FINAL REPORT

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Advanced Dark Energy Telescope (ADEPT)

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Background

In 2006, we proposed to NASA a detailed concept study of ADEPT (the Advanced Dark Energy Physics Telescope), a potential space mission to reliably measure the time-evolution of dark energy by conducting the largest effective volume survey of the universe ever done. A peer-review panel of scientific, management, and technical experts reported back the highest possible “excellent” rating for ADEPT. We have since made substantial advances in the scientific and technical maturity of the mission design.

With this Department of Energy (DOE) award we were granted supplemental funding to support specific extended research items that were not included in the NASA proposal, many of which were intended to broadly advance future dark energy research, as laid out by the Dark Energy Task Force (DETF).

The proposed work had three targets: (1) the adaptation of large-format infrared arrays to a 2 micron cut-off; (2) analytical research to improve the understanding of the dark energy figure-of-merit; and (3) extended studies of baryon acoustic oscillation systematic uncertainties.

Since the actual award was only for ~10% of the proposed amount item (1) was dropped and item (2) work was severely restricted, consistent with the referee reviews of the proposal, although there was considerable contradictions between reviewer comments and several comments that displayed a lack of familiarity with the research. None the less, item (3) was the focus of the work.

To characterize the nature of the dark energy, ADEPT is designed to observe baryon acoustic oscillations (BAO) in a large galaxy redshift survey and to obtain substantial numbers of high-redshift Type Ia supernovae (SNe Ia). The 2003 Wilkinson Microwave Anisotropy Probe (WMAP) made a precise determination of the BAO “standard ruler” scale, as it was imprinted on the cosmic microwave background (CMB) at $z \approx 1090$. The standard ruler was also imprinted on the pattern of galaxies, and was first detected in 2005 in Sloan Digital Sky Survey (SDSS) data. A measurement of the BAO standard ruler as a function of time (or redshift) would provide powerful and reliable observational data to shed light on dark energy. In particular, the BAO data provide the angular diameter distance to each redshift, and directly give the expansion rate, $H(z)$, at each redshift. The SNe measurements provide luminosity distances.

A space mission is required to obtain the three-dimensional position of enormous numbers of galaxies at high redshift. As recognized by the Dark Energy Task Force, BAO systematic errors are naturally low.

Findings

DOE funds were used to support data simulation efforts aimed at assessing the performance and systematic errors limitations of realistic observations. The following are the key findings:

1. The BAO method is robust.
2. Separation of the spectral and imaging detection focal planes vastly improves spectral identifications.
3. Prisms instead of grisms provide higher throughput and cleaner spectra. Prisms are clearly superior.
4. Lower prism dispersions improve signal-to-noise but high prism dispersions improve systematic. To ensure that the experiment is not systematic limited, a high dispersion should be used.
5. Counter-dispersion of the spectra reduces systematic errors on the redshift determination and assists in the reduction of confusion.
6. Small rolls are very effective for the reduction of confusion.
7. Interlopers can be recognized by a variety of methods, which combine to produce a sufficiently “clean” survey data set so as not to limit the dark energy results.
8. A space mission can measure the BAO signature to the cosmic variance limit, limited only by statistics and not by systematic.
9. Density field reconstruction allows for significant BAO accuracy improvements, well beyond that assumed by the Dark Energy Task Force.
10. The BAO method is statistically powerful. It is more powerful than previously estimated, and far more powerful than high redshift Type Ia supernovae, for which the ultimate distance accuracy is limited by flux calibration accuracy.
11. The BAO technique is far simpler than the weak lensing technique and likely to produce more robust dark energy solutions.

These findings were shared with both DOE and NASA.