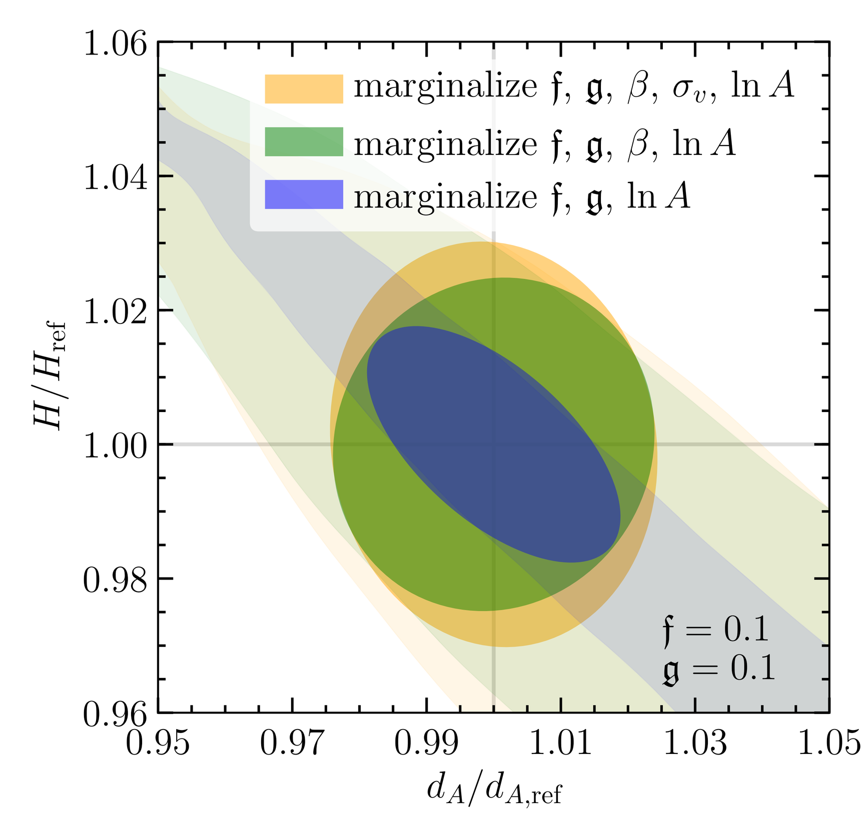
Joint power spectrum fitting

We account for the OIIE interlopers by fitting the LAE and OIIE power spectra simultaneously. Since the information from the cross-correlation is sufficient to measure the interloper fractions, a precise model for the interlopers is not needed.


Ly-α emitter (LAE) sample


[O II] λ3727 emitter (OIIE) sample

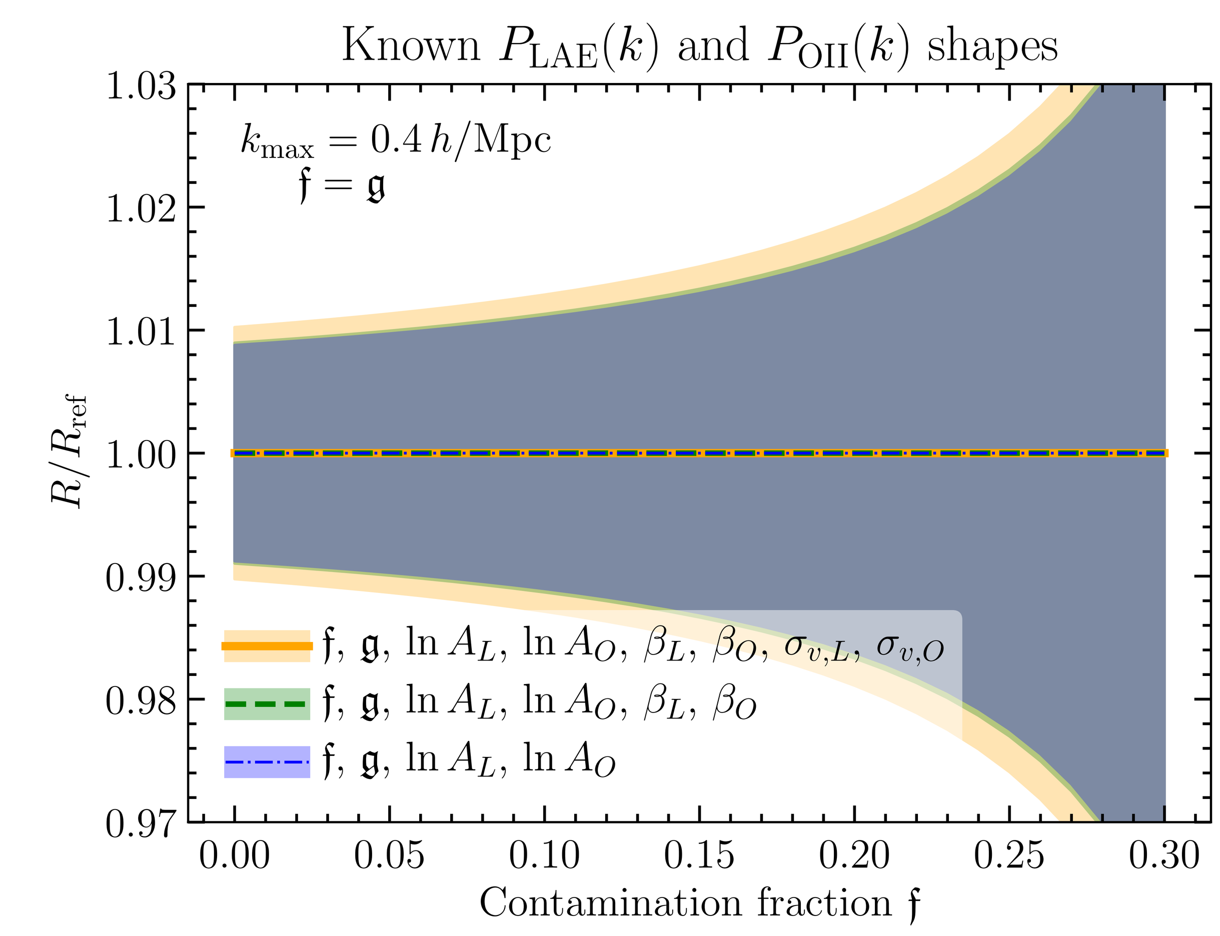
Unbiased Distance Measurement



The ellipses indicate 68% errors from a Fisher analysis.

Joint fitting removes interloper bias: The error ellipses are centered on the fiducial value of the reference cosmology.

The distance $R = (d_A^2/H)^{1/3}$ is constrained primarily by baryon accoustic oscillations (BAO), whereas $d_A H$ is constrained by the Alcock-Paczynski test.



Conclusion

The method presented here is first and foremost a diagnostic to measure the contamination fraction in emission line surveys such as HETDEX. Furthermore, by jointly fitting the interloper and survey galaxy power spectra, we can remove the interloper bias. Spherical harmonic space is a natural choice for observations on the sky, and it allows to incorporate lensing of the light from the survey galaxies by the matter associated with the interlopers.

References:
1. Pullen *et al.* 2015
2. Leung *et al.* 2017
3. Hill *et al.* 2010

Contact:
hsggebhardt@psu.edu