

## Academia Sinica Press Release

# Earth's Natural Laws Still Apply in Distant Universe, Researchers Say

The laws of nature are the same in the distant Universe as they are here on Earth, according to new research conducted by an international team of astronomers including Sebastien Muller, postdoctoral fellow at the Institute of Astronomy and Astrophysics - Academia Sinica, in Taipei. Their research, published in the leading journal "Science" on June 20, shows that one of the most important and fundamental numbers in physics, the proton-electron mass ratio, is exactly the same, in a galaxy 6 billion light years away, as it is in the laboratories on earth. The ratio is approximately 1836.15.

A strong limit on the proton-to-electron mass ratio was obtained from observations of molecules at high redshift by the scientists, who include postdoctoral researcher Sebastien Muller.

According to Michael Murphy, an astrophysicist from Swinburne University of Technology in Australia who is the lead author of the study, this is an important finding, as many scientists debate whether the laws of nature may have been different in earlier times and at distant places in the Universe.

"We have been able to show that the laws of physics are the same in this galaxy half way across the visible Universe as they are here on Earth," he said.

The astronomers made their discovery by effectively looking back in time at a distant quasar, labeled B0218+357. The quasar's light, which took 7.5 billion years to reach us, was partially absorbed by ammonia gas in an intervening galaxy.

Not only is ammonia useful in most bathroom cleaning products, it is also an ideal molecule to test our understanding of physics in the distant Universe, the scientists say. The wavelengths at which ammonia absorbs radio energy from the quasar are sensitive to this special nuclear physics constant, the proton-electron mass ratio.

By comparing the ammonia absorption with that of other molecules, namely hydrogen

cyanide and the formyl ion they were able to determine the value of the proton-electron mass ratio in this galaxy and confirm that it is the same as it is on Earth.

The aim of the astronomers is to continue testing the laws of nature in as many different places and times in the Universe as possible. “We want to see how well the laws of nature stand up in untested situations, by looking well beyond our little portion of space and time,” said M. Murphy. In order to do this, the astronomers will need to locate more absorbing galaxies.

“Only a few such galaxies have been found to date. Our target is the best amongst them for this type of study. Things should change when the next generation interferometer, the Atacama Large Millimeter Array (ALMA), is set up in Chile. ALMA should allow us to discover many more absorbing galaxies, allowing us to study the physical conditions in the young and distant Universe with unprecedented sensitivity” says Sebastien Muller. “Astronomy is amazing in that it gives us the ability to measure the mass ratio of such tiny particles as protons and electrons at such large distances.”

Taiwan is a partner in the ALMA project, currently under construction in Chile.

The research team Michael T. Murphy, Victor V. Flambaum, Sebastien Muller and Christian Henkel published their work in an article titled “Strong Limit on a Variable Proton-to-Electron Mass Ratio from Molecules in the Distant Universe” on June 20 in “Science.”

Caption:

"The absorption of the  $\text{HCO}^+$ , HCN and  $\text{NH}_3$  molecules was observed with the Plateau de Bure interferometer (France) and Effelsberg radio telescope (Germany), in a distant galaxy located in front of the quasar B0218+357. The comparison of the different absorption profiles allowed the astronomers to measure the proton-to-electron mass ratio in the intervening galaxy and conclude that it is the same as on Earth."

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