Dark Energy and Structure Growth

Prof. Matt Dobbs’ *research group at McGill specializes in the design, construction, and operation of novel instrumentation and experiments to explore the early universe. They were involved in building and analyzing data from the 2500 square-degree South Pole Telescope - Sunyaev-Zeldovich (SPT-SZ) Survey.*

What question were you trying to answer?

The effect of Dark Energy on the expansion history of the universe (the size of the universe vs. time) is well measured through a combination of supernovae, galaxy distribution surveys, and other probes. We wanted to measure how dark energy affected the growth of structures in the universe and see if those effects were consistent with predictions from models.

Why did you find this question interesting?

In my view, the dark sector, with dark energy at the helm, is the biggest mystery in physics. Anything that probes it in a different way, to find cracks in our (lack of) understanding, is really interesting!

What did you find?

Dark energy affects the growth of structure exactly as one would expect from a simple cosmological constant. The lambda CDM standard model of cosmology has held up to yet another test, despite us being no closer to understanding the dark sector.

What does doing your research look like?

Building the world’s most sensitive millimeter-wave telescope in one of the world’s most hostile environments – the South Pole. The data analysis is tricky and time consuming, taking a team of physicists several years. But this analysis is not the unique thing that sets our measurements above others – instead, it is the technology that was custom built for the South Pole Telescope (SPT) that gives us the edge on this and other Cosmic Microwave Background (CMB) measurements.

Did anything unexpected happen during this project?

We built this project 10 years ago to measure the effect of dark energy on the growth of structure. However, with a combination of the CMB power spectrum and our galaxy cluster survey, we can very precisely measure the signatures neutrino masses. Our cosmology telescope can place some of the most precise limits to date on the sum of the neutrino masses — well beyond what is possible in particle physics laboratories!


The South Pole Telescope and the Antarctic night sky

I am going to the South Pole in November to install an upgrade to the SPT camera. The new camera’s primary purpose is to provide the most sensitive measurements (or limits) of gravitational waves emitted from a period of inflation in the early universe (a land mark discovery if robustly seen). The camera will also substantially improve our sensitivity to neutrino mass signatures.

Why this is important

The SPT provides the most precise measurements of the CMB at small angular scales. These data are used by the collaboration to make detailed measurements of dark energy and neutrino properties. They are also used by the broader community to combine with other probes and test many aspects of cosmology and astrophysics.

The neutrino results are particularly important — they provide a window to particle physics that may never be available to terrestrial laboratories or collider-based experiments. This has spurred major new investments by funding agencies and private foundations to build more powerful millimeter-wave telescopes, such as the Simons Observatory, which recently received more than $50m of private, government and institutional funding.

de Haan, T, B. A. Benson, L. E. Bleem, **M. A. Dobbs**, **G. P. Holder**, et al. (2016a), *Cosmological Constraints from Galaxy Clusters in the 2500 square-degree SPT-SZ Survey*, ArXiv e-prints arXiv:1603.06522.