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The Dark Energy Survey

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Dark Energy is the dominant constituent of the universe and we have little understanding of it. We describe a new project aimed at measuring the dark energy equation of state parameter, w, to a statistical precision of $\sim$5%, with four separate techniques. The survey will image 5000 deg^2 in the southern sky and collect 300 million galaxies, 30,000 galaxy clusters, and 2000 Type Ia supernovae. The survey will be carried out using a new 3 deg^2 mosaic camera mounted at the prime focus of the 4m Blanco telescope at CTIO.

Keywords: Dark energy ; galaxies; supernovae.

1. Introduction

Although dark energy is the dominant constituent in the universe, the nature of dark energy is largely a mystery. The effects of dark energy are manifested in the expansion rate of the universe and the rate of growth of structure. Observations of distant Type Ia supernovae[1],[2] provide direct evidence that the expansion of the universe is accelerating. The CMB temperature anisotropy points to a spatially flat universe and measurements of large-scale structure and galaxy clusters limit the density of matter (mostly dark) to about 30% of that of a flat universe. The remaining 70% of the energy density of the universe is attributed to dark energy. The current limit on the dark energy equation of state parameter from the combination of different measurements is $w < -0.75$. No single experiment measures w to better than 30%. More precise measurements of w are needed to help pin down the nature of dark energy and to constrain the theoretical models.

The Dark Energy Survey (DES) is proposed[a] in response to the NOAO Announcement of Opportunity for the Blanco Instrumentation Partnership that offered up to 30% of the observing time over a five year period in exchange for a new instrument. The primary scientific goal of the DES is to measure w using four independent and complementary techniques: galaxy cluster counting, measurement of the galaxy angular power spectrum, weak lensing, and using Type Ia supernovae.

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[a]For the complete proposal and more information see www.darkenergysurvey.org

To make these measurements, we propose to build a new 2.2 deg. field of view corrector and a 3 deg.[2], 62-CCD mosaic camera for the CTIO Blanco 4m telescope. This Dark Energy Camera (DECam) can be completed by 2009 and then used to carry out the Dark Energy Survey, a 4-band *griz* imaging survey of 5000 $\deg^2$ in the South Galactic Cap over the next five years. The survey will produce an archive that will be available to the public a year after the images are collected. The multiple-tiling survey strategy is designed to reach 10σ magnitude limits in $griz = 24.7, 24.3, 24.1, 23.9$, and obtain 2% photometric calibrations. The DES proposal was submitted to NOAO in July 2004.

2. The Dark Energy Survey Science

The DES area is chosen specifically to overlap the planned 4000 $\deg^2$ Sunyaev-Zel'dovich effect (SZE) cluster survey to be carried out by the South Pole Telescope[3]. The DES will provide accurate photometric redshifts for $\sim 90\%$ of the SPT clusters. Independent optical and SZE galaxy cluster identification and mass determination from the DES and SPT, respectively, will provide a means to understand systematic uncertainties. The angular power spectrum measurements will probe galaxy clustering as a function of redshift out to $z \sim 1$. In contrast to the galaxy and cluster surveys, which measure the distribution of light, weak lensing is a direct measurement of the mass in the universe. Shape measurements of the 300 million DES galaxies at a surface density of 10-20 galaxies/arcmin^2 will be used to determine both cosmic shear and galaxy-shear correlations. Finally, a time-domain survey of a 40 $\deg^2$ area will obtain the largest sample, ~ 2000, Type Ia supernovae, at redshifts $z \sim 0.3 - 0.8$. We expect that each measurement will have a statistical precision of $\sim$ 5-10% and that by combining all four measurement techniques, and including the ability to correlate with the SZE cluster data from the SPT, the DES will provide powerful new constraints on the nature of dark energy.

3. Dark Energy Survey Instrument

The DES instrument includes a large mosaic camera, a five element optical corrector, four filters, and the associated infrastructure for operation at the Blanco telescope. Figure 1 shows a cross section of the proposed instrument. There is space between 3rd and 4th lenses to allow the filters to flip in and out of the optical path. The 5th optical element is the camera window. A scroll shutter is located just in front of the camera. The camera vessel is comprised of two pieces, the front section holds the focal plane, CCD cables and the custom electronic feedthrough boards. The rear section houses the LN2 cooling reservoir and cryo coolers. The cooling reservoir will be connected to the focal plane with copper braid straps. Outside the camera are two crates for the front-end electronics and data acquisition system.

The focal plane consists of 62 2K x 4K CCD modules (0.27"/pixel) arranged in a hexagon inscribed within the 2.2° diameter field of view. Focus and guide CCDs are located at the edge of the focal plane. High QE in the red is important to achieve

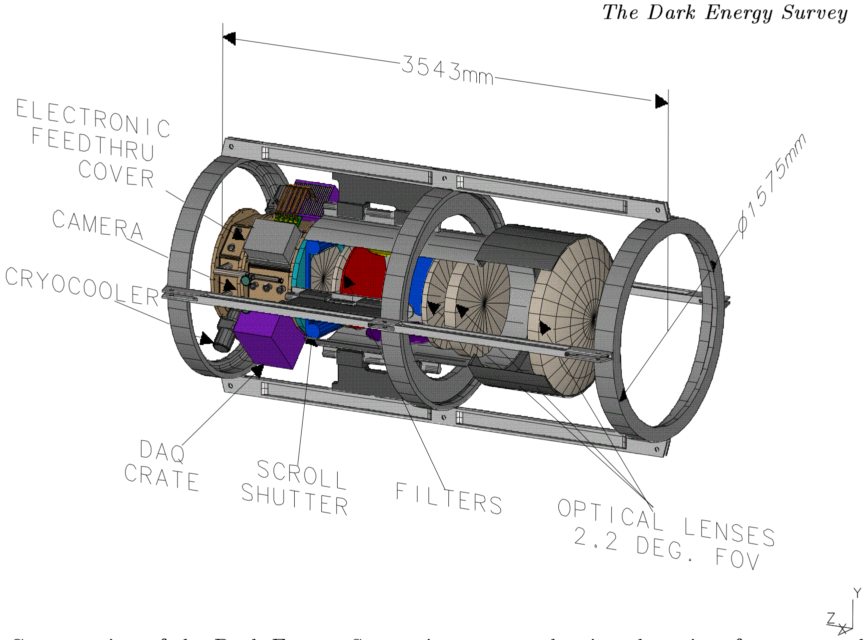

Fig. 1. Cross section of the Dark Energy Survey instrument showing the prime focus cage, the camera and the optical corrector.

complete galaxy samples and accurate photometric redshifts at $z \sim 1$. To meet this requirement we plan to use the 250 μm thick fully-depleted CCDs that have been developed[4] at the Lawrence Berkeley National Laboratory (LBNL). At Fermilab, we will establish a packaging factory to produce four-side buttable modules for the LBNL devices, as well as to test and grade the CCDs.

4. Conclusions

The DES is a proposal to build a new instrument for the 4m Blanco telescope at CTIO and then to use this instrument, starting in 2009, to study one of the fundamental questions of our time, the nature of dark energy. The DES will greatly enhance the capabilities available to the user community on the Blanco and will produce a public archive of 300 million galaxies, 30,000 galaxy clusters and 2000 Type Ia supernovae. With this data, the DES will be in a unique position to measure w to a statistical precision of $\sim 5\%$ with 4 nearly independent techniques and to build both scientific and technical foundations for the future dark energy experiments, JDEM and LSST.

References

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