Weak Gravitational Lensing in GOODS

Overview

Alongside neutrino and electromagnetic radiation observation, gravity stands as an independent probe of the cosmos. Gravitational lensing in particular, since it arises solely from spacetime curvature, is maturing as a viable means of mapping baryonic and dark matter in the sky. Theorists have shown that gravitational lensing's weakest regime probes structure on the largest known scales—those of galaxy clusters. Their theories allow physicists to directly measure, for example, the cosmological parameter σ_8, which normalizes the power spectrum of mass density perturbation within an eight megaparsec sphere.

Modern technology is beginning to allow for this new kind of measurement. Weak lensing analysis requires accurate images of many distant galaxies, and the Great Observatories Origins Deep Survey (GOODS) fulfills these requirements. The GOODS collaboration, which, in part, utilizes the Hubble Space Telescope, has produced images that resolve galaxies up to a redshift of about six.

By analyzing the weak gravitational lensing in GOODS, what are the shear and convergence maps in those fields? What is the curl of the shear? If nonzero, can the systematic errors that cause this be identified and the images deconvolved, and to what degree? What is the mass power spectrum? Does this observed power spectrum determine or bound σ_8? Some astrophysicists have shown us how to answer these questions, such as Kaiser, Squires, and Broadhurst (1995); Rhodes, Refregier, and Groth (2000); and Refregier and Bacon (2003).

Deliverable

In my own attempt to answer these questions, I will write a research paper for this semester's BPURS program. It will summarize the theories, other physicists' weak lensing measurements, and any of my own findings to date from weak lensing analysis of GOODS. Among others, I will describe the work of the above authors. Various maps from GOODS that I will have generated, such as shear, convergence, and mass density fluctuation, will appear in this paper, along with descriptions of their significance.

Responsibilities

To put the weak lensing theories into practice, I use standard scientific computing tools such as C++ and Matlab in GNU/Linux operating systems. Jodi Lamoureux, scientific staff with George Smoot's observational astrophysics research group at the Lawrence Berkeley National Laboratory (LBNL), guides me on these technical aspects as well as on my general approach. She now works on gravitational lensing computer algorithms and models for the planned Supernova Acceleration Probe, and I use many of her algorithms when analyzing the GOODS data.

Systematic error will distort the signal, presumably, and identifying and correcting for it will constitute much of my responsibility. This involves analyzing the instruments and algorithms that generated the data, and perhaps filtering the error out. If we can do this, we will be gazing through a novel window on our universe.