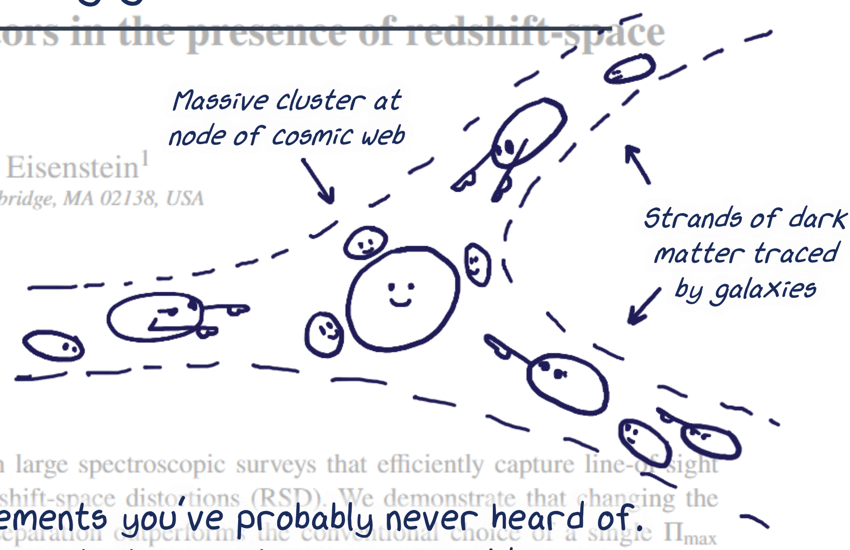
We have an idea for improving measurements of pointing galaxies

~~Optimal intrinsic alignment estimators in the presence of redshift-space~~ distortions



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TL;DR

~~ABSTRACT~~

We present estimators for quantifying intrinsic aligments in large spectroscopic surveys that efficiently capture line-of-sight (LOS) information while being relatively insensitive to redshift-space distortions (RSD). We demonstrate that changing the LOS integration range, Π_{max}, as a function of transverse separation outperforms the conventional choice of a single Π_{max} value. T[illegible] and RSD. Although these estimators incorporate additional LOS information, they are projected correlations that exhibit signal-to-noise ratios comparable to 3D correlation functions, such as the IA quadrupole. Using simulations from Abacus Summit, we evaluate these estimators and provide recommended Π_{max} values and weights for projected separations of 1 - 100 h^{-1} Mpc. These will impr[illegible] weak lensing and direct cosmological applications.

We have ideas for improving measurements you've probably never heard of. When measuring how much galaxies point at each other, you should care more about galaxies that are close together. Except if they're too close, then you should care about ones a bit further away. This paper tries to explain this non-obvious idea and test it with simulations. It might be useful for making measurements in future big galaxy surveys!

Key:

Key words: keyword1 – keyword2 – keyword3

✱ Full annotation coming soon! ✱

1 INTRODUCTION

Large-scale structure is subtly imprinted in the orientations of galaxies. The most common form of this intrinsic alignment (IA) is for the long axis of elliptical galaxies to be aligned along the large-scale gravitational tidal field. Characterizing these correlations is critical for weak lensing studies; IA can bias the matter power spectrum by 30% as measured by cosmic shear (Hirata et al. 2004), and cosmological results from photometric surveys are particularly sensitive to IA modeling (Kirk et al. 2015; Dark Energy Survey and Kilo-Degree Survey Collaboration et al. 2023). In principle, IA can also measure any cosmological effect that leaves an imprint on the large-scale tidal field, including primordial physics and the nature of dark energy (Chisari & Dvorkin 2013). See Joachimi et al. (2015); Troxel & Ishak (2015) for reviews and Lamman et al. (2024a) for a guide to IA estimators and formalisms. Spectroscopic surveys, combined with imaging data, provide the best direct measurements of IA, including the Sloan Digital Sky Survey (SDSS) (Singh et al. 2015) and first year of data from the Dark Energy Spectroscopic Instrument (DESI) (Siegel et al. in prep). However, common conventions for measuring IA were largely developed for photometric surveys. The advent of large spectroscopic surveys like DESI, with their potential to yield insights on IA for both upcoming imaging surveys and direct applications, means it is time to revisit these estimators.

IA are most commonly measured as projected statistics. The projected shapes of galaxies are measured relative to the underlying matter density, as traced by galaxies, and these correlations are averaged over a total LOS distance $2\Pi_{max}$. Common Π_{max} choices are 60 - 100 h^{-1}Mpc. Some advantages of these projected statistics are that they are less sensitive to LOS uncertainties and can be more directly related to weak lensing measurements, which are sensitive to transverse modes. As with galaxy clustering, several recent studies explore higher-order statics which take advantage of the full 3D information provided in spectroscopic surveys (Schmitz et al. 2018; Kurita et al. 2021; Pyne et al. 2022; Bakx et al. 2025). Unlike galaxy clustering, the nature of tidal alignments and projected shapes leads to most information lying along the transverse direction (Figure 1). In the case of tidal alignment, on average the long axis of galaxies are oriented towards a tracer. Because we observe only the projected shape of galaxies, this results in a weaker signal along the LOS, especially at small transverse separations. Therefore, an IA quadrupole estimator that essentially up-weights the signal in the transverse direction can increase the signal-to-noise ratio (SNR) of measurements (Singh et al. 2024).

A disadvantage of using these 3D estimators in practice is redshift-space-distortions (RSD). In redshift space, galaxy peculiar velocities create a "smearing" along the LOS below separations of about 3 h^{-1}Mpc (Jackson 1972), known as the fingers-of-god effect (FOG). On larger scales, infall into overdense regions produces a LOS "squashing" (Kaiser 1987), known as the Kaiser effect. This means the IA signal does not follow a perfect μ relation in redshift space, and 3D IA correlations must successfully model these effects.

Here we present a set of alternative estimators that preserve the advantages of both classic and 3D measurements: a Π_{max} which varies with transverse separation and a LOS weighting based on both

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