

Variable physical laws

Physical quantities such as the speed of light, the gravitational constant and the electron mass are believed to be the same independent of where and when they appear in the universe. Therefore, they are known as constants of nature.

Should they deviate from their actual values the universe would have looked different and neither man nor other living organisms would have existed. But imagine that the fundamental constants – and thereby also the fundamental laws – are not at all constant but have gradually changed over time.

Implications that this is the case have been known for some time and are now supported by new measurements – for instance from Lund University, Sweden.

The constants are so fundamental that it is usually impossible to detect any possible changes since the tools we use to measure these changes are also changing. For instance, if the size of the atoms would increase the atoms in the measuring device would also increase to the same extent and everything would appear normal.

But there are dimensionless constants, i.e. they are independent of units. On April 21 this year new findings were published in *Physical Review Letters* implying that a dimensionless constant – the ratio between the electron mass and the proton mass – has changed with time.

And shortly measurements will be presented in Monthly Notices of the Royal Astronomical Society showing that another dimensionless constant, called the fine structure constant, is also varying with time.

The measurements have been performed at Lund Observatory in Sweden by professor Sveneric Johansson and his PhD student Maria Aldenius in collaboration with Dr Michael Murphy, Cambridge, UK.

The fine structure constant is a combination of the speed of light, the electron charge, Planck's constant and the vacuum permittivity. It characterizes the electromagnetic force that keeps the atom together.

To study the time variation of this constant the aged light from distant quasars – extremely powerful and bright objects billions of light years away – has been compared with modern laboratory data. When the quasar's light passes through intervening gas clouds an absorption spectrum is formed – a continuous spectrum with dark absorption lines.

These dark lines form characteristic signatures of the chemical elements present in the clouds. Studies of systematic shifts in the line positions compared to laboratory spectra indicate changes in the fine structure constant.

"Previous measurements of this type have been based on lighter elements like magnesium, silicon and aluminum," says Sveneric Johansson. "But it was difficult to make any clear conclusions from that study."

In 1999 an Australian research group led by John K Webb suggested that the number of elements investigated should be increased. In Lund we were asked to help with new laboratory measurements and we increased the accuracy further by doing all measurements simultaneously from the same laboratory source. Now we have included magnesium and the heavier elements iron, titanium, chromium and manganese in our measurements.

"The result is that the uncertainty of the ruler is lowered by a factor of ten. But the picture from previous measurements of the fine structure constant seems not to have changed."

The changes of both the proton/electron mass ratio and the fine structure constant are very tiny. The fine structure constant has changed by some parts per million during six billions years.

There is no reason to worry – unless you are a physicist or astronomer and don't want to change the model of the universe we have today. But Sveneric Johansson thinks that the results are more exciting than troublesome.

"Our view of the universe is in many ways not complete, he says. The content of 90% of the matter in universe is unknown – the so called "dark matter". And there are contradictory opinions about what happened after the Big Bang. Therefore, we should welcome all new knowledge even if it does not agree with our present conception of the world."

Source: The Swedish Research Council

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