Mapping the (Infant) Universe

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Abstract

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On March 21st 2013, the European Space Agency (ESA) revealed the much anticipated results from the Planck satellite, the most detailed picture of the faint microwave radiation known as the Cosmic Microwave Background (CMB), the remnant heat from the Big Bang. Launched in May 2009, Planck is designed to observe the entire sky in radio waves using nine frequency channels, each frequency being sensitive to different phenomena and different physics.

Planck's temperature map of the entire sky offers us the best glimpse into the early Universe, and shows us what the Universe looked like when it was just 380,000 years old. This remnant radiation, present everywhere in space, is the furthest we can see with light, effectively providing us with a baby picture of the universe. Back then the Universe was a very dense and hot soup of particles such as electrons, protons and particles of light called photons. Nothing could travel very far in space, until the Universe had expanded and cooled enough such that Hydrogen atoms could form, allowing light to escape into space, and form the cosmic microwave background.

As the Universe expanded and cooled so did the radiation, and today that remnant heat can be detected in the microwave region of the electromagnetic spectrum. Its measurement is a great confirmation of the Big Bang theory for the origin of the Universe. Although the CMB is remarkably uniform in temperature at about 2.725 Kelvin, nonetheless there are tiny deviations or fluctuations in its temperature, and that is what the Planck map shows us. These tiny fluctuations represent the early distribution of matter, where colder (blue) spots represent areas with density slightly above the average density of the Universe, whereas the hotter spots (orange) show areas with density a bit below the average. These differences in density of matter early on are amplified by gravity as the Universe expands, forming seeds that eventually lead to formation of stars and galaxies. They offer a unique window into how structure forms in the Universe.

Planck's sensitive instruments have provided new measurements of the contents of the Universe, its age and its geometry (whether space is flat or curved) with unprecedented accuracy. Planck's new data suggest a Universe slightly older than previously thought, with an age of 13.8 billion years. The new measurements suggest our Universe is made up of just 4.9% atoms, while the remaining 95.1% percent are made up of the so called "dark components", which we do not fully understand. Of the 95.1%, 26.8% is made of dark matter, which is matter that we cannot see with our telescopes as it does not interact with light, but we can indirectly infer its presence through the gravity it exerts on its surroundings. The rest of the Universe, about 68.3% is made of dark energy, a mysterious component of the Universe that describes the accelerated rate of expansion of the Universe. Such accurate measurements are important to cosmologists as they have the ability to test our current theories and models of how the Universe came into being and how it has since evolved. The Planck results have elevated cosmology, the study of the large-scale structure and evolution of the Universe, to a precision science, pushing further our understanding of the Universe, and forcing us to rethink our theories. You can view the interactive Planck map at: http://astrog80.astro.cf.ac.uk/Planck/Chromoscope/