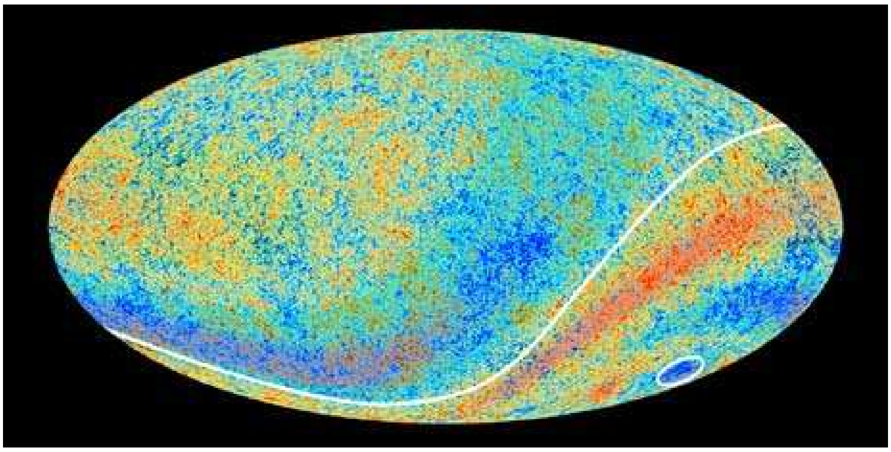
The nature of cosmic expansion

Most of us have had a lifetime to accept that the Universe originated with the Big Bang, but it was only in March that the world was presented with direct evidence for a period of exponentially rapid "inflationary" expansion in the first squillionths of a second of the Universe's existence. Cosmic expansion subsequently decelerated over most of the life of the Universe due to the attractive force of gravity. But expansion appears to have started accelerating again – by modest amounts – late in cosmic history, a discovery which earned the 2011 Nobel Prize in Physics.

The standard model of cosmology explains this late acceleration of expansion in terms of a "dark energy", but the mysterious nature of this dark energy is the biggest problem in cosmology today.

Professor David Wiltshire from the University of Canterbury has proposed an alternative to the standard model in which dark energy is a misidentification of the gravitational energy gradients that grow large as matter condenses into galaxies, stars and planets while empty voids grow large in low density regions. With Marsden funding, he has devised ways of testing his "timescape cosmology".

One such test is the way it accounts for cosmic expansion. The standard model assumes that the universe expands uniformly. Any deviations from a smooth expansion, caused by the growth of cosmic structures, are treated as "peculiar velocities" and are added to the background expansion.



In 2013 the Planck satellite found increased significance for anomalies in the primordial ripples of the Cosmic Microwave Background radiation. One anomaly is an asymmetry in the average temperatures on opposite hemispheres of the sky (indicated by the curved line), with slightly higher average temperatures in the southern hemisphere. This runs counter to the prediction made by the standard model that the Universe should be broadly similar in any direction we look. There is also a cold spot that extends over a patch of sky that is much larger than expected (circled). Explaining inhomogeneity by differential expansion of space, rather than peculiar motions of objects, may completely change our understanding of these puzzles. Graphic: European Space Agency and the Planck Collaboration.

Professor David Wiltshire.

The thermal radiation left over from the Big Bang, the Cosmic Microwave Background, is remarkably uniform over the sky with differences of only parts in a thousand. The largest difference points in a particular direction in the sky. If it is purely due to our own peculiar velocity, then the whole Local Group of galaxies (to which we are gravitationally bound) must be moving at 635 km/sec towards the constellation Hydra. If we could somehow propel ourselves to undo both this motion and that of the Sun within the Local Group, we would be in the standard "cosmic rest frame" in which both the Cosmic Microwave Background and the expansion of the universe should appear the most uniform.

Professor Wiltshire and his team have analysed the expansion of the Universe in a model independent way, and found that – contrary to standard expectation – it is considerably more uniform in the rest frame of the Local Group of galaxies than it is in the standard cosmic rest frame. The analysis suggests that the Local Group is not moving with a velocity of 635 km/s; rather, a significant fraction of the variation of the Cosmic Microwave Background may arise from a 0.5% differential expansion of space on "nearby" scales of 300 million light years.

This observation is consistent both with Einstein's theory of general relativity in which differential expansion of space is a typical feature, and with the timescape cosmology. On the other hand, it is very difficult to reconcile with the standard cosmology and will not be rapidly accepted by the scientific community. However, it may shed immediate light on distinct anomalies that have been seen in the Cosmic Microwave Background data for a decade.

The research has been published in Physical Review D 88, 083529 (2013).

FOR MORE INFORMATION
Professor David Wiltshire
Department of Physics and Astronomy
University of Canterbury
Private Bag 4800, Christchurch 8140
Tel: (03) 364 2473
Email: david.wiltshire@canterbury.ac.nz