New equation set for the big bang

Dr Prince: developing a new mathematical tool.
Background image courtesy of NASA & STScI.

Researchers at La Trobe University are set to make a 'big bang' in the world of mathematics with the development of a new equation in the field of differential geometry.

Co-developer, Geoff Prince, an Associate Professor in La Trobe's Department of Mathematics, said the new equation makes it possible to analyse the focusing effects produced by electromagnetic and other forces as well as the gravitational one in Einstein's General Theory of Relativity.

Knowledge of the effects of some of these forces is fundamental to the understanding of the 'big bang' theory on the origins of our universe.

Working with PhD student Michael Jerie, Dr Prince said the discovery extends the utility of Raychaudhuri's equation of cosmology. This is the classic equation that predicts the convergence and divergence of geodesics – the curves that light and non-electrically charged matter follow in space and time.

He said that working in the 1970's, British relativists Roger Penrose and Stephen Hawking used Raychauduri's equation to show for the first time that, under reasonable physical assumptions, the big bang was the inevitable beginning of the Universe.

Dr Prince explained that geodesics were curves of the shortest length in ordinary geometry. In the theory of relativity, they are the curves in space and time followed by light and electrically neutral matter. The earth and sun move on geodesics in space-time. Until now, Raychauduri's equation could only be applied to describe the divergence and convergence of the orbits of particles that are not electrically charged.

Dr Prince said the new development extends significantly the application of Raychaudhuri's equation. 'It is a new tool which, among other things, allows the analysis of focusing of beams of electrically-charged particles in the presence of electromagnetic fields within the framework of relativity theory.

'As an analogy, if people on different parts of the Equator all simultaneously travelled north at the same rate along lines of longitude (geodesics on the Earth's surface), they would converge on the same place – the North Pole.

> 'We can now discover how electrons in a given electromagnetic field will focus'

The classical Raychaudhuri's equation predicts this. On the other hand, if the individuals were electrically charged, the Earth's magnetic field would change this convergent behaviour and the new equation is the tool to use.'

'For the first time we can now discover how electrons in a given electromagnetic field will focus. On the other hand we might want to design an electromagnetic field that can focus a beam of electrons anywhere we want.

'Michael and I developed this new generalisation of Raychauduri's equation to describe the convergence or divergence of arbitrary families of curves. The important point is that the work was done in a completely abstract setting. The applications come in a wide variety of areas because of this. Mathematics maintains its central role exactly because of this power to deliver abstract results with wide applicability.'

The new equation – which its creators call the generalised Raychauduri's equation – came under renewed discussion at conferences in Poland and the Czech Republic in August.

Dr Prince has worked in this field for more than two decades in collaboration with colleagues in universities in Belgium, Britain Spain, USA and Italy.

'When I was doing my PhD studies there were only about 10 of us in the area. Our numbers have grown and there were around 50 at the conference in Poland,' he said.

Dr Prince is a Fellow of the Australian Mathematical Society and a member of the American Mathematical Society and the Nonlinear Mathematics Network. ■