Large scale structure analysis with infrared-selected galaxies

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Why study the largest scales in the universe? These scales probe relic conditions in the early universe that are not accessible to any current laboratory experiment. Cosmology thus helps us uncover mechanisms responsible for phenomena in the natural world, and does so in a way that other sciences can not. Recent progress has been remarkable, and today cosmology gives us a basic accounting of the matter and energy content in the universe.

But some ninety-five percent of the universe's contents have never been seen in a lab, and are not even described by the standard model of particle physics (e.g. Planck Collaboration et al., 2013b; Hinshaw et al., 2013). The dark matter—whose gravity tugs at normal matter but does not otherwise collide or interact—and the dark energy—whose gravitational interaction is repulsive rather than attractive—are strange to us. This project explores the distribution of matter in the universe. This may be revealed by spatial fluctuations in counts of galaxies (Fig 1), by association with hot gas (Fig 2), or through weak gravitational lensing (Fig 3).

The dark components of the universe reveal some of their properties through fluctuations in the matter density. Dark matter forms the scaffolding for large scale structures in the universe, while dark energy moderates the growth of those structures by accelerating the universe's expansion (e.g. Suzuki et al., 2012; Blake et al., 2011; Riess et al., 2011). The study of matter fluctuations is therefore worthwhile (Huterer et al., 2013).

We have used infrared-selected galaxy cluster candidates to search for traces of their associated hot gas. We employ distortions to the Cosmic Microwave Background's (CMB) blackbody spectrum (Sunyaev-Zeldovich effect). The candidates were selected in the mid-infrared with NASA's Spitzer space telescope. Using data from the Atacama Cosmology Telescope, we see in Fig 2 a flux decrement at 150 GHz, evidence of this gas. At longer wavelengths, we see emission from dust associated with the same sources. Any dust emission at 150 GHz complicates the measurement of the hot gas, and we are currently investigating how to best mitigate this systematic effect.

In the future, galaxies from NASA's Wide-Field Infrared Survey Telescope (WFIRST) will trace out large scale structure deep into the sky. We have demonstrated an algorithm to improve the matter reconstruction using lensing of the background CMB, improving the quality of such data (Fig 3).

References
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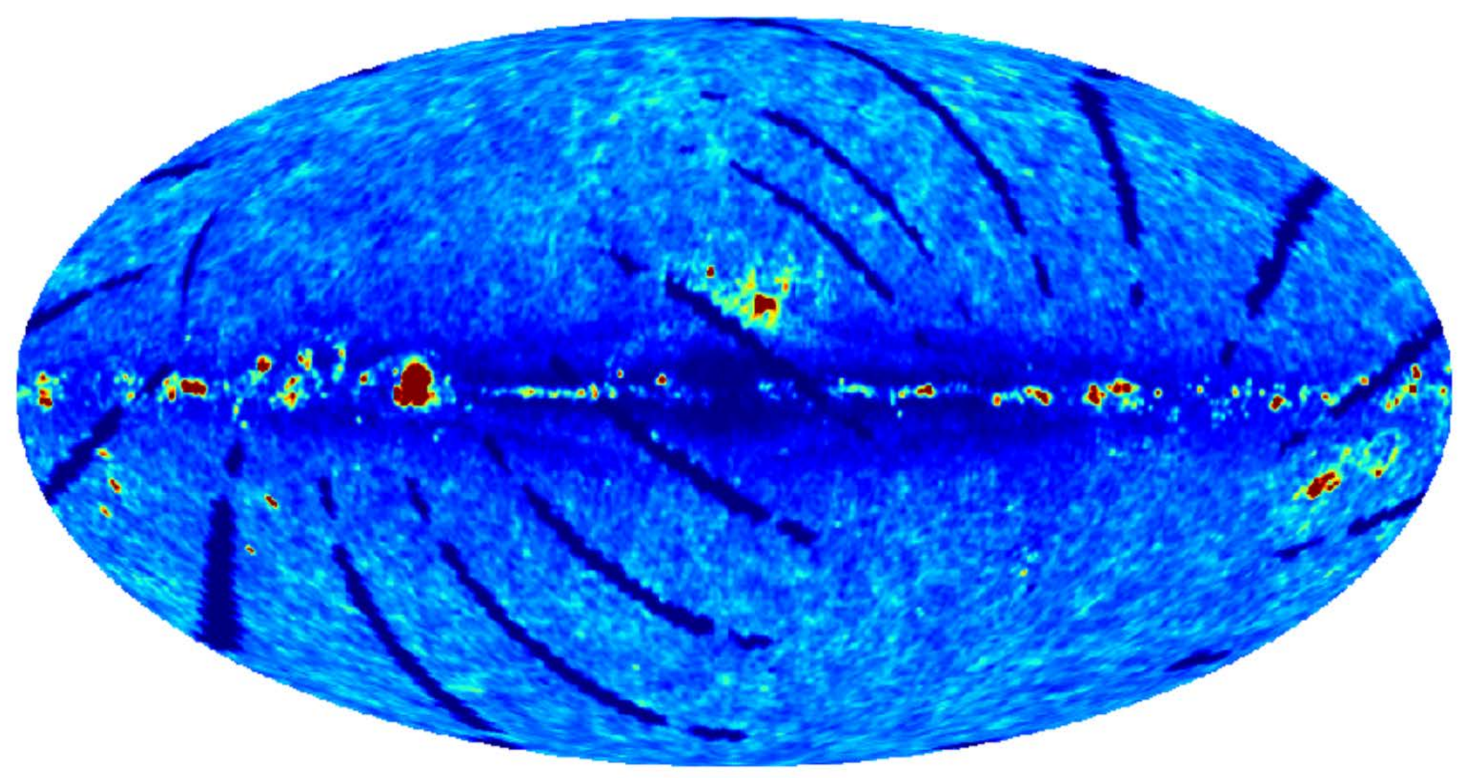
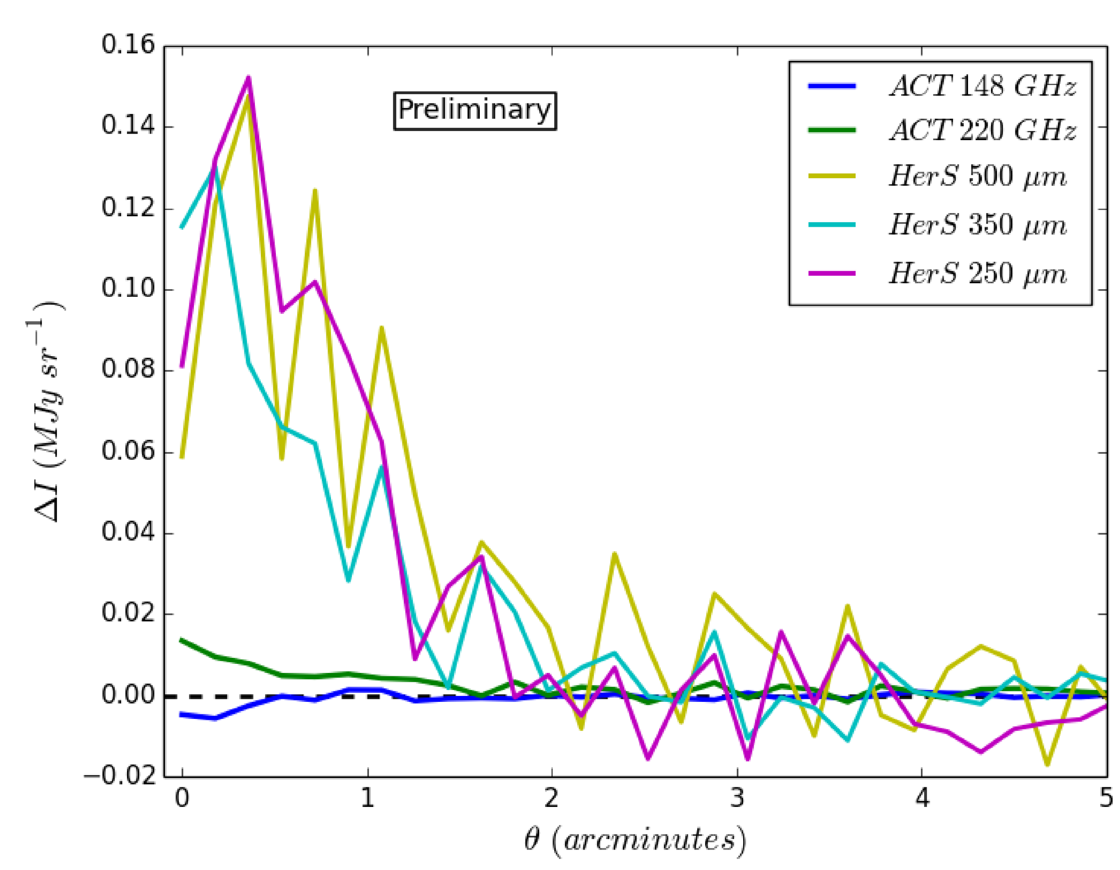


Fig 1. Infrared-selected galaxies from the WISE survey trace the distant cosmic web of structure over the sky. (Some residual contamination from the Milky Way lies in the mid-plane; contamination from the Moon makes the dark stripes.)

Fig 2. Evidence for hot gas (at 150 GHz) and dust emission (other bands) in galaxy cluster candidates selected in the mid-infrared.



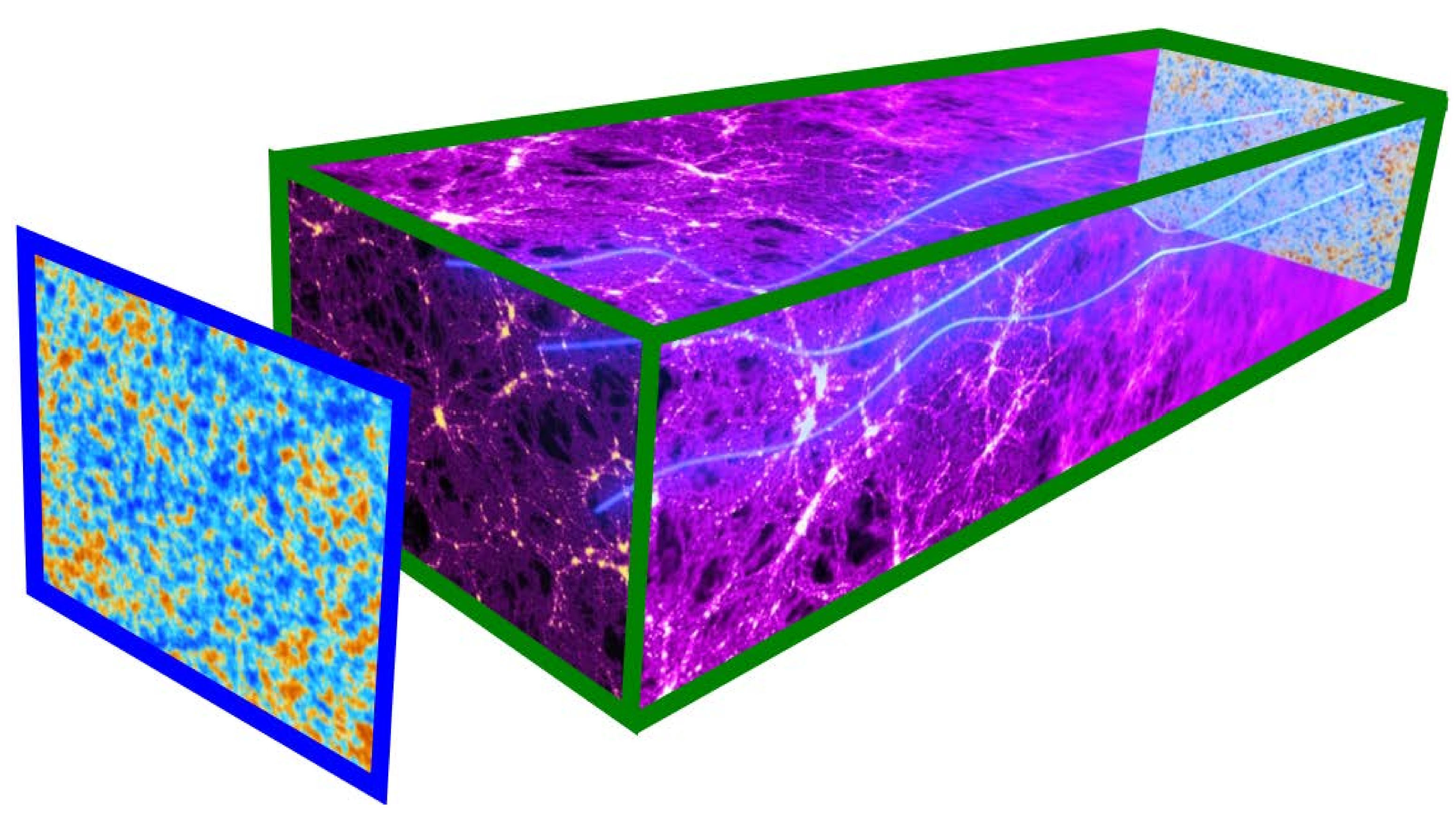
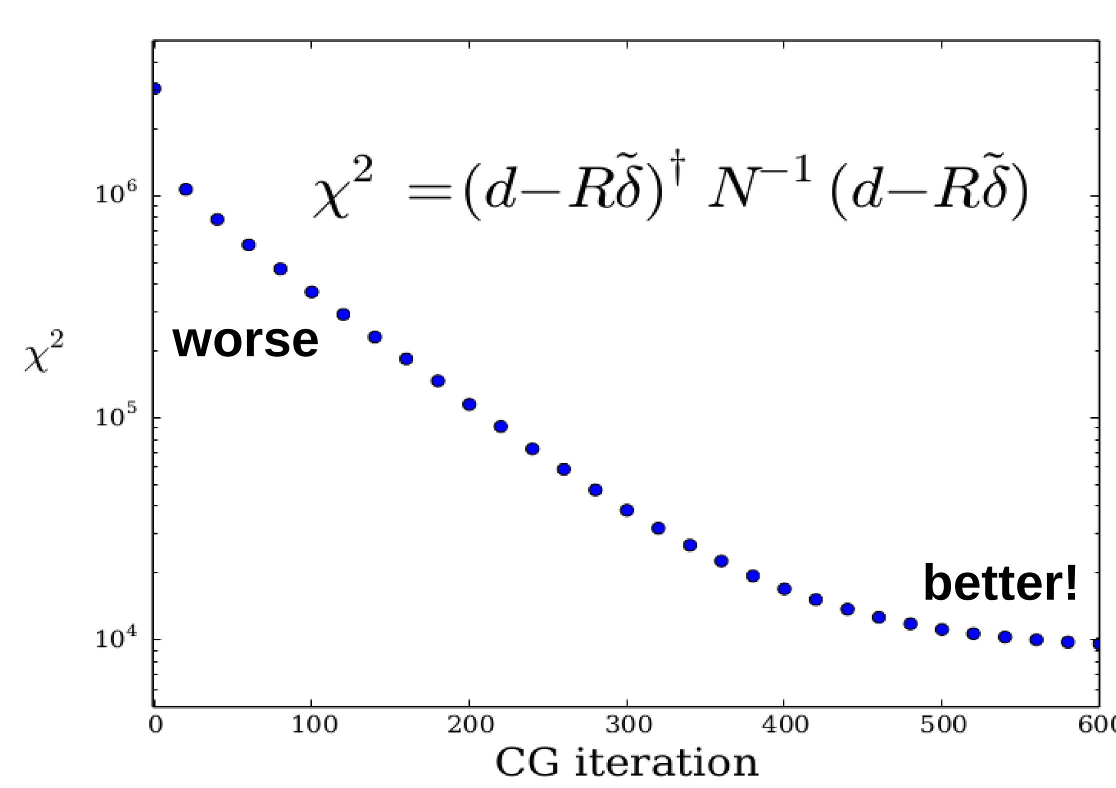


Fig 3. We have shown an algorithm that improves the reconstruction of the matter distribution with lensing of the CMB.



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