A new frontier in testing ΛCDM: Transdimensional inference of dark subhalos

Tansu Daylan

Harvard University Department of Physics

with Francis-Yan Cyr-Racine, Ana Diaz Rivero, Cora Dvorkin, and Douglas P. Finkbeiner

CfA AstroStat Day, Cambridge, MA

20 September 2017

Rosetta stone of ΛCDM

✓ Dark subhalos predicted by ΛCDM hold the key to understanding structure formation at small scales.
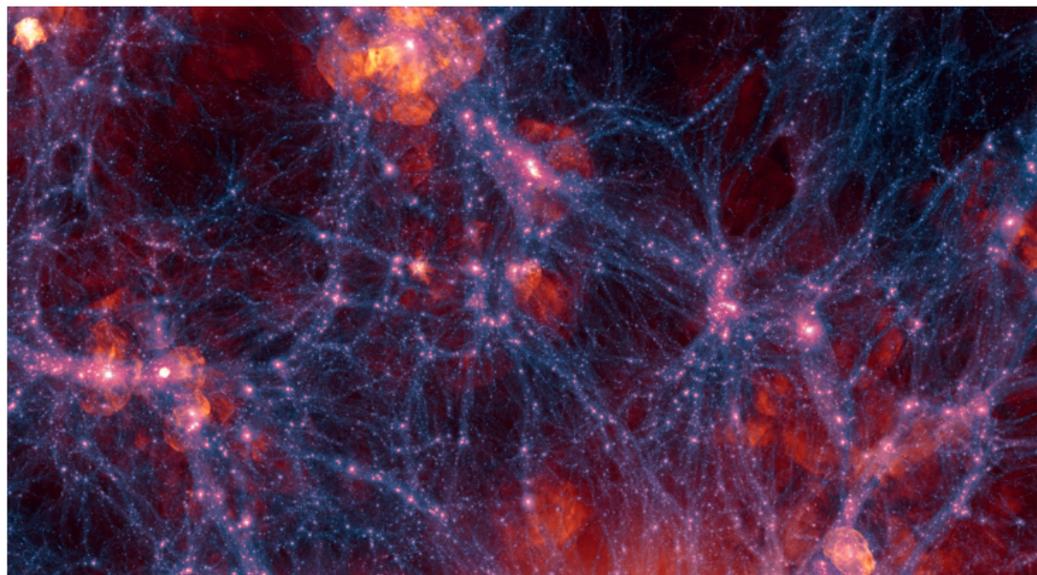
(**Illustris Collaboration**)

Cosmic discovery land
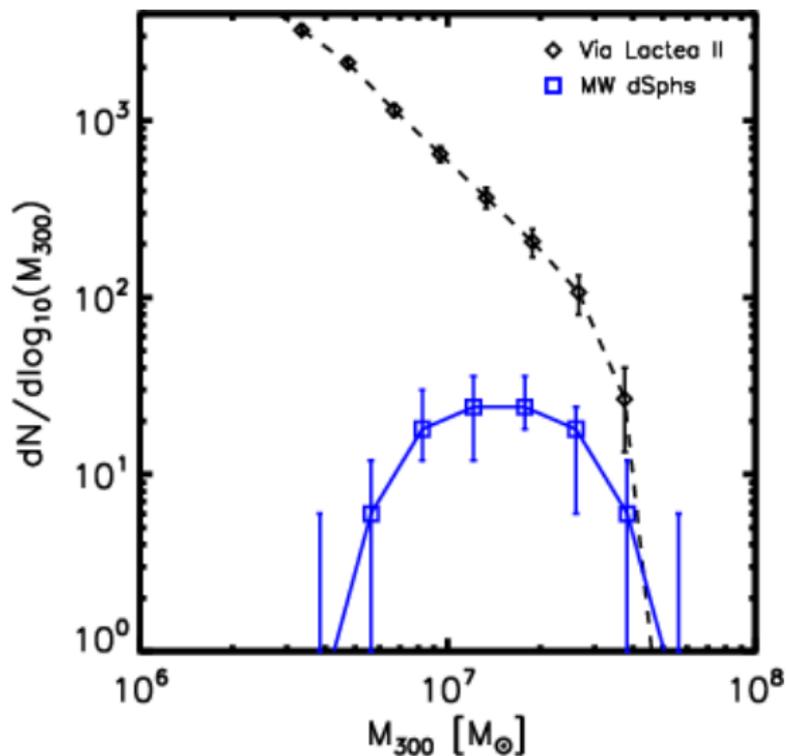
(**Bullock2010**)

Strong lensing

✓ Through strong lensing of background light, galaxies (and their subhalos) act as gravitational lenses and allow us to probe small-scale structure in ΛCDM halos.

SDSS J1038+4849

Probabilistic Cataloging

✓ The relevant inference problem is based on low signal-to-noise data and subject to a highly degenerate likelihood topology.

✓ We implement an inference framework that can account for within and across model covariances that makes it unnecessary to formally detect objects (e.g.. subhalos).

PCAT/Lens metamodel
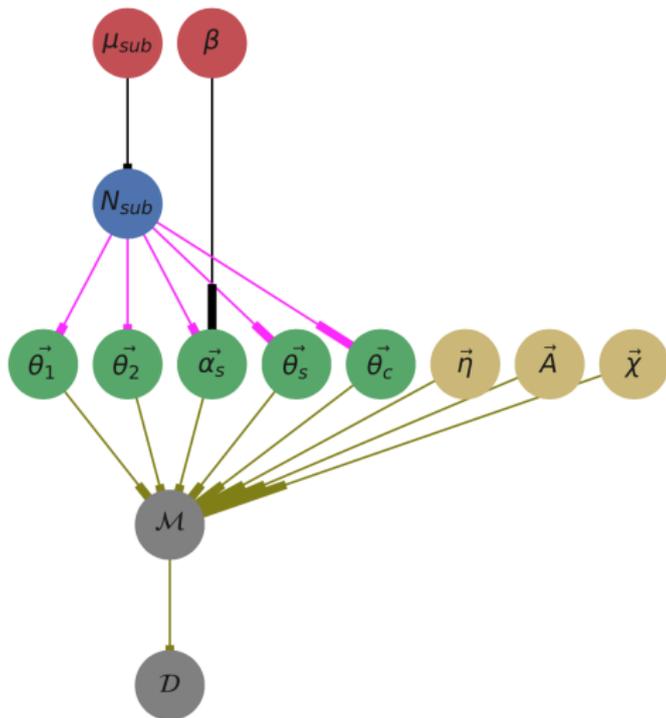
Transdimensional sampling of the subhalo catalog space
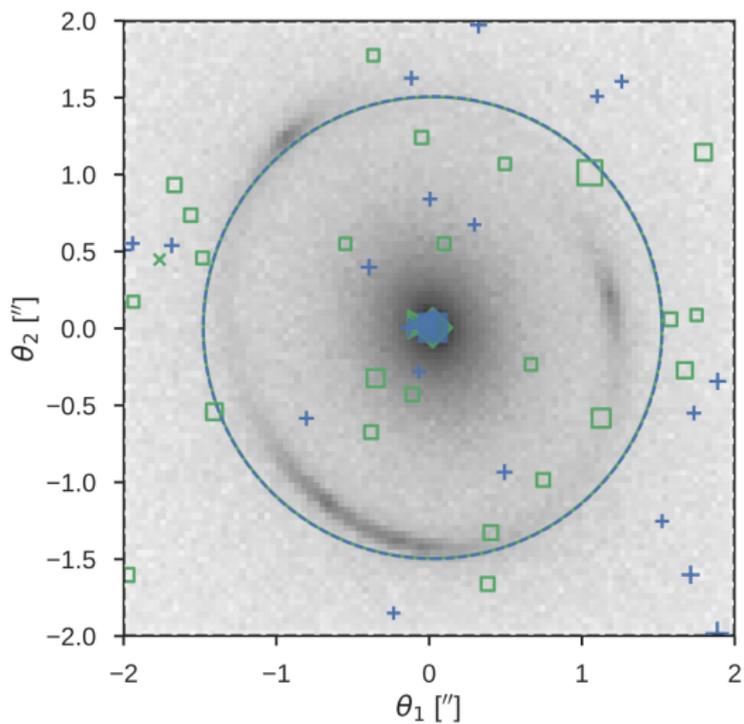
Posterior median convergence of the metamodel
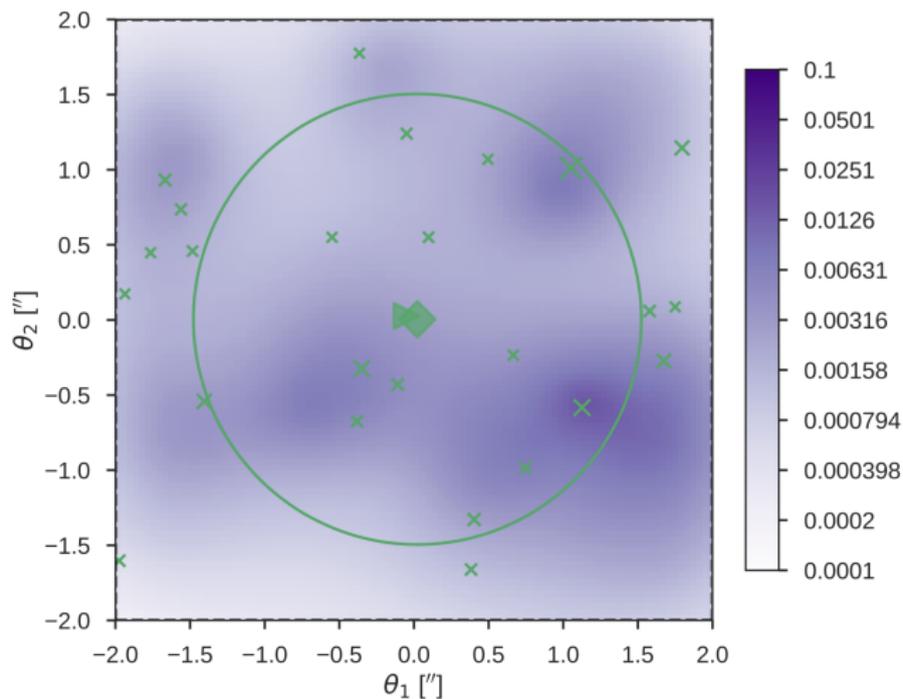
Posterior median convergence of the one subhalo model
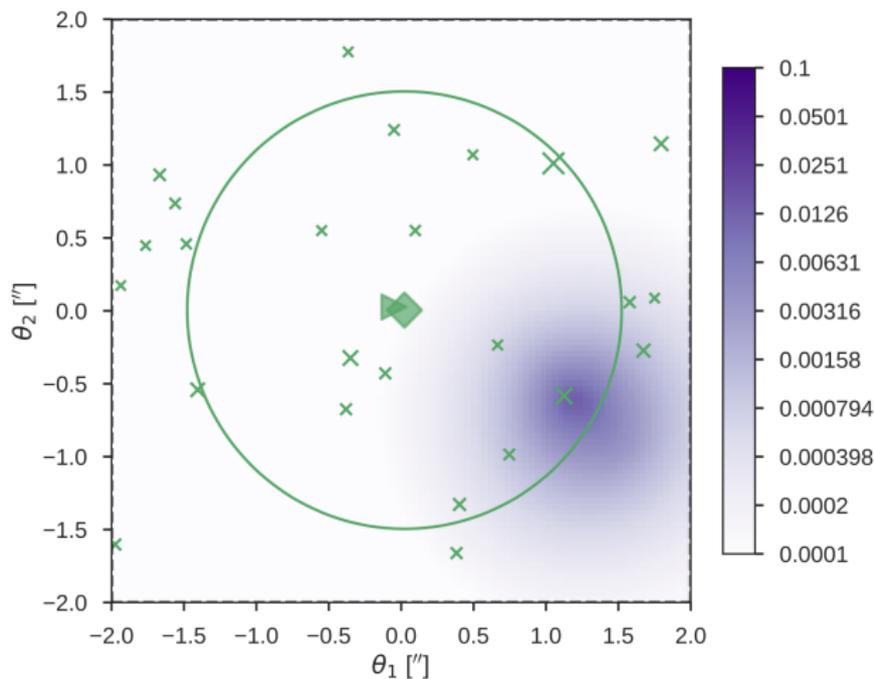
Subhalo mass distribution
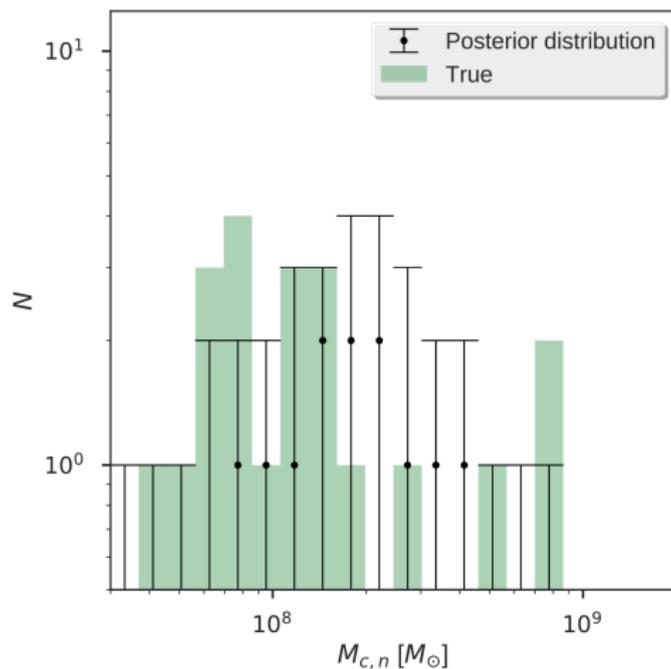
Bias in the macrolens modeling
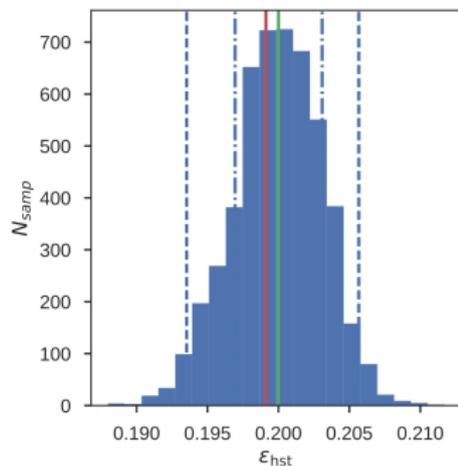
(a) Nominal
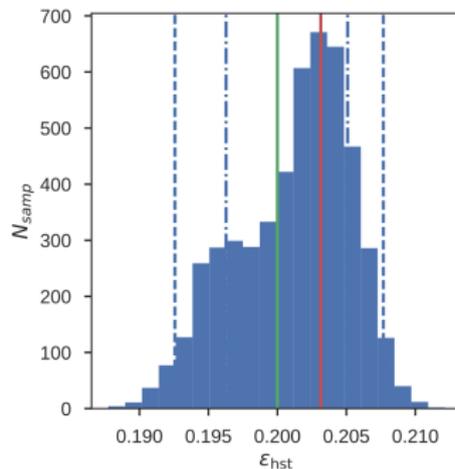
(b) One-subhalo

Posterior substructure mass fraction
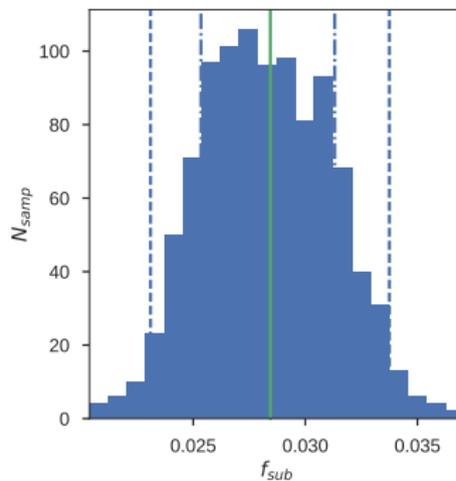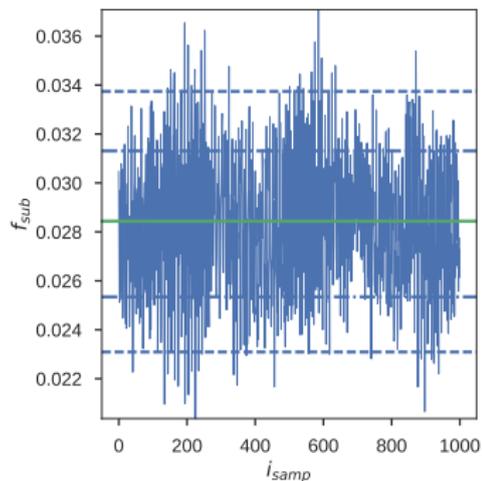
Conclusion

- ✓ Probabilistic cataloging
  - ✓ obviates detection of subhalos when inferring their population characteristics,
  - ✓ offers improved modeling for strongly lensed systems that take within and across model covariances into account,
  - ✓ provides a mechanism to combine information from multiple systems, thereby increasing the statistics of light-deflecting subhalos.
- ✓ Near future datasets such as WFIRST and JWST imaging will also yield higher signal-to-noise measurements of subhalos.