Observations of early universe hint at a giant excess of anti-neutrinos

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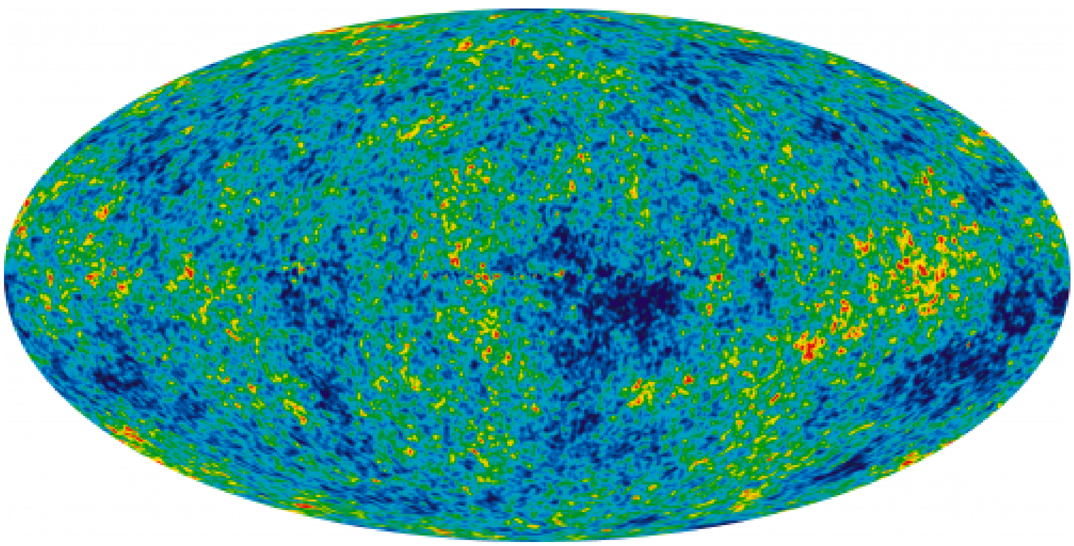

Nine year WMAP image of background cosmic radiation (2012) Credit: NASA

(Phys.org) —Scientists have a great deal of evidence to support the fact that the universe contains much more baryonic matter than baryonic anti-matter, a phenomenon known as baryon asymmetry. Baryons, which are defined as being made of three quarks, include protons and neutrons and make up the bulk of the atomic matter that we're familiar with in everyday life. But much less is known about the possibility of a lepton asymmetry, in which there are unequal amounts of leptons and anti-leptons in the universe. The best known examples of leptons are electrons and neutrinos. Neutrinos in particular are much harder to detect than baryons because they're much lighter, and so much less energetic.

In a new study, physicists Dominik J. Schwarz and Maik Stuke at Bielefeld University in Germany have published a paper in the *New Journal of Physics* in which they show that recent data from cosmic microwave background (CMB) experiments suggests that the universe contains an excess of anti-neutrinos (defined by their opposite chirality rather than opposite charge) compared with normal neutrinos. Further, this lepton asymmetry could potentially exceed the baryon asymmetry, which is 10^{-10}, by several orders of magnitude. The total number of leptons could also exceed the total number of baryons in the universe.

"A 'leptonic universe' is a universe that contains many more leptons than baryons," Schwarz told *Phys.org*. "A universe with a vast amount of anti-neutrinos in it would be something unexpected. I can't say how it would change the overall picture, as we are just at the beginning to explore this idea."

Finding evidence for a lepton asymmetry is not easy. For one thing, leptons have such low energy that large numbers of them can easily hide in the neutrino background and escape scientists' attempts to detect them. But, as Schwarz and Stuke explain, leptons could be observable in the early universe because they would have affected nucleosynthesis (the production of nuclei that occurred just a few moments after the Big Bang) and the CMB (the radiation left over from the photon decoupling that occurred when the universe was about 400,000 years old).

In particular, leptons would have affected the production of helium in the early universe. In this study, the physicists measured the abundance of primordial helium in the universe using new CMB data from three sources: the Atacama Cosmology Telescope, the Southpole Telescope, and the WMAP Team. By comparing the results of this global analysis with previous results of helium abundance from local observations of extragalactic regions, the scientists could put some constraints on lepton asymmetry.

The data indicated that we may live in a universe ruled by anti-neutrinos instead of normal ones, which could have implications for how we currently understand what happened in the early universe. In addition, the anti-neutrino surplus would theoretically lead to an increase in the expansion rate of the universe. However, the data so far does not rule out the standard scenario of Big Bang nucleosynthesis.

"With regard to Big Bang Nucleosynthesis, [confirmed lepton asymmetry] would certainly falsify the standard scenario, which assumes that there is no lepton asymmetry," Schwarz said. "However, the new model for nucleosynthesis would not be radically different; it would just incorporate this new ingredient."

In the future, the physicists hope that upcoming CMB data releases and improved measurements of primordial abundances will allow for further testing of lepton asymmetry.

"I think it would be surprising if the asymmetry in leptons turns out to be much larger than the asymmetry in baryons," Schwarz said. "Although in some sense, we should honestly admit that we don't know how the matter anti-matter asymmetry comes along. Thus we should not be surprised but rather open-minded."

More information: Dominik J. Schwarz and Maik Stuke. "Does the CMB prefer a leptonic Universe?" *New Journal of Physics*. 15 (2013) 033021. DOI: 10.1088/1367-2630/15/3/033021