Examination of radiation left from birth of universe could alter theories

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Using relic radiation from the birth of the universe, astrophysicists at the University of Illinois have proposed a new way of measuring the fine-structure constant in the past, and comparing it with today.

By focusing on the absorption of the cosmic microwave background by atoms of neutral hydrogen, the researchers say, they could measure the fine-structure constant during the "dark ages," the time after the Big Bang before the first stars formed, when the universe consisted mostly of neutral hydrogen and helium.

The fine-structure constant characterizes the strength of the electromagnetic force, which is one of the four fundamental forces in physics. But, the fine-structure constant may not be constant. Recent observations of quasars – starlike objects billions of light-years away – have found a slightly different value for the fine-structure constant.

"If the fine-structure constant does vary over time and space, we could use it as a probe of new physics beyond the standard model and beyond general relativity," said Benjamin Wandelt, a cosmologist at the Illinois, who developed the proposed measurement technique with graduate student Rishi Khatri.

A varying fine-structure constant also could help explain the mysterious dark energy that pervades the universe, Wandelt said, and help constrain what kind of theory would unite the four fundamental forces into a "theory of everything." Using light from quasars, astronomers can look for variations in the fine-structure constant from the present up to 5 billion years ago. Using the spectra of neutral hydrogen, astronomers can peer much further back in time.

“There is a void from about 300,000 years after the Big Bang, when radiation that formed the cosmic microwave background was emitted, to about 500 million years later, when the first stars formed,” Wandelt said. “Our measurement technique could probe the fine-structure constant during this period, known as the dark ages.”

When a neutral hydrogen atom absorbs a photon of light from the cosmic microwave background, the electron flips its spin, causing a slight difference in its spectrum.

The telltale fingerprint of this atomic transition at a wavelength of 21 centimeters can serve as a sensitive search for past values of the fine-structure constant, said Wandelt and Khatri, who describe their measurement technique in a paper accepted for publication in the journal Physical Review Letters, and posted on its Web site.

While most radio telescopes are too small to look for variations in the fine-structure constant, there are new instruments in the design or construction phase – including the Long Wavelength Array and the Low Frequency Array – that will provide the first limits when brought on line.

“The measurements would be tricky, but not impossible,” Wandelt said.

Source: University of Illinois at Urbana-Champaign