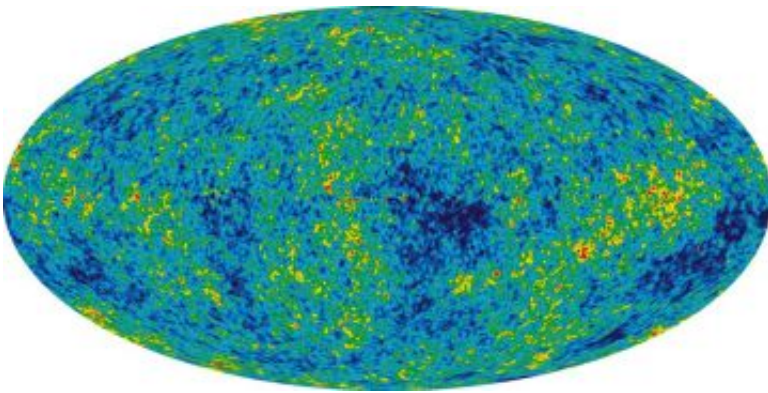


WMAP reveals neutrinos, end of dark ages, first second of universe

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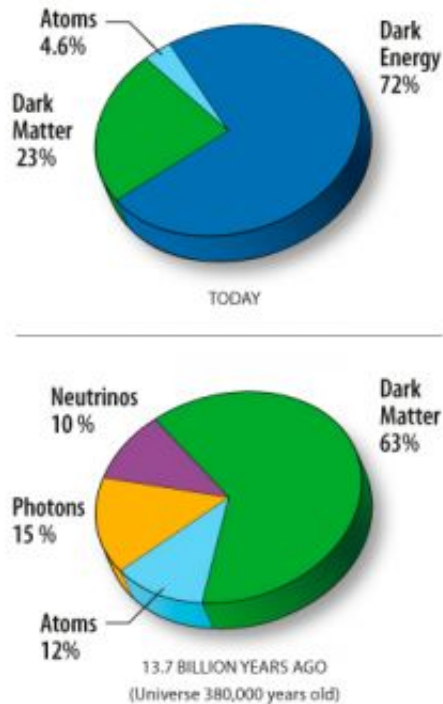
WMAP cosmic microwave fluctuations over the full sky with 5-years of data. Colors represent the tiny temperature fluctuations of the remnant glow from the infant universe: red regions are warmer and blue are cooler. Credit: WMAP Science Team

NASA released this week five years of data collected by the Wilkinson Microwave Anisotropy Probe (WMAP) that refines our understanding of the universe and its development.

It is a treasure trove of information, including at least three major findings:

- New evidence that a sea of cosmic neutrinos permeates the universe
- Clear evidence the first stars took more than a half-billion years to create a cosmic fog

-- Tight new constraints on the burst of expansion in the universe's first trillionth of a second



WMAP measures the composition of the universe. The top chart shows a pie chart of the relative constituents today. A similar chart (bottom) shows the composition at 380,000 years old (13.7 billion years ago) when the light WMAP observes emanated. The composition varies as the universe expands: the dark matter and atoms become less dense as the universe expands, like an ordinary gas, but the photon and neutrino particles also lose energy as the universe expands, so their energy density decreases faster than the matter. They formed a larger fraction of the universe 13.7 billion years ago. It appears that the dark energy density does not decrease at all, so it now dominates the universe even though it was a tiny contributor 13.7 billion years ago. Credit: NASA/WMAP Science Team

"We are living in an extraordinary time," said Gary Hinshaw of NASA's

Goddard Space Flight Center in Greenbelt, Md. "Ours is the first generation in human history to make such detailed and far-reaching measurements of our universe."

WMAP measures a remnant of the early universe - its oldest light. The conditions of the early times are imprinted on this light. It is the result of what happened earlier, and a backlight for the later development of the universe. This light lost energy as the universe expanded over 13.7 billion years, so WMAP now sees the light as microwaves. By making accurate measurements of microwave patterns, WMAP has answered many longstanding questions about the universe's age, composition and development.

The universe is awash in a sea of cosmic neutrinos. These almost weightless sub-atomic particles zip around at nearly the speed of light. Millions of cosmic neutrinos pass through you every second.

"A block of lead the size of our entire solar system wouldn't even come close to stopping a cosmic neutrino," said science team member Eiichiro Komatsu of the University of Texas at Austin.

WMAP has found evidence for this so-called "cosmic neutrino background" from the early universe. Neutrinos made up a much larger part of the early universe than they do today.

Microwave light seen by WMAP from when the universe was only 380,000 years old, shows that, at the time, neutrinos made up 10% of the universe, atoms 12%, dark matter 63%, photons 15%, and dark energy was negligible. In contrast, estimates from WMAP data show the current universe consists of 4.6% percent atoms, 23% dark matter, 72% dark energy and less than 1 percent neutrinos.

Cosmic neutrinos existed in such huge numbers they affected the

universe's early development. That, in turn, influenced the microwaves that WMAP observes. WMAP data suggest, with greater than 99.5% confidence, the existence of the cosmic neutrino background - the first time this evidence has been gleaned from the cosmic microwaves.

Much of what WMAP reveals about the universe is because of the patterns in its sky maps. The patterns arise from sound waves in the early universe. As with the sound from a plucked guitar string, there is a primary note and a series of harmonics, or overtones. The third overtone, now clearly captured by WMAP, helps to provide the evidence for the neutrinos.

The hot and dense young universe was a nuclear reactor that produced helium. Theories based on the amount of helium seen today predict a sea of neutrinos should have been present when helium was made. The new WMAP data agree with that prediction, along with precise measurements of neutrino properties made by Earth-bound particle colliders.

Another breakthrough derived from WMAP data is clear evidence the first stars took more than a half-billion years to create a cosmic fog. The data provide crucial new insights into the end of the "dark ages," when the first generation of stars began to shine. The glow from these stars created a thin fog of electrons in the surrounding gas that scatters microwaves, in much the same way fog scatters the beams from a car's headlights.

"We now have evidence that the creation of this fog was a drawn-out process, starting when the universe was about 400 million years old and lasting for half a billion years," said WMAP team member Joanna Dunkley of the University of Oxford in the U.K. and Princeton University in Princeton, N.J. "These measurements are currently possible only with WMAP."

A third major finding arising from the new WMAP data places tight constraints on the astonishing burst of growth in the first trillionth of a second of the universe, called “inflation”, when ripples in the very fabric of space may have been created. Some versions of the inflation theory now are eliminated. Others have picked up new support.

"The new WMAP data rule out many mainstream ideas that seek to describe the growth burst in the early universe," said WMAP principal investigator, Charles Bennett, of The Johns Hopkins University in Baltimore, Md. "It is astonishing that bold predictions of events in the first moments of the universe now can be confronted with solid measurements."

The five-year WMAP data were released this week, and results were issued in a set of seven scientific papers submitted to the *Astrophysical Journal*. For further information, see wmap.gsfc.nasa.gov .

Source: NASA/Goddard Space Flight Center

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