It all began with an end - New theory on origin and future of the universe

The universe's clock has neither a start nor finish, yet time is finite according to a New Zealand theorist. The theory, which tackles the age-old mystery of the origin of the universe, along with several other problems and paradoxes in cosmology, calls for a new take on our concept of time – one that has more in common with the "cyclic" views of time held by ancient thinkers such as Plato, Aristotle and Leonardo da Vinci, than the Christian Calender and Bible-influenced belief in "linear" time now so deeply imbedded in modern western thinking.

Following its initial publication on the arXiv physics archive at Cornell University earlier this year [url: http://arxiv.org/pdf/physics/0612053], the author of the theory, Peter Lynds, presented a second paper about it at the International Conference on Complex Systems in Boston on November 1 [url: http://necsi.org/events/iccs7/viewpaper.php?id=225]. Another group also presented a conference paper about the theory.

Lynds' theory involves the second law of thermodynamics, a bedrock of physics and the explanation behind why we only ever experience events evolving in one time direction in nature. This law is related to the fact that heat can never pass spontaneously from a colder to a hotter body. As a function of heat's ability to disperse, hot flows to cold. Because of this, natural processes that involve energy transfer tend to have one direction and to be irreversible. However, what would happen if, due to certain extreme physical conditions, heat was unable to flow to cold and was forced to flow to hotter?

In his theory, Lynds posits that rather than this inevitably happen and the second law of the thermodynamics be breached just before the universe gravitationally collapses to a big crunch or matter reaches the centre of a black hole, the order of events should reverse direction. As all of the laws of physics – with the exception of the second law of thermodynamics – are time reversible and work equally well in opposing directions, Lynds asserts that no laws of physics would be contravened by such a reversal, while it would also allow the second law of thermodynamics to continue to hold. This is contrast to previous theories involving thermodynamic time reversal, including those by Thomas Gold in the 1960s and Stephen Hawking in the 1980s, which all involve the second law of thermodynamics being breached. Such theories have generally been dismissed by physicists because of contradictions directly resulting from such a second law violation – contradictions that Lynds says his theory avoids.

Lynds asserts that if many billions of years from now the universe stops expanding and contracts to a big crunch, such a revised conception of thermodynamic time reversal leads to a coherent picture of the cosmos in which there is no differentiation between past and future, and the so-called beginning of the universe, the big bang, can equally be said to be in the past or future of the big crunch. This means that the big bang and the big crunch can also equally be said to *cause* one another, therefore providing an answer to that most intractable of questions: what caused the big bang?

Furthermore, because events are always evolving away, rather than ever towards one, there are no gravitational "singularities" – hypothesized points where gravity and heat become infinite and the laws of physics break down. Aside from proposed avoidance mechanisms in theories such as String theory and Loop quantum gravity, singularities have been a troublesome but inescapable feature of mathematical physics ever since the 1960s when work by Sir Roger Penrose and Stephen Hawking showed that they must result at the big bang, the big crunch, and inside black holes – provided Albert Einstein's general theory of relativity is correct and some basic assumptions are met. One of the assumptions underlying the Penrose and Hawking singularity theorems is that events and times *converge* towards a singularity. In

Lynds' theory, events and times are always *diverging* or evolving away from a potential singularity, so none are encountered. "The reversal of the order of events so that the second law of thermodynamics can continue to hold, would appear to be a very good way on Nature's part of avoiding singularities, while also guaranteeing that the universe can remain continuous and without causal contradiction," says Lynds.

Significantly, the theory also addresses a famous paradox posed by the 18th-century German philosopher Immanuel Kant, which concludes that the idea of the universe extending back infinitely in time is contradictory, while its antithesis – the idea that the universe began at some finite time in the past – also results in contradiction. Kant asked that if the universe did have a beginning, what happened beforehand to *cause* it? And what before that? Kant noted that there would always be an infinite number of "what before that's." On the other hand, if time extended back forever, there would be an infinite period of time before any event – something that Kant also considered absurd. "With a universe that stretches back infinitely in time and has no starting point, it would also be impossible for the universe to evolve forward, not only to where it is today, but at all," says Lynds. Because his theory asserts that the universe is finite, but yet also has no beginning or *first cause* (because the big bang is caused by the big crunch, which would normally be thought of as being in the future of the big bang), Kant's paradox disappears. "A universe in which time is cyclic is really the only possible answer to a paradox such as Kant's," says Lynds. "In relation to how telling it is, I do not think that people have generally realised just what a perfect paradox Kant put forward. It shows that there is something very much going wrong with our regular assumptions regarding time, cause and cosmology."

Lynds says that in this theory, "it is simply the order of events that reverse – something that would be immediate – and not a case of time 'flowing backwards.' A good way to think about it is to picture a clock, with the big bang being at time = 0, the universe beginning to contract at 6 o'clock, and the big crunch being at 12 o'clock. Just before 12, the clock resets and immediately resumes at 0. Although the hands of the clock will continue to rotate indefinitely, it is the very same 12 hour interval that plays over, not a later one; there are no past or future cycles of the universe. It is one and the same." Unlike models of the universe where the universe is said to "bounce" and expand again after a big crunch, Lynds says that his model also does not breach any conservation of energy laws, while it rules out the possibility of time travel. "In a little way, it does have some connection to the words 'back to the future' though," says Lynds. "Just without flux capacitors, DeLorians and time travel."

A further implication of Lynds' theory involves another notoriously stubborn problem in cosmology. If the initial conditions of the universe at the big bang approximately 13.7 billion years ago had been even slightly different – say, if the ratio of electrons to protons had been different by one part in 10^{37} – the evolution of the universe from the big bang through to today would have been impossible. A similar point can be made about numerous physical constants and values, including the weak and strong nuclear force constants, the gravitational constant, and the level of entropy – the measure of the disorder or randomness of energy and matter within a system. Surely such apparent cosmological "fine-tuning" needs explanation; why were conditions at the big bang seemingly so "special"?

"Such a question comes down to a question of initial conditions determining later or final ones—in this case, the big bang and the universe as we know it today," says Lynds. "But if initial and final, past and future, are equally exchangeable, such a question becomes meaningless. That is, in light of the model, if the big crunch or the universe today could equally be said to determine conditions at the big bang (as the former could just as much be said to be in the past of the big bang as the future of it), one could equally ask why conditions at the big crunch or today are so special. As such, other than perhaps positing that if it were different, the universe would not exist (and neither would we to ask questions about it), because no objective causal order to events or conditions in the universe exists, conditions at

the big bang (and today and at the big crunch) *just are,* and can have no causal explanation." Lynds continues, "This does not explain why the universe exists at all (rather than not), nor do I think that it takes away at all from its mystery and the impression of it being extraordinarily well-designed. Indeed, that the universe can be the way it is, and yet not have any causal explanation, would suggest that Nature is even more deserving of our incredulity."

Lynds says that the most profound implication of his theory is a purely philosophical one. "Although if properly taking into account what is happening in respect to time in the model, there are no past or future cycles of the universe, if the past and future are thought of in the regular way, with a meaningful differentiation being made between them, then the universe can be interpreted as repeating over, exactly, an infinite number of times. As well as meaning that everything is determined and that our sense of having free will is an illusion, it also means that, when someone dies, many billions of years later, they will live their lives again. As a person would be dead and non-conscious during this period, however, for them anyway, such life after death might as well be immediate. Furthermore, because the model means that all different times (those represented by a clock) share equal reality, as does the "block" view of time provided by general relativity, there is an equal sense in which a person is 1, 20, 60 or any other age they might reach. Lynds continues, "The prospect of having to repeat one's life over may seem a disturbing prospect for some, but I do not think it should, as with no possible memory of any previous cycle, it might as well just be the once. Once, but with the additional consideration that, when one dies, it will not be final. I personally find genuine comfort in this idea."

However, Lynds has some caveats for his theory. "It is reliant on the universe being closed and eventually collapsing," says Lynds. "At the moment, it is very uncertain whether there is enough mass in the universe to cause it to eventually collapse, or if it will continue expanding forever. If the universe isn't closed, my theory is wrong. The detail behind what causes the reversal is also non-quantitative and speculative, while the paper in general is a bit awkward, it sitting somewhere between physics and philosophy, and moving over some different areas. It is a bit of an ugly duckling, in that it doesn't neatly fit anywhere."

From a historical perspective, Lynds notes the idea that time might be cyclic is an old one and was very popular in ancient times. "In relation to it being an old idea, the saying "there is nothing new under the sun" is itself actually from a passage about cyclicity in the book of Ecclesiastes circa 250BC," says Lynds. "It wasn't until the Middle Ages when Christianity really took hold in Europe and the Christian Calendar became firmly established, that the view of time being linear and going in a straight line, the one we are all now so familiar with in modern western society, actually became prominent. Indeed, around this period, a belief in time being cyclic was actually outlawed by the Catholic Church and chargeable as blasphemy, as it was opposed to the unique chronology of events described in the Bible; a drama that, according to scripture, takes place only once."

Lynds says he is expecting his theory to be controversial – a theory that he has only now begun to pursue after it came to him one night in 1998 while laying in bed. Lynds, a 31-year-old who is without university qualification, is familiar with controversy, with another theory causing waves in 2003. That theory also involved questioning long-held assumptions about time and physics – the existence of instants in time and of time in general – and another famous problem, Zeno's paradox. "I doubt that people who believe the universe was created will like it as it leaves no place for a Creator, while due to its nature and some of the questions involved, I feel it will probably invite cynicism from some as well. It is also very counterintuitive, requiring one to see beyond a number of deeply imbedded intuitions and assumptions regarding time. For the moment, I'm more just happy to get it out there."

About Lynds' theory, Dr. Paul Frampton, Louis D. Rubin Jr. Distinguished Professor of Physics at the University of North Carolina at Chapel Hill, says, "I enjoyed reading Lynds'

article about an endless and beginningless universe, especially as I have myself worked on such a model recently (Phys. Rev. Lett. 98, 071301, 2007). Lynds addresses the key issue of the second law of thermodynamics in a novel way and I'll be curious to see how far he can take it."

Dr. Jonathan Vos Post, a former Professor of Astronomy at Cyprus, College. California, and Professor of Mathematics at Woodbury University, California, says, "I consider Peter Lynds's arXiv paper to be a bold and magnificent speculation. Those who attack him are misguided, in that Peter Lynds' arguments need to be put in proper historical context, which is apparently outside the educational background of those who prematurely dismiss the subtleties of Peter Lynds insights. Let me refer back to an 1895 paper by the immortal [Ludwig] Boltzmann, which has recently attracted attention in the controversy over so-called "Boltzmann Brains." The reference is *Nature* 51, 413 (1895). [Long quote by Ludwig Boltzmann concerning the second law of thermodynamics and the possibility of universe later returning to its present state]. Peter is cursed with having brilliant theories that his detractors falsely assume are based on ignorance. His startling re-analyses of (1) Zeno's paradox, (2) the nature of Time, and (3) the nature of consciousness, have been spuriously opposed by naive critics who claim that Peter does not know (1) Calculus, (2) Relativity, (3) Psychology. To the contrary, I hold that his ability to ask "simple" questions, and give extraordinary answers, is close in many ways to the genius of Einstein, Feynman, Hawking, Paul Erdos, John Wheeler, Stephen Wolfram, and Frank Zappa."

Dr. Werner Israel, a Professor of Physics and Astronomy at the University of Alberta, Canada, and a Fellow at Canada's Institute for Advanced Study Cosmology and Gravity Programme, says, "I found Peter Lynds' ideas on possible reversals of time's arrow interesting, in part because I have entertained less bold but not dissimilar ideas myself. In 1991 I co-authored a note in *Nature* which speculated on the possibility that the growth of entropy near a big crunch might be, not reversed exactly, but enormously diluted by a process called mass inflation at the inner horizons of coalescing black holes. This would make a transition to an expanding phase very nearly reversible thermodynamically."

Sir. Roger Penrose, Emeritus Rouse Ball Professor of Mathematics at the University of Oxford, says, "Whereas he seems to be quite knowledgeable on many of the relevant issues, his own proposal is actually very difficult to make sense of. He seems to be arguing for a picture in which one's time-sense somehow reverses in the circumstance of approaching a future singularity, such as that inside a black hole. I am not enthusiastic about his scheme, in so far as I can actually understand it---and that's because I consider that his scheme really does not make sense, not because I am too wedded to conventional ideas to be able to accept revolutionary new ideas! Of course he might well take the opposite view!"

Dr. Gabriel Chardin, a Professor at the Department of Astrophysics, Particle Physics, Nuclear Physics and Associated Instrumentation (DAPNIA) at the Saclay Laboratory of the French Atomic Energy Commission (CEA) in France, says, "I am sympathetic with the general idea Lynds develops. On the other hand, his paper, dealing with important and real questions in cosmology, is using only partially the tools that I would expect to find in such a study. In particular, entropy in a cosmological context should be given in my opinion a large importance to define the arrow of time, using for example the holographic principle."

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The second law of thermodynamics, developed by Austrian Ludwig Boltzmann in the late 19th century, is related to the fact that heat can never pass spontaneously from a colder to a hotter body. Hot flows to cold. As a result of this, natural processes that involve energy transfer tend to have one

direction and to be irreversible. This law also predicts that the entropy of an isolated system increases with time, with entropy being the measure of the disorder or randomness of energy and matter within a system. Because of the second law of thermodynamics, both energy and matter in the universe are becoming less useful, or more disordered, as time goes on. As the second law of thermodynamics is thought to give a one-way direction in time to events, it is also sometimes refereed to as “The arrow of time.”