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## The Universe: The new Axis of Evil

**We thought we knew all about the Big Bang - but a blip in the cosmic afterglow is threatening our ideas. Marcus Chown reports**

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Ever since 1965, when two researchers at Bell Telephone Labs in New Jersey stumbled on it by accident, astronomers have known that the Universe is alive with the dim "afterglow" of the big bang fireball.

Now, something unexpected has cropped up in that afterglow - a feature dubbed "the axis of evil". Some think it is being caused by the gravity of a tremendous concentration of 100,000 galaxies in our cosmic backyard. Others say it is telling us there is something wrong with our big bang picture of the Universe.

The axis of evil is the biggest surprise thrown up by Nasa's Wilkinson Microwave Anisotropy Probe (WMAP). Launched on 30 June 2001, it has, from its vantage point 150 million kilometres beyond the Earth on the extension of the line joining our planet to the Sun, been taking the temperature of big bang afterglow, known as the "cosmic background radiation". Understanding exactly what WMAP has found requires a little diversion into the technicalities of the background radiation.

It is coming from every direction in the sky and its average temperature is minus 270C. Of key importance are subtle variations in temperature from place to place - "hot spots" that are ever-so-slightly warmer than average, and "cold spots" that are ever-so-slightly cooler.

These arise because the matter in the fireball of the big bang was slightly lumpy. (One lump became your home - the Milky Way.)

The hot spots and cold spots in the big bang afterglow come in all sizes. For instance, there are big blotches that stretch across much of the sky and, superimposed on these, smaller goosepimples.

To make sense of it all, astronomers like to break up their "temperature map" of the sky into manageable chunks they call "multipoles". The simplest is the "dipole" - merely one huge hot spot and one huge cold spot. It has nothing to do with the big bang. Rather, it is caused by the motion of the Milky Way, which is flying through space at about a million kilometres per hour. This makes the afterglow of the big bang appear hotter in the direction the Milky Way is flying and colder in the opposite direction.

The second simplest chunk of the cosmic background radiation is the "quadrupole". This is like the dipole, but is made up of two hot regions and two cold regions. Next comes the "octupole", which is comprised of three hot regions and three cold regions.

The simplest multipole chunks of the big bang radiation correspond to the biggest blotches, the more complex to the smallest freckles.

If the standard big bang picture of the Universe is correct, the blotches and freckles should be scattered randomly about the sky. "The big surprise is they are not," says Chris Vale of the University of California at Berkeley. "The quadrupole and octupole blotches are aligned with each other - along the axis of evil."

Nobody knows why. Could it be that all our preconceived notions about the big bang are wrong, or is it something less

challenging? Vale leans towards the latter. He notes that the dipole direction is at right angles to the direction of the axis of evil. Recall that the dipole direction has nothing to do with the big bang, whereas the axis direction does, so their positions should not be related. "The fact that they are hints at an unexpected connection," says Vale.

According to Vale, if there is a giant concentration of mass in the local universe, its tremendous gravity could be distorting the cosmic background. The phenomenon is known as "gravitational lensing". It could cause the big hot spot of the dipole to "spill over" into the smaller hot spots. "The dipole hot spot is several hundred times hotter than the quadrupole," says Vale. "So it is not necessary for much to spill over to explain the axis of evil." Vale claims the best candidate for the local mass concentration is the "Shapley Supercluster" in our cosmic backyard, which contains 100,000 galaxies. It is not visible to the naked eye, despite covering at least 1,000 times the apparent size of the full Moon.

Other astronomers think Vale could be on to something. "Vale's model generates a good match of what we see," says WMAP scientist Gary Hinshaw of the Goddard Space Flight Center in Greenbelt, Maryland. "It's remarkable."

However, some physicists wonder whether the axis of evil requires a rethink of our ideas about the Universe. They include Joao Magueijo at Imperial College in London, who coined the term "the axis of evil". According to Magueijo, there may be something seriously wrong with our big bang models.

Big bang models come out of Einstein's theory of gravity. The only way theorists can apply the hideously complicated theory to the Universe is to make two simplifying assumptions. One is that the Universe is roughly the same in all places, and the other is that it is roughly the same in all directions.

But if the Universe is the same in all directions, as the big bang models require, that means that the hot spots and cold spots in the afterglow of the big bang should be randomly splattered about the sky - the big temperature splotches and the small temperature goose pimples should have no preferred direction. The fact that they are aligned along the axis of evil leads Magueijo to suggest that maybe the assumptions behind the big bang models are wrong. In other words, the Universe is not the same in all places or directions, but has a special direction.

According to Magueijo, there are a number of ways the Universe could have a special direction. One is if we live in a "slab universe". This is a Universe in which space is infinite in two directions but in the other is only about 20 billion light years across - the diameter of the observable universe.

Another possibility is that we live in torus-shaped universe, like a giant ring doughnut. Yet another is that Universe is spinning. But how could such a weird state of affairs have arisen? "That's the big question," Magueijo says.

So perplexing is the axis of evil that Hinshaw and WMAP's principal investigator, Chuck Bennett, have obtained a grant for a five-year examination of the WMAP data. They hope to explore the possibilities that the WMAP instrument was in error, or that something else went wrong. "There's no question there's stuff that looks unusual," says Bennett.

We will have to wait and see whether the study reveals the axis of evil to be a cosmic mirage, or shows the big bang model to be in serious trouble.

Marcus Chown is author of *The Universe Next Door* (Headline)

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