22. Detail Attachments

a. Purpose
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Analyze astronomical data from the Dark Energy Survey (DES) to constrain the properties of Dark Energy.

b. Approach

The approach is to use gravitational lensing effects in DES data to constrain the properties of Dark Energy. Erin Sheldon is a member of DES with data rights, and in collaboration with Mike Jarvis of Penn he is leading the lensing effort in DES.

Lensing measurements are critical to the goals of DES. The primary Dark Energy probes used by DES are the power spectrum of mass density fluctuations in our universe measured from gravitational lensing (cosmic shear) and the number density of galaxy clusters as a function of their mass and cosmic time. The masses of these clusters are also measured using gravitational lensing. Using the combined probes, DES will constrain the equation of state parameter w=pressure/density for Dark Energy to ~3%.

DES will see first light in 2011. In the interim, data processing pipelines and analysis codes to measure gravitational lensing will be written. This data will be used to calibrate the masses of the galaxy clusters used in the cosmological analyses.

This cluster lensing work is a natural continuation of earlier work by Erin Sheldon in the Sloan Digital Sky Survey (SDSS), which are the most sensitive of this type to date. The processing pipelines for DES are an extension of those used in the SDSS, as are the analysis tools used to extract cosmological parameters. The volume and depth of DES is sufficiently large to allow these measurements to be made in many bins of cosmic time, with which the cosmological analysis will be extended to constrain the properties of Dark Energy.

In contrast to cluster lensing measurements, cosmic shear is the correlation of shears across the sky independent of the location of foreground structures. Since the shear is related to mass, the cosmic shear can be used to directly infer statistics of the underlying mass distribution, the evolution of which is directly related to the properties of Dark Energy. Because the signal need not be modeled in terms of cluster halos, the interpretation of cosmic shear can be simpler than cluster lensing, but the measurement is more sensitive to systematic effects. Thus cosmic shear is quite complimentary to clusters.

The analysis and infrastructure development created for DES will also lead naturally to work on the Large Scale Synoptic Telescope (LSST) of which ES is a participating member.

This work will be in collaboration with a postdoc, as well as Mike Jarvis and Bhuvnesh Jain from the University of Pennsylvania, not supported by this proposal. Erin Sheldon and the postdoc will be supported at 100%.

c. Technical Progress

First Year

The project will enter commissioning a few months before the first year of this award begins. Over the last three years pipelines and analysis codes have been developed to process the DES data. These have been tested and tuned using sophisticated simulations developed within the DES. This code can process individual images from DES as well as combine multi-epoch data into a single best measurement for each detected astronomical object. Completing the latter multi-epoch processing code was a major milestone in DES lensing pipeline development, as it is required to optimally process the data. Using computers at BNL, all of the currently available simulated data have been processed.

As the first commissioning data arrives, the data will be evaluated and these codes tested and improved to work with real data.

In addition to work on real data, internal competitions are planned to recover the true cosmology from the simulations.

Survey proper will begin in Fall 2012. A new challenge will be the automated analysis of the data as it arrives in steady stream throughout the observing season, breaking only for bright time. This will test how well the automated processing is streamlined and the scalability of the system. First analysis of the data in a cosmological context will begin after the first season.

d. Future Accomplishments

Second Year

Operations will continue as before, tuning the algorithms and pipelines as lessons are learned from the data. Many re-processings of the data will occur. A short turnaround time must be established between processing, debugging, and analysis.

During the second year publications will emerge based on the first year of data. These will include analysis of clusters to determine the mass-observable relation, a key component in extracting cosmology from galaxy clusters.

Third Year

Continuing much the same as previous years. Primary technical challenges will be attaining the required accuracy as the precision increases and scaling the analysis with the data size. The first analyses using multi-epoch data will emerge in year three.

Fourth Year

Continue much the same as previously. Multiple re-processings of the data. Continue to improve and pipelines and methods. Multi-epoch processing will start so show more benefit.

Fifth Year

Continue as previously. A full reprocessing of all data. The final data will be taken by the end of this year, and final, definitive papers will emerge. Final analysis of the full dataset to extract cosmological information will reach the 3% level in measurements in the Dark Energy equation of state parameter.

e. Relationships to Other Projects

The technology, methods, and physical insight gained from DES will be applied directly to the LSST project. This is natural as both are ground based imaging surveys with a time-doman component and a strong focus on gravitational lensing and cosmology.

f. Explanation of milestones