BACK TO THE BEGINNING

By

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The possible discovery of the Higgs boson leads us one step closer to how the universe started – and where it may be headed.

The ancients believed that the world was made from four “elements” – earth, air, fire, and water – but that the heavens were something quite different, the “fifth essence”. We have now learned that everything, from here on earth out to the remotest galaxies, is made of similar atoms, which are themselves each composed of smaller particles. And it’s testimony to how far we’ve got that it takes a vast machine to disclose anything fundamentally new in the subatomic world.

While physicists probe ever smaller scales, astronomers deploy ever more powerful telescopes to search deeper into space and further back in time. Our cosmic horizons have vastly enlarged. Our sun is one of a 100 billion stars in our galaxy, which is itself one of many billion galaxies in range of our telescopes. This entire panorama emerged from a hot dense “beginning” nearly 14 billion years ago. One nanosecond after the big bang, every particle in the universe carried as much energy as can be generated by the Large Hadron Collider.

As always in science, each cosmological advance brings into focus some new questions that couldn’t previously have even been posed – for instance, “Why is the universe expanding the way it is?” and “Why does it contain the particular ‘mix’ of atoms that we find in stars and galaxies?” The answers lie in the era when the universe was even less than a nanosecond old, and far hotter and denser than we can simulate in any lab.

According to a popular conjecture, our entire universe “inflated” from a hyper-dense blob no bigger than an orange. This universe is governed by the laws that Einstein discovered. But to confront the overwhelming mystery of what banged and why it banged, Einstein’s theory isn’t enough. It doesn’t adequately describe the very beginning. That’s because it “smooths out” space and time into a continuum. We know that no material can be chopped into arbitrarily small pieces because eventually you get down to discrete atoms. Likewise, even space and time can’t be divided up indefinitely. Space has a grainy and “quantized” structure – but on a scale a trillion times smaller than atoms. During the very earliest instants after the “big bang”, everything was so immensely squeezed that quantum fluctuations could shake the entire “embryo universe”.

If physicists achieved a complete understanding of all the particles and forces in the universe, it would be the summit of an intellectual quest that began with the Greeks, and continued with the insights of Newton, Einstein, and their successors. It would reveal a fundamental “order” in the world, describable by numbers and equations. It would supremely vindicate what the great physicist Eugene Wigner dubbed “The unreasonable effectiveness of mathematics in the natural sciences”.

The very large and the very small – cosmos and microworld – are two great frontiers of science. Twenty-first century scientists may successfully unify them. Until that is done we won’t properly understand why the universe is expanding as it is.

But this unification would not be the end of science, indeed, we could still be near the beginning. Consider an analogy – suppose you’d never seen chess being played, you could, by watching a few games, infer the rules. But in chess, learning how the pieces move is just the entry gate to the absorbing progression from novice to grand master. The beauty of that game lies in the rich variety that the rules allow.

Likewise, the greatest scientific challenges are not to discover nature's building blocks, but to elucidate how they combine together into an immense variety of materials, and – above all – into the complex structures of life. This is the challenge that engages the 99 percent of scientists who are neither particle physicists nor astronomers.

It may seem incongruous that scientists can make confident statements about remote galaxies, or about exotic subatomic particles. While being baffled about issues close at hand that we all care about – diet and common disease, for instances. But this is because living things embody intricate structures that render them far more mysterious than atoms or stars.

Will scientists ever fathom all of nature's complexities? Perhaps they will. However, we should be open to the possibility that we might, far down the line, encounter limits because our brains just don't have enough conceptual grasp.

Einstein averred that "the most incomprehensible thing about the universe is that it is comprehensible". He was right to be astonished. It's amazing these minds can comprehend so much of the counterintuitive microworld of atoms, and phenomena billions of light years away. Nonetheless there seems no reason why human mental capacity should be matched to all deep aspects of reality.

And here astronomers like myself can offer a special perspective. The stupendous time spans of the evolutionary past are now part of common culture. But most educated people, though fully aware that our biosphere is the outcome of several billion years of Darwinian evolution, still somehow think that humans are the culmination of the evolutionary tree. That hardly seems credible to astronomers. They're mindful that our sun formed 4.5 billion years ago, but also that it's got 6 billion years more. And the expanding universe will continue – perhaps forever – destined to become ever colder, ever emptier. To quote Woody Allen, "Eternity is very long, especially toward the end".

Any creatures witnessing the sun's demise won't be human – they'll be as different from us as we are from a bug. Post-human evolution, here on earth or far beyond, could be as prolonged as the Darwinian evolution that has led to us – and even more wonderful. Moreover, evolution could in future proceed far more rapidly than in the past, driven by technology rather than natural selection. Indeed if one day there are communities living in space, they'd surely wish to use the resources of genetics to adapt their offspring to an alien environment – and we earthlings would surely wish them good luck. Whatever ethical constraints we'd want to impose on such techniques here on earth. Whether the really long-range future lies with organic post-humans or with intelligent machines is a matter for debate. But we would be anthropocentric to believe that all of science is within humanity's grasp – and that no enigmas will remain to challenge our post-human descendants.