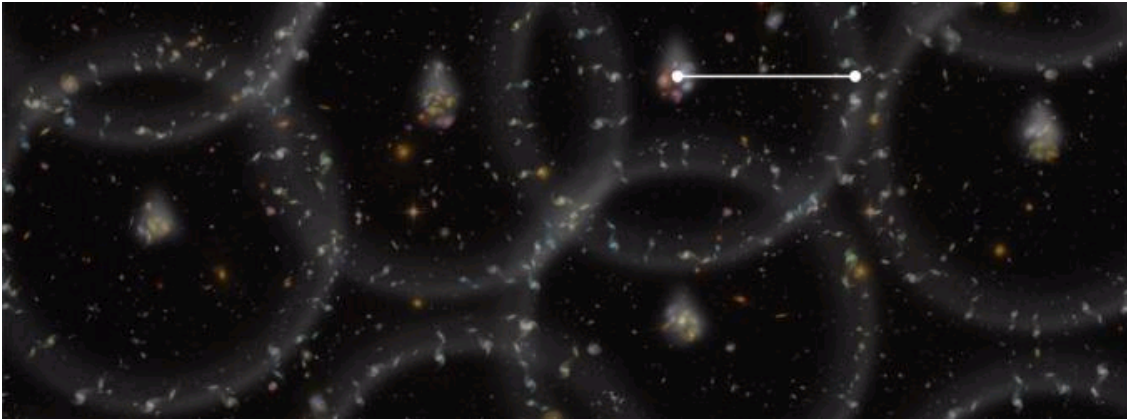




A One-Percent Measure of Galaxies Half the Universe Away

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Cambridge, MA - Researchers from the Baryon Oscillation Spectroscopic Survey (BOSS) today announced that they have measured the distance to galaxies more than six billion light years away to an unprecedented accuracy of just one percent. Their measurements place new constraints on the properties of the mysterious "dark energy" thought to permeate empty space, which causes the expansion of the Universe to accelerate.

"There are not many things in our daily life that we know to one-percent accuracy," said David Schlegel, a physicist at Lawrence Berkeley National Laboratory (LBNL) and the principal investigator of BOSS. "I now know the size of the Universe better than I know the size of my house."

The new distance measurements were presented today at a meeting of the American Astronomical Society by astronomer Daniel Eisenstein (Harvard-Smithsonian Center for Astrophysics), the director of the [Sloan Digital Sky Survey III](#) (SDSS-III), the worldwide collaboration of which BOSS is a part.

"Determining distance is a fundamental challenge of astronomy," said Eisenstein. "You see something in the sky - how far away is it? Once you know how far away it is, learning everything else about it is suddenly much easier."

Throughout history, astronomers have met this challenge using many different techniques: for example, distances to planets in the solar system can be measured quite accurately using radar, but for more distant objects, astronomers must turn to less-direct methods.

Regardless of the method, every measurement has some uncertainty, which can be expressed as a percentage of the thing being measured. For example, if you measure the distance from Washington, D.C. to New York (200 miles) to within two miles of the true value, you have measured to an accuracy of one percent.

Only a few hundred stars and a few star clusters are close enough to have distances measured to one-percent accuracy. Nearly all of these stars are only a few thousand light-years away, and all are still within our own Milky Way galaxy. Reaching out a million times farther away, the new BOSS measurements probe far beyond our Galaxy to map the Universe with unparalleled accuracy.

With these new, highly accurate distance measurements, BOSS astronomers are making new inroads in the quest to understand dark energy. "We don't yet understand what dark energy is," explained Eisenstein, "but we can measure its properties. Then, we compare those values to what we expect them to be, given our current understanding of the Universe. The better our measurements, the more we can learn."

Making a one-percent measurement at a distance of six billion light-years requires a completely different technique from measurements in the solar system or the Milky Way. BOSS, the largest of the four projects that make up the Sloan Digital Sky Survey III (SDSS-III), was built to take advantage of this technique: measuring the so-called "baryon acoustic oscillations" (BAOs), subtle periodic ripples in the distribution of galaxies in the cosmos.

These ripples are imprints of pressure waves that moved through the early Universe, which was so hot and dense that particles of light (photons) moved along with the protons and neutrons (known collectively as "baryons") that today make up the nuclei of atoms. The original size of these ripples is known, and their size today can be measured by mapping galaxies.

Making these measurements required mapping the locations of 1.2 million galaxies. BOSS uses a specialized instrument that can make detailed measurements of 1000 galaxies at a time.

The BOSS measurements are consistent with a form of dark energy that stays constant through the history of the Universe. This "cosmological constant" is one of just six numbers needed to make a model that matches the shape and large-scale structure of the Universe. Schlegel likens this six-number model to a pane of glass, which is pinned in place by bolts that represent different measurements of the history of the Universe.

"BOSS now has one of the tightest of those bolts, and we just gave it another half-turn," said Schlegel. "Each time you ratchet up the tension and the glass doesn't break, that's a success of the model."

This release is being **issued jointly** with the Sloan Digital Sky Survey III.

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Headquartered in Cambridge, Mass., the Harvard-Smithsonian Center for Astrophysics (CfA) is a joint collaboration between the Smithsonian Astrophysical Observatory and the Harvard College Observatory. CfA scientists, organized into six research divisions, study the origin, evolution and ultimate fate of the universe.

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