BigBOSS receives favorable review from the National Optical Astronomy Observatory

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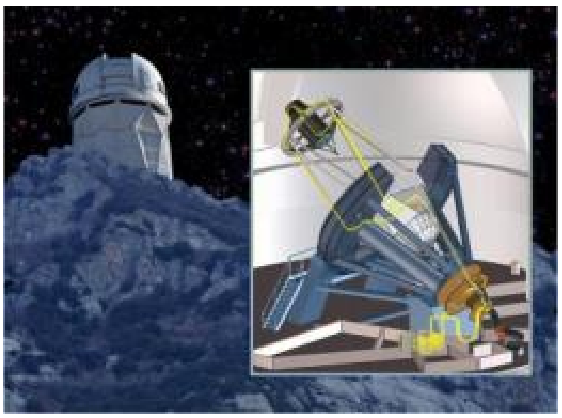

Under the BigBOSS proposal, the NOAO Mayall Telescope (left) would be modified (inset) to cover a wider field of view and equipped with a new spectrographic instrument capable of precisely measuring nearly 5,000 galaxies or stars simultaneously. Credit: Mayall Telescope photo by Pete Marenfeld (NOAO/AURA/NSF)

The National Optical Astronomy Observatory (NOAO), the National Science Foundation's (NSF's) research and development center for ground-based astronomy, has announced its conditional approval of the BigBOSS Collaboration's proposal to use 500 nights of valuable observing time on the NOAO 4-meter Mayall Telescope on Kitt Peak, Arizona. The time would be used to build the biggest-ever map of the universe, for investigating the mysterious dark energy that permeates the universe.

Key to the successful inauguration of BigBOSS will be construction of a remarkable new spectrographic instrument capable of making simultaneous measurements of thousands of astronomical objects. The instrument will be available to all users of the Mayall telescope, and the data is expected to be available in an archive for all astronomers and the public. The BigBOSS Collaboration plans to seek funding needed for this instrumentation and associated software from NSF and the U.S. Department of Energy.

"Approving BigBOSS to use the Mayall Telescope is the first step toward an ambitious program to explore the expansion of the universe in detail," says the BigBOSS Collaboration's principal investigator, cosmologist David Schlegel of the Physics Division at DOE's Lawrence Berkeley National Laboratory (Berkeley Lab).

"BOSS" stands for Baryon Oscillation Spectroscopic Survey. In the course of observations over five years, the BigBOSS program will target 50 million objects and find precise locations for almost 20 million galaxies and quasars, reaching back 10 billion years to the youthful universe. The BigBOSS map will encompass 10 times the volume of the current best map of the universe, now being assembled by the Sloan Digital Sky Survey III's BOSS project, whose first data were released to the world January 11, 2011, on their public website, www.sdss3.org/ .

The goal of both BOSS and BigBOSS is to examine the expansion history of the universe and study the nature of dark energy; both projects are led by Berkeley Lab. The idea for BigBOSS emerged when studies for the proposed Joint Dark Energy Mission space satellite indicated that very large numbers of high-redshift galaxies could be observed and accurately measured using reliable, economical ground-based telescopes.

BigBOSS, enabled by Kitt Peak's Mayall Telescope and using the new spectrographic instrument, will reach much farther in space and farther back in time than BOSS, across wider reaches of the sky. Important contributions to the new instrument will come from BigBOSS's 35 collaborating institutions in the U.S. and abroad, including institutions in France, the United Kingdom, China, Spain, and Korea.

Says Schlegel, "By measuring baryon acoustic oscillation, BigBOSS will study dark energy and can even test whether General Relativity is valid. What's more, the BigBOSS instrument will give the astronomical community an unprecedented opportunity to make millions of observations for projects not connected to our primary effort."

Baryon oscillation as a ruler to measure the universe

Baryon acoustic oscillation is cosmology-speak for the way galaxies tend to bunch up at roughly 500-million-light-year intervals. These density oscillations had their origin in the pressure waves that moved through the liquid-like plasma of the early, hot universe. When the growing universe "decoupled" – cooled down enough so that light and matter could go their separate ways – the density oscillations were recorded in the cosmic microwave background, where they can still be read today.

Since those regions denser in matter became the seeds of today's galaxies and groups of galaxies, the cosmic microwave background provides the starting point for a natural ruler to measure how the universe has expanded since decoupling. The greater the number of galaxies and quasars that can be used to measure density fluctuations accurately over time, the more accurate the cosmic ruler will be. This is the primary purpose of BigBOSS and its new spectrographic instrument.

"BigBOSS Collaboration members Mike Sholl of the University of California at Berkeley's Space Sciences Laboratory and Ming Liang of NOAO discovered that the 4-meter Mayall was capable of a three-degree field of view – much, much larger than had previously been recognized," says BigBOSS director Michael Levi of Berkeley Lab's Physics Division.

Arjun Dey, BigBOSS Collaboration member and NOAO astronomer, says, "BigBOSS will provide a much-needed unique and powerful scientific capability for the venerable Mayall Telescope. Its ability to obtain measurements of nearly 5,000 galaxies or stars simultaneously will enable ground-breaking studies into the nature of dark energy and the structure of our Milky Way galaxy, and will also provide an instrument of unprecedented astrophysical grasp for the U.S. astronomical community. Re-instrumenting and repurposing existing telescopes like the Mayall provide the most cost-effective way of addressing the most important scientific questions of our time."

Levi adds, "To enable this science, a new astronomical CCD is being developed at Berkeley Lab's microsystems laboratory under the direction of BigBOSS instrument scientist Natalie Roe. The new CCD will be supersensitive in the red and infrared wavelengths needed to image very distant objects."

Measuring the redshift of each galaxy reveals how much the universe has expanded since its light left that galaxy. A red shift of 0.5, for example, means the universe has expanded 50 percent since the emission of the light. Comparing how distance varies with redshift for many millions of galaxies at different times in the history of the universe will allow precise calibration of the spacing of density oscillations at different epochs.

The mystery of dark energy

Dark energy was discovered as a result of comparing the brightness and redshift of individual Type Ia supernovae, which revealed that the universe is expanding at an accelerating rate. Dark energy has "negative pressure" – that is, by stretching space it counteracts the mutual gravitational attraction of all the matter in the universe, which would otherwise slow down expansion. Although dark energy is thought to constitute some 70 percent of the density of the universe, its nature is unknown.

Theories of dark energy abound, falling into two broad camps. Either dark energy is constant and acceleration is steady, or dark energy varies in time, perhaps even in space. A third possibility is even more radical: dark energy is an illusion, brought on because Einstein's General Theory of Relativity, the best explanation of gravitation we have, is wrong or incomplete. With a bigger map of the universe and a more precise measurement of its expansion history, BigBOSS will go a long way toward providing the data needed to choose among these possibilities.

Far beyond dark energy and the measurement of baryon acoustic oscillations, the BigBOSS instrument and the publicly available databases BigBOSS creates will have a major scientific impact on astronomy. The biggest-ever galactic survey will provide new data on cosmological questions including the large- and small-scale structure of the universe, neutrino mass, warm dark matter, and the geometry of space. BigBOSS will provide an unparalleled resource for studying the evolution of galaxies, including our own. It will provide a wealth of new data on quasars. And it will be available for studying such topics as galaxy clusters, planetary nebulae, giant stars, binary stars, and a host of other individual observing programs.

Provided by Lawrence Berkeley National Laboratory