

Academia Sinica Press Release

Astronomers Develop New Techniques for Studying Dark Energy

A multinational team of astronomers have developed new techniques to map large cosmic structures and delved further into the nature of the enigmatic “dark energy” postulated to make up the most of mass and energy of the Universe. The project, initiated by Dr. Tzu-Ching Chang, a Postdoctoral Fellow of the Institute of Astronomy and Astrophysics at Academia Sinica, delineated the “cosmic web” by investigating the radio waves coming from the very distant hydrogen gas in space. The research was published in the leading scientific journal *Nature* on July 22, 2010 (US Eastern Time).

Dark energy is a hypothetical force used to account for whatever is accelerating the expansion rate of the Universe. It is believed to constitute approximately 75 percent of the mass and energy of the Universe. A range of competing theories for the cause of dark energy have emerged since the discovery of the acceleration in 1998. In an effort to evaluate those theories, over the years astronomers have endeavored to perfect the measurement of large-scale cosmic structures (e.g. galaxy clusters).

Sound waves in the extremely early Universe are thought to have left detectable imprints on the large-scale distribution of galaxies and gas in the Universe. The galaxies, separated by immense voids, form a foam-like structure known as the “cosmic web”. By measuring how such large-scale structures have changed over the last few billion years, scientists hope to gain insight that could indicate which theory of dark energy is the most accurate.

The mainstream approach to mapping the cosmic web involves searching for hydrogen gas in these individual, distant galaxies through the observation of their radio emission. However, this often proves to be a daunting challenge beyond the technical capabilities of current instruments, as radio waves of those distant galaxies generally are too faint to be individually detected.

In this study, the team used an alternative method, namely measuring the aggregate radio emission from many unresolved galaxies in the cosmic web. For their study, the researchers used the Robert C. Byrd Green Bank Telescope (GBT) located at the site of the National Radio Astronomy Observatory (NRAO) in the US, and were able to find and map the hydrogen gas in many galaxies at once.

More importantly, the astronomers developed new techniques that removed both man-made radio interference and radio emission from nearer astronomical sources, to leave the extremely faint radio waves coming from the very distant hydrogen gas. The result was a map of part of the “cosmic web” that correlated neatly with the structure shown by the earlier optical study.

“Our project mapped hydrogen gas to greater cosmic distances than ever before, and shows that the techniques we developed can be used to map huge volumes of the Universe in three dimensions and to test the competing theories of dark energy,” said Dr. Chang. “These observations detected more hydrogen gas than all the previously-detected hydrogen in the Universe, and at distances ten times farther than any radio wave-emitting hydrogen seen before,” she added.

The GBT is presently the world’s largest fully steerable radio telescope. The NRAO is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

The full article entitled “Hydrogen 21-cm Intensity Mapping at Redshift 0.8” is available online at the *Nature* website at:

<http://www.nature.com/nature/journal/v466/n7305/full/nature09187.html>.

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