Relative masses of 7-billion-year-old protons and electrons confirmed to match those of today's particles

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The mass of the proton in relation to its much lighter counterpart, the electron, is known to great precision: the proton has 1836.152672 times the mass of the electron. But has it always been so?

Quite possibly, according to new research which taps the cosmos as a vast fundamental-physics laboratory. A study of a distant galaxy strongly suggests that the proton-to-electron mass ratio, denoted by the Greek letter mu (μ), has remained essentially constant for at least half the age of the universe. The findings appeared online December 13 in Science.

Julija Bagdonaite of VU University Amsterdam and her colleagues used the 100-meter Radio Telescope Effelsberg [above right] to measure the absorption of radiation by methanol, a form of alcohol, in the ancient universe. Methanol (CH_3OH) imprints multiple absorption lines on a spectrum of light, owing to the molecule's various rotational states, and the interplay among those states depends on the relative masses of the constituent electrons and protons.

The researchers detected methanol absorption lines in a so-called gravitational lens system called PKS1830-211—a chance alignment of a faraway galaxy backlit by an even more distant source of radiation. The foreground galaxy lies at redshift 0.89, meaning that its light has traversed the cosmos for roughly half of the 13.7 billion years that have elapsed since the big bang. (Redshift is an empirical measure used to gauge vast cosmic distances.) The galaxy's gravity bends radio waves from the background object—a flaring supermassive black hole called a blazar—and imprints its own spectral signature in the process, due to the presence of methanol and other molecules in the galaxy. "The absorptions of the radio waves have occurred seven billion years ago," Bagdonaite said in a prepared statement. "And the radio waves traveling to Earth carry the fingerprint of the methanol molecules in the distant past."

She and her colleagues determined that the methanol in the PKS1830-211 system behaves just as predicted—the electrons and protons in the ancient molecules had relative masses indistinguishable from those measured in laboratories on Earth today. The value of mu seven billion years ago, they concluded, could not have differed from the present-day value by more than 0.00001 percent.

Any divergence from a stable proton–electron relation would invalidate a core assumption of physics—that the laws of nature remain the same wherever (or whenever) you look. So it's reassuring to know that—in one key respect, at least—the more the universe changes, the more it remains the same.

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