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Changing one of nature's constants

If correct, new finding could upend physicists' view of universe

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The constants, they may be a-changin' — and so may some of the fundamental laws of nature, a controversial new study suggests.

Studying the pattern in which gas clouds absorb the light from distant quasars, astronomers say they have found evidence that one of nature's physical constants changes in a lopsided manner.

Along one direction the fine-structure constant, which governs the strength of the electromagnetic force, grows slightly weaker with time, while in the other direction it grows slightly stronger. The research, by John Webb of the University of New South Wales in Sydney, Australia, and his colleagues, was posted online at arXiv.org on August 25 (http://arxiv.org/abs/1008.3907). The work is the latest in a series of controversial studies on the fine-structure constant, also known as alpha, that the researchers have conducted since 1999.

If the study is correct, it would force physicists to reconsider many of their most cherished ideas about the universe, including the notion, touted by Einstein, that the laws of physics are the same everywhere in the cosmos.

"This would be sensational if it were real, but I'm still not completely convinced that it's not simply systematic errors" in the data, comments cosmologist Max Tegmark of MIT.

Craig Hogan of the University of Chicago and the Fermi National Accelerator Laboratory in Batavia, Ill., acknowledges that "it's a competent team and a thorough analysis." But because the work has such profound implications for physics and requires such a high level of precision measurements, "it needs more proof before we'll believe it."

Webb's team plans to post a more detailed paper on the analysis, "but in the meantime, the physicists' intuition is to worry about systematic errors, which by definition have not yet been understood or modeled," Hogan says. Systematic errors are errors inherent in the measuring device.

The method used to measure the fine-structure constant by Webb's team, as well as by other groups, relies on quasars, powerful beacons whose light passes through and is absorbed by the atoms in gas clouds that lie between the quasars and Earth. If the fine-structure constant changes during the light's journey, atoms in gas clouds at different distances would absorb slightly different wavelengths of light.

By comparing the light absorbed by the atoms in the gas clouds with the light absorbed by the same species of atoms on Earth, researchers can attempt to calculate the value of the fine-structure constant at different distances and times in the universe.
Previous studies by Webb and his collaborators, which used data recorded by just one telescope, at the Keck Observatory atop Hawaii's Mauna Kea, had found that the fine-structure constant remained the same as far back as about 6 billion years ago but then began to slightly weaken at earlier times.

Other teams, including Kim Griest of the University of California, San Diego, and his colleagues, have argued that the Keck spectrometer called HIRES, used by Webb's team, isn't stable enough to measure the fine-structure constant to the precision needed. The level of uncertainty "may make it difficult to use Keck HIRES data to constrain the change in the fine-structure constant," the team noted in the Jan. 1 issue of *Astrophysical Journal* (http://arxiv.org/abs/0904.4725).

The new work by Webb and his colleagues includes more than double their previous amount of data and combines observations from Keck in the north with the Very Large Telescope atop Cerro Paranal in Chile in the south. The locations of the two telescopes allowed the team to compare measurements taken in two different general directions. The observations include gas clouds that date further than 12 billion years back in time. Webb notes that for those six quasars observed with both Keck and the Very Large Telescope, the data are in agreement. In both directions the researchers observed from Earth, the study indicates that the fine-structure constant varied noticeably only very far back, during the first several billion years of cosmic history.

Nonetheless, the study "is as speculative as the previous claims," asserts Patrick Petitjean of the Institute of Astrophysics in Paris, whose team has looked for variations in the fine-structure constant with the Very Large Telescope as far back as about 11.5 billion years ago and found none (*SN: 4/8/04, p. 301*).

But cosmologist Paul Davies of Arizona State University in Tempe says the new evidence for a difference in the strength of the fine-structure constant along different directions "adds a new and potentially more significant twist, enabling us to get to grips with the effect more easily." The newfound spatial variation makes the work more convincing because it's easier to test and is on firmer footing because it's based on data from two telescopes, he adds.

If the fine-structure constant really does vary in both space and time, says Davies, it's an obvious extension that other presumed constants of nature — such as the gravitational constant that determines the strength of the gravitational force — might vary in a similar lopsided manner. "If we can accept a varying fine-structure constant, then all bets are off."