Why is the Universe comprehensible?

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"The most incomprehensible thing about the Universe", said Einstein, "is that it is comprehensible." Why, for instance, are the laws of physics not so complex that they are forever beyond the grasp of a brain made of 1.5 kilograms of jelly and water?

Not only is our Universe comprehensible but it was possible for a man of the 17th century, whose father signed his name with an "X", to discern a law that applies at all times and in all places. That is, of course, Newton's "universal" law of gravity, which explains everything from the motion of the Moon to the tides in the oceans to the cartwheeling of galaxies.

One mind-boggling proposal for why the Universe is comprehensible arises from our knowing how to create a universe. Everything is believed to have begun in an unusual state of the vacuum, with the property that it "inflated" ever faster and, as it did so, created ever more of itself. The Universe, according to this theory of "inflation", was the ultimate free lunch!

To create a new universe, therefore it is necessary only to recreate the conditions of inflation. This is way beyond our capabilities but not perhaps of a super-civilisation millions or billions of years more advanced. Say, one such civilisation does this in each galaxy in the universe, to see what happens, suggested the British physicist Ed Harrison. That would create trillions of baby universes that might each spawn trillions more.

If we live in such a DIY universe, the reason it is comprehensible is because it was created by comprehensible beings. Beings far in advance of us but basically like ourselves. They made our Universe to be like theirs, and their universe was in turn understandable. How could it not be? They had to have enough understanding of it to manipulate it and make a new universe!

Our success in comprehending our Universe has been truly remarkable. Take quantum theory, arguably, the most successful physical theory. It has given us lasers, computers and nuclear reactors. It explains why the ground beneath us is solid and why the Sun shines.

This success of physics in comprehending the Universe comes down to a mysterious thing. As first recognised by Galileo, the laws of nature are mathematical. Bizarrely, the real universe has a mathematical twin which mimics it in every way. As the British physicist Paul Dirac remarked: "God is a mathematician of a very high order."

What this means is that it possible to write down a mathematical formula that predicts things previously unsuspected that, when physicists go out and look for them, they actually find: from antimatter to gravitational waves to the Higgs boson. This is so astonishing that physicists often cannot quite believe it. "Our mistake is not that we take our theories too seriously but that we do not take them seriously enough," said the American physicist Steven Weinberg.

So why is the universe mathematical? The Swedish-American physicist Max Tegmark believes that mathematics *is* physics. He envisions a multiverse of universes, in each of which a different bit of mathematics is implemented. In most universes, the mathematics is too simple to give rise to anything in interesting. But in our universe, which contains a mathematical "theory of everything", it is complex enough to spawn stars and planets and us.

The British physicist Stephen Wolfram, on the other hand, believes we are mistaken in believing our Universe is mathematical. Physicists, like a drunk at midnight looking for their dropped car keys under a streetlight because that's the only place they can look, see only the parts of the Universe that mathematics illuminates. That's only a small portion, Wolfram maintains.

Clearly, there is some regularity to the Universe. But, rather than obeying mathematical rules, Wolfram believes the Universe is being generated by simple computer programs. These are creating everything from a rose to a baby to a spiral galaxy. In order to understand what most of the Universe is doing we have no choice but to run the computer program to see the output. But, within the great universe-generating computation, are bits of where a shortcut exists and the output

can be predicted without running the program. This, says Wolfram, is mathematical physics.

Douglas Adams, who imagined the Earth as a computer run by mice to calculate the answer to the ultimate question - 42 - would be happy.

<Biog>

Marcus's most recent book is *A Crack in Everything: How black holes came in from the cold and took cosmic centre stage* (Apollo, 2025).