Max-Planck-Institut für Radioastronomie

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Earth's laws still apply in distant Universe

Strong limit on a fundamental constant from molecule observations at high redshift

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 Christian Henkel from the Max Planck Institute for Radio Astronomy (MPIfR) in Bonn. Their research, published today in *Science,* shows that one of the most important numbers in physics theory, the proton-electron mass ratio, is almost exactly the same in a galaxy 6 billion light years away as it is in Earth's laboratories – approximately 1836.15.

According to Michael Murphy, Swinburne astrophysicist and lead author of the study, it is an important finding, as many scientists debate whether the laws of nature may change at different times and in different 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 determined this by effectively looking back in time at a distant quasar, labelled B0218+367. 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. Spectroscopic observations of the ammonia molecule were performed with the Effelsberg 100m radio telescope at 2 cm wavelength (red-shifted from the original wavelength of 1.3 cm). The wavelengths at which ammonia absorbs radio energy from the quasar are sensitive to this special nuclear physics number, the proton-electron mass ratio.

"By comparing the ammonia absorption with that of other molecules, we 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," says Christian Henkel from MPIfR, an expert for molecular spectroscopy and co-author of the study.

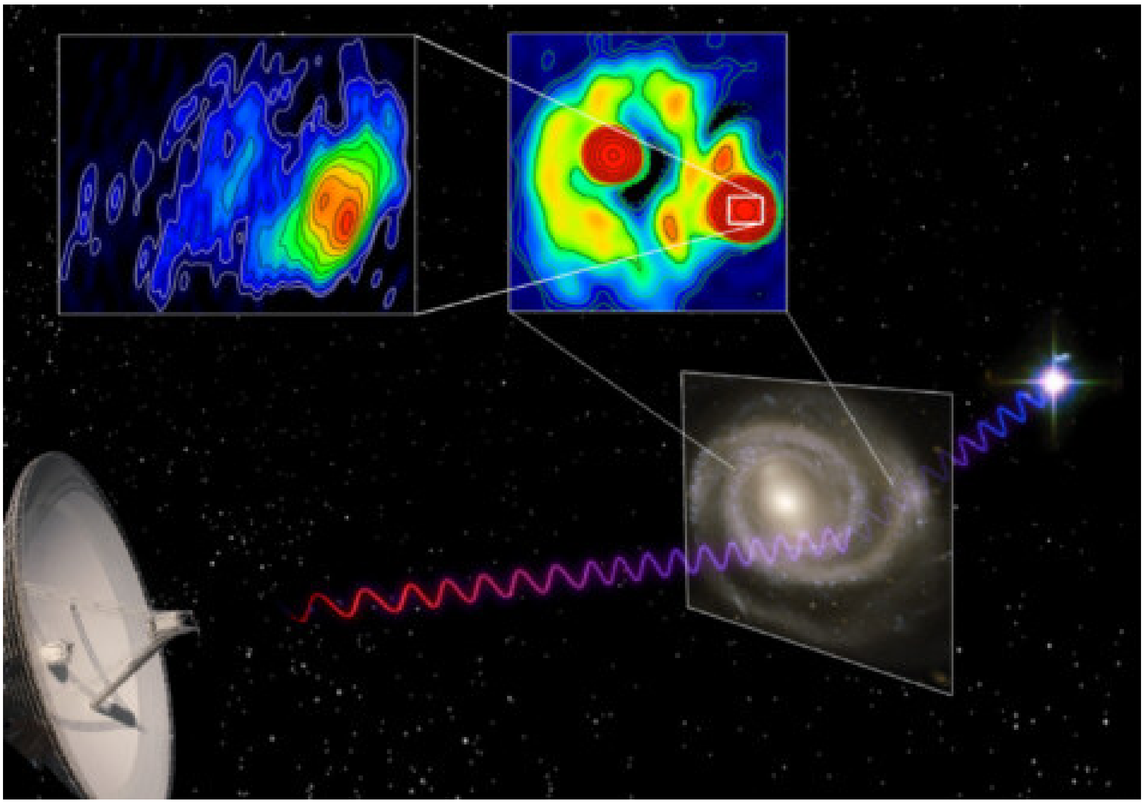

Figure 1: *Observing molecular absorption in distant galaxies using the light of bright, background quasars. As light from the quasar travels to Earth, the Universe continues to expand, stretching the light's wavelength (it gets redder the longer it travels). In our observations, the light is also gravitationally lensed (its path is bent) as it passes through an intervening galaxy; when a radio map of the field is made, two quasar images appear. However, the molecular absorption clouds are only along the line of sight to one image. Furthermore, when very high resolution images are made of that quasar image, some structure is evident - a core (the brightest part of the image) and a knotty jet extending away from the quasar core. It's only towards the quasar core that molecular absorption is thought to occur.*

Images: Telescope: N. Junkes; Radio insets: A. Biggs; Intervening galaxy: NASA, ESA, STScI & W. Keel; Quasar: NASA, ESA, STScI &

E. Beckwith (Click image for higher resolution).

The astronomers' aim is to continue testing the laws of nature in as many different places and times in the Universe as possible, in order to see how well the laws of nature stand up in untested situations. They will need to locate more absorbing galaxies. The studied galaxy, B0218+367, is the only target for this kind of research so far. There must be many more target galaxies out there, as soon as the right telescopes to find them are available.

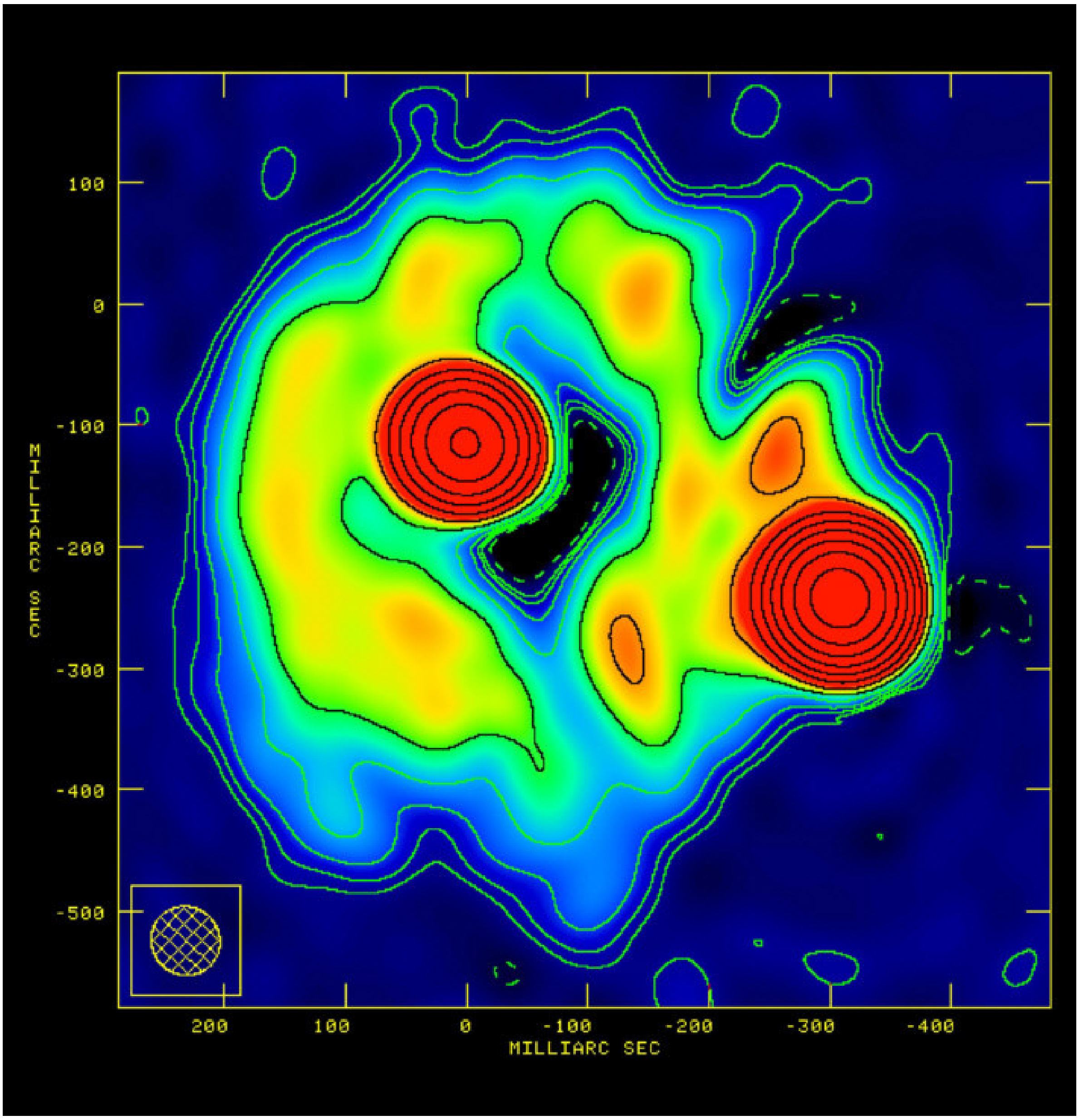

Figure 2: R*adio contour map of the quasar B0218+367 at about 7.5 billion light years distance. The galaxy containing absorbing ammonia molecules lies about 6 billion light years away and, though it is not seen in this radio map, gravitationally lenses the background quasar light to produce two bright quasar images on the sky (big red circles). The physical size of the image (at the distance of the absorbing galaxy) is about 19,000 light years across.*

Image: Andi Biggs (MERLIN Image, click for higher resolution).

According to Murphy, this problem could be overcome with the proposed Square Kilometre Array (SKA) telescope project. "The SKA is the largest, most ambitious international telescope project ever conceived. When completed it will have an enormous collecting area, and will allow us to search for more absorbing galaxies." The location of the SKA, which has been short-listed to Western Australia or Southern Africa, will be announced within the next two years.

By continuing their research into the forces of nature, the astronomers also hope to find a window into the extra dimensions of space that many theoretical physicists think may exist.

Original paper:

Strong Limit on a Variable Proton-to-Electron Mass Ratio from Molecules in the Distant Universe, Michael T. Murphy, Victor V. Flambaum, Sébastien Muller, Christian Henkel, Science, 2008, June 20 issue.

Further Information:

Project page at Swinburne with images and additional information.

Millimeter and Submillimeter Astronomy at MPIfR.

Effelsberg 100m radio telescope

Swinburne University of Technology, Australia.

University of New south Wales, Australia.

Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan.

MERLIN radio interferometer (image of B0218+367).

Square Kilometer Array (SKA).

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