

Vision Transformers for Weak Lensing Cosmological Inference

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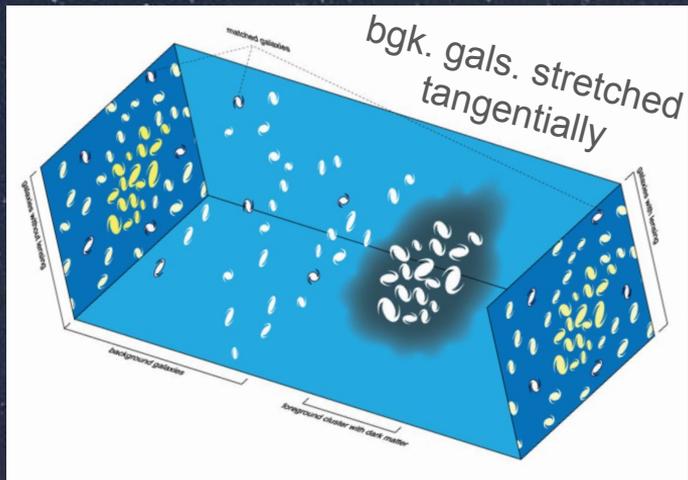
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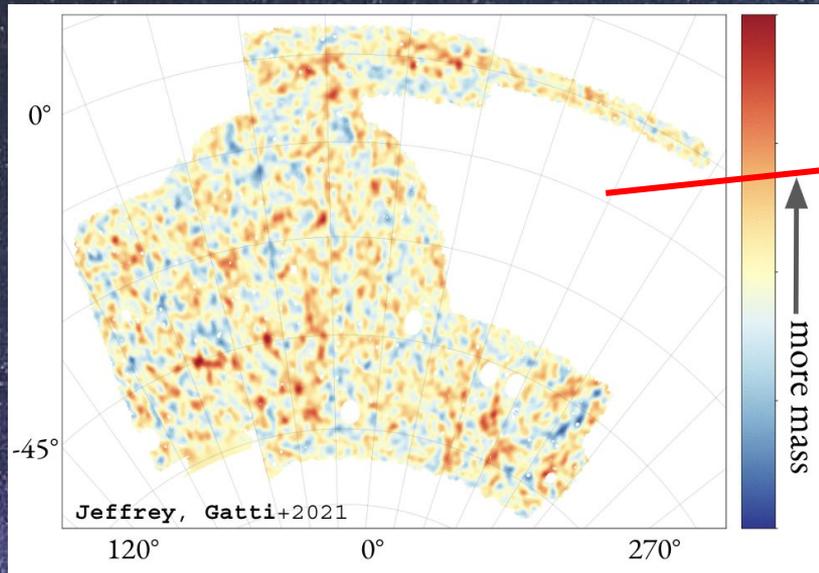
Non-Gaussian Information in Weak Lensing Surveys

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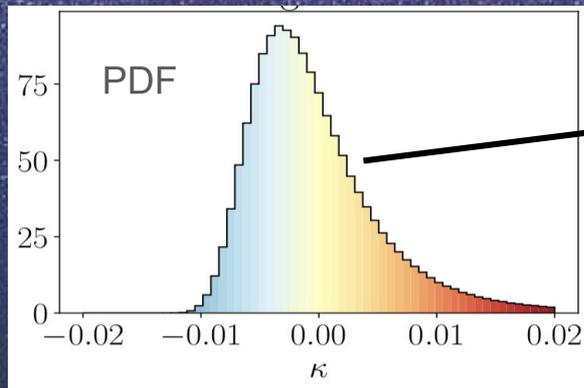
→ Fluctuations in the **matter density field** can be mapped by distortions of background galaxies' ellipticities

→ Conventional two-point statistical approaches cannot encode **smaller scale non-Gaussian** info, arising from **gravitational interactions**



Typical Data Products of WL surveys

Measure the spin-2 shear field (galaxy shapes) & convert to convergence (mass) maps

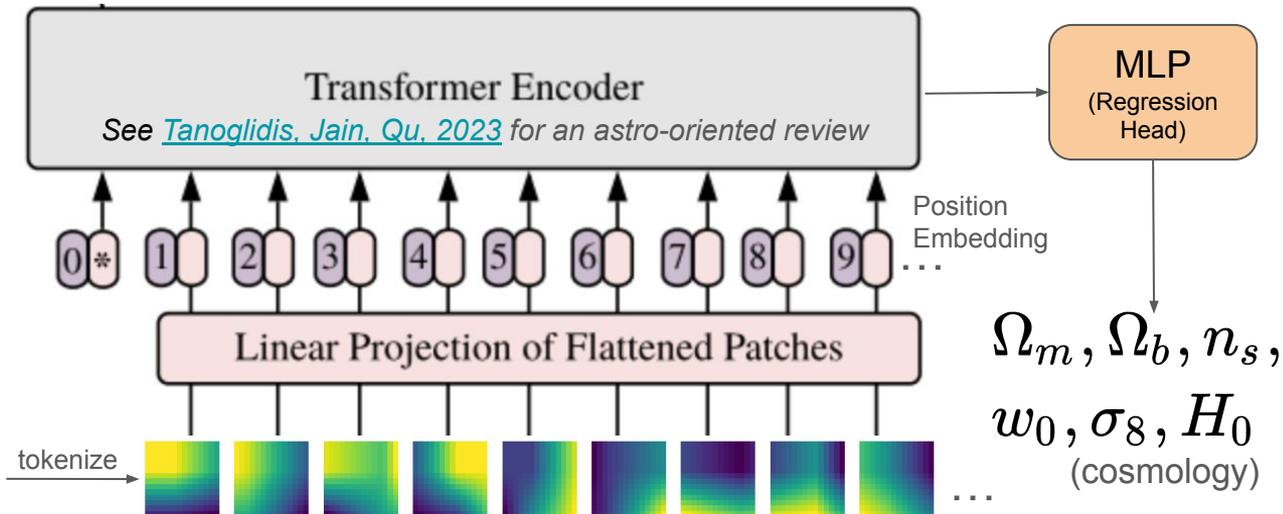
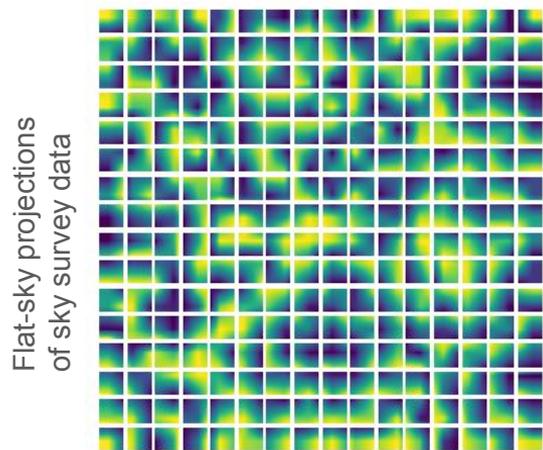


Convergence field is non-Gaussian → higher mass tail due to gravitational interactions at smaller scales

Maps encode all information, missed by 2pt stats.

ViT: Transformer Architecture for Image Processing

ViT Schematic (Derived from the ViT paper [Dosovitskiy et al 2021](#))



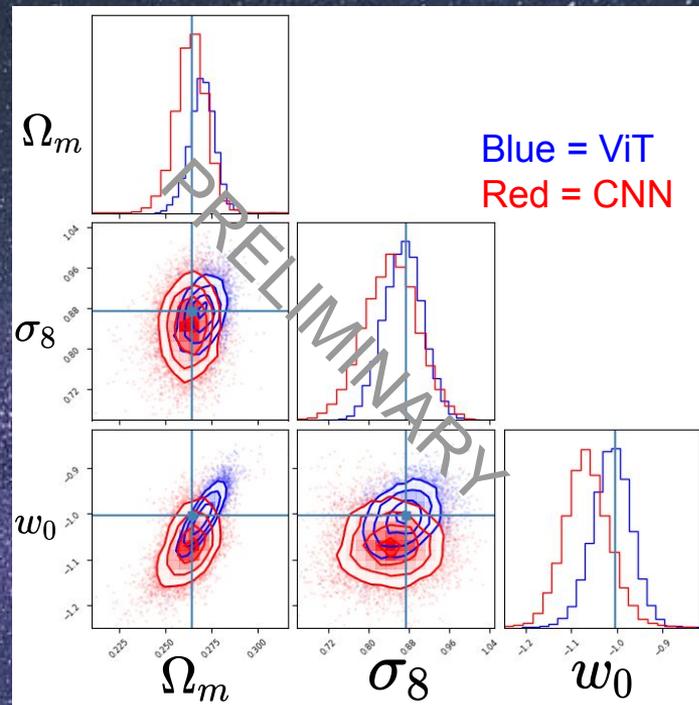
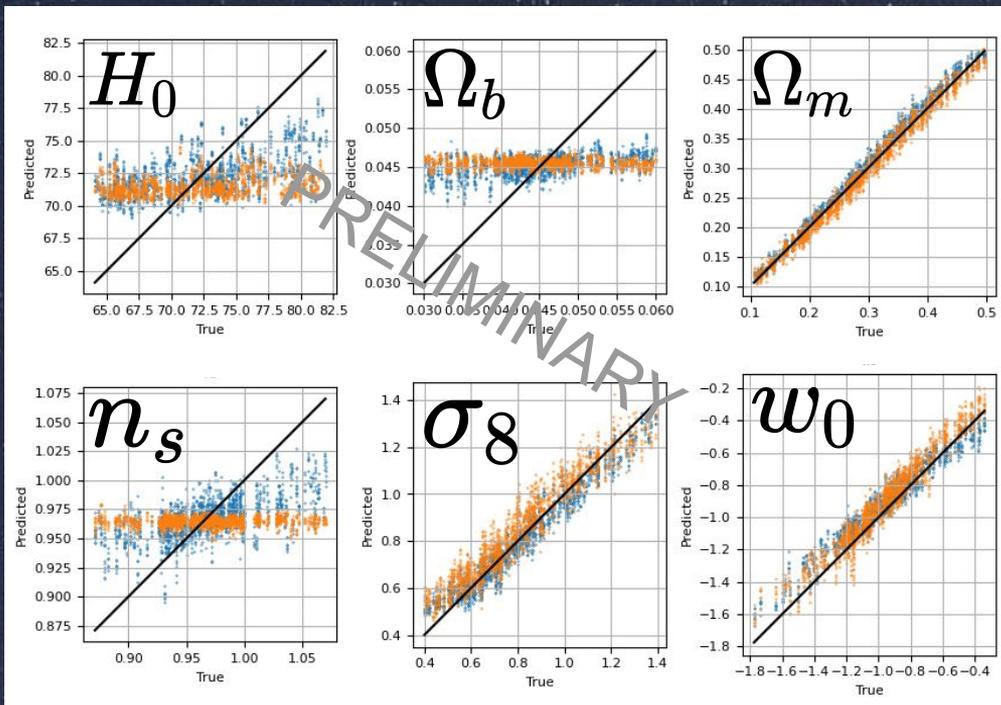
- Borrowing the [Transformer Architecture](#), typically used for Natural Language Processing
- Self-Attention over Tokens (= words in a sentences = patches from an image)

Past Astronomical Applications for ViTs:

- Galaxy Morphology Classification (with GalaxyZoo): [Lin et al 2022](#)
- Strong Gravitational Lens Parameter Estimation: [Huang et al 2022](#)
- Cosmology from 3D dark-matter-halo lightcones: [Hwang et al 2023](#)
- Extended target detection in multi-band photometric surveys (with SDSS DR17): [Jia et al 2023](#)

Comparing ViT to Residual Convolutional Networks (ResNet)

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- Use [CosmoGridV1 simulations](#) to generate *w*CDM maps with DESY3-like noise levels and sky coverage
- ViT-B/16 and ResNet-50, pretrained with ImageNet.
- Predictions used as summaries for extracting posterior with Simulated-Based Inference & NPE using [sbi](#)
- Comparable/better constraints for Ω_m , w_0 , σ_8

- Work in Progress!
(a.k.a., don't trust me, yet!)
- Validation tests, performance for LSSTY1 & LSSTY10, interpretation, constraints from real DES maps...

Thank you!

Details glossed over in the interest of time, contact me at shubh@sas.upenn.edu
or find me in-person at the NY/CCA node.