Multiverse of Stone

A trip around the many universes

Philip Ball, July 2015

With the Crawick Multiverse, landscape architect and designer Charles Jencks has set the archaeologists of the future a delightful puzzle. They will spin theories of various degrees of fancifulness to explain why this earthwork was built in the rather beautiful but undeniably stark wilds of Dumfries and Galloway. Is there a cosmic significance in the alignment of the stone-flanked avenue? What do these twinned spiralling tumuli denote, these little crescent lagoons, these radial splashes of stone paving? Whence these cryptic inscriptions "Balanced Universe" and "PIC" on slabs and monoliths?

The Crawick Multiverse

If any futurist historian is on hand to explain, there are two ways in which her story might go. Either she will say that the monument marks the moment when ancient science awoke to the realization that, as every child now knows, ours is not the only universe but is merely one among the multiverse of worlds, all springing perpetually into existence in an expanding matrix of "false vacuum", each with its unique laws of physics. Or she will explain (with a warning that we should not Whiggishly mock the seemingly odd and absurd ideas of the past) that the Crawick site was built at a time when scientists seriously entertained so peculiar and now obviously misguided a notion.

If only we could tell which way it will go! But right now, that's anyone's guess. Whatever the outcome, Jencks, the former theorist of postmodernism who today takes risks simultaneously intellectual, aesthetic, critical and financial in his efforts to represent scientific ideas about the cosmos at a herculean scale, has

created an extraordinarily ambitious landscape that manages to blend Goldsworthy-style nature art with cutting-edge cosmology and more than a touch of what might be interpreted as New Age paganism. At the grand opening of the Crawick (pronounced "Croyck") Multiverse in late June, no one seemed too worried if the science will stand up to scrutiny. Instead there were pipe bands, singing schoolchildren, performance art and generous blasts of Hibernian weather.

Jencks is no stranger to this kind of grand statement. His house at Portrack, near Dumfries and a 30-minute drive from Crawick, sits amidst the Garden of Cosmic Speculation, a landscape of undulating turf terraces, stones, water pools and ornate metal sculptures that represents all manner of scientific ideas, from the spacetime-bending antics of black holes and the helical forms of DNA to mathematical fractals and the "symmetry-breaking" shifts that produced structure and order in the early universe. Jencks opens the garden to the public for one day each year to raise funds for Maggie's Centres, the drop-in centres for cancer patients that Jencks established after the death of his wife Maggie Keswick Jencks from cancer in 1995.

A panorama of Charles Jencks' Garden of Cosmic Speculation at Portrack House, Dumfries. (Photo: Michael Benson.)

Jencks also designed the lawn that fronts the Scottish National Gallery of Modern Art in Edinburgh, a series of crescent-shaped stepped mounds and pools inspired by chaos theory and "the way nature organizes itself", in Jencks' words. By drawing on cutting-edge scientific ideas, Jencks has cultivated strong ties with scientists themselves, and a plan for a landscape at the European particle-physics centre of CERN, near Geneva, sits on the shelf, awaiting funding.

Charles Jencks' science-inspired land art in the Garden of Cosmic Speculation (left) and the garden of the Scottish National Gallery of Modern Art in Edinburgh (right).

The Multiverse project began when the Duke of Buccleuch and Queensberry, whose ancestral home at Drumlanrig Castle stands near to Crawick, asked Jencks to reclaim the site, dramatically surrounded by rolling hills but disfigured by the

slag heaps from open-cast coal mining. When work began in 2012, the excavations unearthed thousands of boulders half-buried in the ground, which Jencks has used to create a panorama of standing stones and sculpted tumuli.

"As we discovered more and more rocks, we laid out the four cardinal points, made the north-south axis the primary one, and thereby framed both the far horizons and the daily and monthly movements of the sun", Jencks says. "One theory of pre-history is that stone circles frame the far hills and key points, and while I wanted to capture today's cosmology not yesterday's, I was aware of this long landscape tradition."

Visitors to the site should recognize the spiral form of our own Milky Way Galaxy, Jencks says – but the layout invites them to delve deeper into cosmogenic origins. The Milky Way, he says, "emerged from our Local Group of galaxies, but where did they come from? From the supercluster of galaxies, and where did they come from? From the largest structures in the universe, the web of filaments? And so on and on." Ultimately this leads to the questions confronted by theories of the Big Bang in which our own universe is thought to have formed – and to questions about whether this cosmic outburst, or others, might also have spawned other universes, or a multiverse.

How many universes do you need?

A decade or two ago, allusions to the notion that there are many – perhaps infinitely many – universes would have been regarded as dabbling on the fringes of respectable science. Now the multiverse idea is embraced by many leading cosmologists and other physicists. That's not because we have any evidence for it, but because it seems to offer a simultaneous resolution to several outstanding problems on the wild frontier where fundamental physics – the science of the immeasurably small – blends with cosmology, which attempts to explain the origin and evolution of all the vastness of space.

"In the last twenty years the multiverse has developed from an exotic speculation into a full-blown theory", says Jencks. "From avant-garde conjecture held by the few to serious hypothesis entertained by the many, leading thinkers now believe the multiverse is a plausible description of an ensemble of universes."

To explore how the multiverse came in from the cold, Jencks convened a gathering of cosmologists and particle physicists whose eminence would rival the finest of international science conventions. While the opening celebrations braved the elements at Crawick, the scientists were hosted by the duke at Drumlanrig Castle – perhaps the most stunning example of French-inflected Scottish baronial architecture, fashioned from the gorgeous red stone of Dumfries. In one long afternoon while the sun conveyed its rare blessing on the jaw-dropping gardens outside, these luminaries explained to an invited audience why they have come to suppose a multiplicity of universes beyond all reasonable measure: why an understanding of the deepest physical laws is compelling us to make the position of humanity in the cosmos about as insignificant as it could possibly be.

Drumlanrig Castle near Dumfries, where scientists convened to discuss the multiverse.

It was a decidedly surreal gathering, with Powerpoint presentations on complex physics amidst Louis XIV furniture, while massive portraits of the duke's illustrious ancestors (including Charles II's unruly illegitimate son the 1st Duke of Monmouth) looked on. When art historian Martin Kemp, opening the proceedings with a survey of spiral patterns, discussed the nature art of Andy Goldsworthy, only to have the artist himself pop up to explain his intentions, one had to wonder if we had already strayed into some parallel universe.

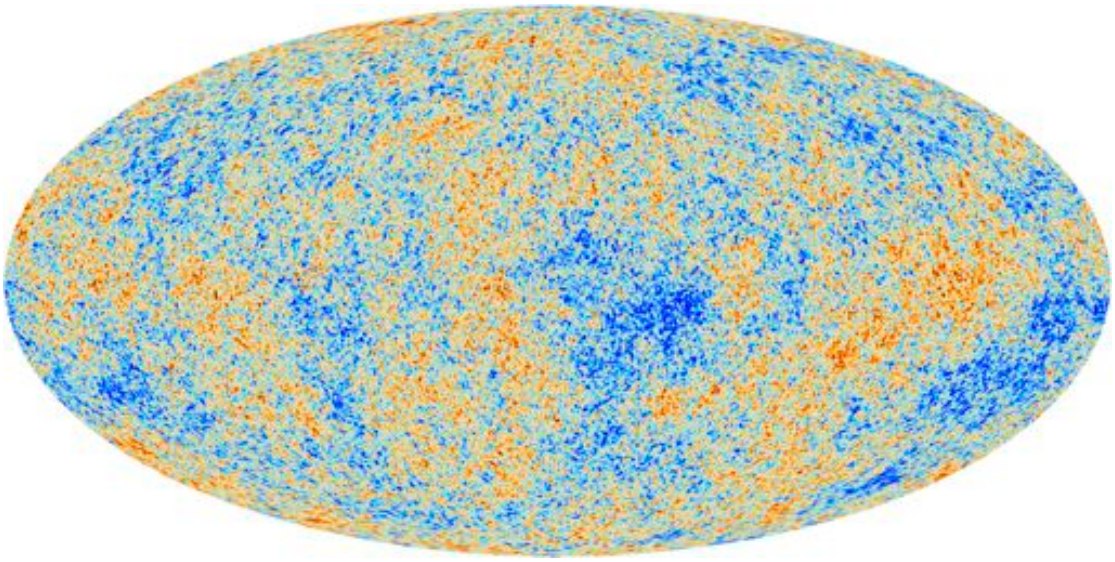
Martin Rees, Astronomer Royal and past President of the Royal Society, suggested that the multiverse theory represents a "fourth Copernican revolution": the fourth time since Copernicus shoved the earth away from the centre of creation that we have been forced to downgrade our status in the heavens. Yet curiously, this latest perspective also gives our very existence a central role in any explanation of why the basic laws of nature are the way they are.

Here's the problem. A quest for the much-vaunted Theory of Everything – a set of "simple" laws, or perhaps just a single equation, from which all the other principles of physics can be derived, and which will achieve the much-sought reconciliation of gravity and quantum theory – has landed us in the perplexing situation of having more alternatives to choose from than there are fundamental particles in the known universe. To be precise, the latest version of string theory, which many physicists who delve into these waters insist is the best candidate for a "final theory", offers 10^{500} (1 followed by 500 zeros) distinct solutions: that many possible variations on the laws of physics, with no obvious reason to prefer one over any other. Some are tempted to conclude that this is the fault of string theory, not of the universe, and so prefer to ditch the whole edifice, which without doubt is built on some debatable assumptions and remains far beyond our means to test directly for the foreseeable future.

If that were all there was to it, you might well wonder if indeed we should be wiping the board clean and starting again. But cosmology now suggests that this

crazy proliferation of physical laws can be put to good use. The standard picture of the Big Bang – albeit not the one that all physicists embrace – posits that, a fraction of a second after the universe began to expand from its mysterious origin, it underwent a fleeting instant of expansion at an enormous rate, far faster than the speed of light, called inflation. This idea explains, in what might seem like but is not a paradox, both why the universe is so uniform everywhere we look and why it is not *perfectly* so. Inflation blew up the "fireball" to a cosmic scale before it had a chance to get too clumpy.

That primordial state would, however, have been unavoidably ruffled by the tiny chance variations that quantum physics creates. These fluctuations are now preserved at astronomical scales in slight differences in temperature of the cosmic microwave background radiation, the faint afterglow of the Big Bang itself that several satellite-based telescopes have now mapped out in fine detail. As astrophysicist Carlos Frenk explained at Drumlanrig, the match between the spectrum of temperature variations – their size at different distance scales – predicted by inflationary theory and that measured is so good that, were it not so well attested in so huge an international effort, it would probably arouse suspicions of data-rigging.



The temperature variations of the cosmic microwave background, as mapped by the European Space Agency's Planck space telescope in 2013. The tiny variations correspond to regions of slightly different density in the very early universe that seeded the formation of clumps of matter – galaxies and stars – today.

What has this got to do with multiverses? Well, to put it one way: if you have a theory for how the Big Bang happened as a natural phenomenon, almost by definition you no longer have reason to regard it as a one-off event. The current view is that the Big Bang itself was a kind of condensation of energy-filled empty space – the "true vacuum" – out of an unstable medium called the "false vacuum", much as mist condenses from the moist air of the Scottish hills. But this false vacuum, for reasons I won't attempt to explain, should also be subject to a kind of inflation in which it expands at fantastic speed. Then our universe appears as a sort of growing "bubble" in the false vacuum. But others do too: not just 13.6

billion years ago (the age of our universe) but constantly. It's a scenario called "eternal inflation", as one of its pioneers, cosmologist Alex Vilenkin, explained at the meeting. In this view, there are many, perhaps infinitely many, universes appearing and growing all the time.

The reason this helps with string theory is that it relieves us of the need to select any one of the 10^{500} solutions it yields. There are enough homes for all versions. That's not just a matter of accommodating homeless solutions to an equation. One of the most puzzling questions of modern cosmology is why the vacuum is not stuffed full of unimaginable amounts of energy. Quantum theory predicts that empty space should be so full of particles popping in and out of existence all the time, just because they can, that it should hold far more energy than the interior of a star. Evidently it doesn't, and for a long time it was simply assumed that some unknown effect must totally purge the vacuum of all this energy. But the discovery of dark energy in the late 1990s – which manifests itself as an acceleration of the expansion of our universe – forced cosmologists to accept that a tiny amount of that vacuum energy does in fact remain. In this view, that's precisely what dark energy is. Yet it is so tiny an amount – 10^{-122} of what is predicted – that it seems almost a cosmic joke that the cancellation should be so nearly complete but not quite.

But if there is a multiverse, this puzzle of "fine-tuning" goes away. We just happen to be living in one of the universes in which the laws of nature are, out of all the versions permitted by string theory, set up this way. Doesn't that seem too much of an extraordinary good fortune? Well no, because without this near cancellation of the vacuum energy, atoms could not exist, and so neither could ordinary matter, stars – or us. In any universe in which these conditions pertain, intelligent beings might be scratching their heads over this piece of apparent providence. In those – far more numerous – where that's not the case, there is no one to lament it.

The pieces of the puzzle, bringing together the latest ideas in cosmology and fundamental physics, seem suddenly to dovetail rather neatly. Too neatly for some, who say that such arguments are metaphysical sleight of hand – a kind of cheating in which we rescue ourselves from theoretical problems not by solving them but by dressing them up as their own solution. How can we test these assertions, they ask? And isn't it defeatist to accept that there's ultimately no fundamental reason why the fundamental constant of nature have the values they do, because in other universes they don't?

But there's no denying that, without the multiverse, the "fine-tuning" problem of dark energy alone looks tailor-made for a theologian's "argument by design". If you don't want a God, astrophysicist Bernard Carr has quipped (only half-jokingly), you'd better have a multiverse. It's not the first time a "plurality of worlds" has sparked theological debate, as philosopher of religion Mary-Jane Rubenstein reminded the Drumlanrig gathering – his interpretation (albeit not simply his assertion) of such a multiplicity was partly what got the Dominican friar Giordano Bruno burnt at the stake in 1600.

Do these questions drift beyond science into metaphysics? Perhaps – but why should we worry about that, Carr asked the meeting? At the very least, if true science must be testable, who is to say on what timescale it must happen? (The current realistic possibilities at CERN are certainly more modest, as its Director General Rolf Heuer explained – but even they don't exclude an exploration of other types of multiverse ideas, such as a search for the mini-black holes predicted by some theories that invoke extra, "invisible" dimensions of space beyond our familiar three.)

Reclaiming the multiverse

How much of all this finds its way into Jencks' Crawick Multiverse is another matter. In line with his thinking about the hierarchy of "cosmic patterns" through which we trace our place in the cosmos, many of the structures depict our immediate environment. Two corkscrew hillocks represent the Milky Way galaxy and its neighbour Andromeda, while the local "supercluster" of galaxies becomes a gaggle of rock-paved artificial drumlins. The Sun Amphitheatre, which can house 5,000 people (though it's a brave soul who organizes outdoor performances on a Scottish hillside at any time of year), is designed to depict the crescent shapes of a solar eclipse. The Multiverse itself is a mound up which mudstone slabs trace a spiral path, some of them carved to symbolize the different kinds of universe the theory predicts.

The local universe represented in the Crawick Multiverse.

But why create a Multiverse on a Scottish hillside anyway? Because, Jencks says, "it is our metaphysics, or at least is fast becoming so. And all art aspires to the condition of its present metaphysics. That's so true today, in the golden age of

cosmology, when the boundaries of truth, nature, and culture are being rewritten and people are again wondering in creative ways about the big issues." "I wanted to confront the basic question which so many cosmologists raise: why is our universe so well-balanced, and in so many ways? What does the apparent fine-tuning mean, how can we express it, make it comprehensible, palpable?"

"Apart from all this", he adds, "if you have a 55-acre site, and almost half the available money has to go into decontamination alone, then you'd better have a big idea for 2000 free boulders."

Charles Jencks introduces his multiverse. (Photo: Michael Benson.)

The sculptures and forms of the Crawick Multiverse reflect Jencks' own unique and sometimes impressionistic take on the theories. For example, he prefers to replace "anthropic" reasoning that uses our own observation of the observable universe as an explanation of apparent contingencies with the notion that this universe (at least) has a tendency to spawn ever more complexity: his Principle of Increasing Complexity (PIC). He is critical of some of science's "Pentagon metaphors – wimps and machos (candidates for the mysterious dark matter that exceeds the amount of ordinary visible matter by a factor of around four), selfish genes and so on. "The universe did not start in a big bang", Jencks says. "It was smaller than a quark, and noise wasn't its most significant quality." He prefers the term "Hot Stretch".

But his intention isn't really pedagogical – it's about giving some meaning to this former site of mining-induced desolation. "I hope to achieve, first, something for the economically depressed coal-mining towns in the area", Jencks says. "Richard [Buccleuch] had an obligation to make good the desolation, and he feels this responsibility strongly. I wanted to create something that related to this local culture. Like Arte Povera it makes use of what is to hand: virtually everything comes from the site, or three miles away. Second, I was keen on getting an annual festival based on local culture – the pipers in the area, the Riding of the Marches, the performing artists, the schools."

Visitors to the site seem likely to be offered only the briefest of introductions to the underlying cosmic themes. That's probably as it should be, not only because the theories are so provisional (they'll surely look quite different in 20 years time, when the earthworks have had a chance to bed themselves into the landscape) but because, just like the medieval cosmos encoded in the Gothic cathedrals, this sort of architecture is primarily symbolic. It will speak to us not like a lecture, but through what Martin Kemp has called "structural intuitions", an innate familiarity with the patterns of the natural world. Some scientists might look askance at any suggestion that the Crawick Multiverse can be seen as a sacred place. But it's hard to imagine how even the most secular of them, if they really take the inflationary multiverse seriously, could fail to find within it some of the awe that a peasant from the wheatfields of the Beauce must have experienced on entering the nave of Chartres Cathedral – a representation in stone of the medieval concept of an orderly Platonic universe – and stepping into its cosmic labyrinth.