Humankind's Existentially Lucky Numbers

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The Large Hadron Collider sprung back to life this month, smashing subatomic particles with nearly double the energy used to discover the Higgs boson, a landmark in understanding the makeup of the physical world. With the Higgs now in the bag, researchers are setting their sights on more exotic fare: signs of a new physics that not only describes the universe but explains why it is the way it is.

Four fundamental forces rule reality, but why is the number not three or five or 17? Matter is built from a grab bag of particles whose masses differ so wildly that they appear to have been handed out by a punch-drunk God. The proton weighs 0.9986 as much as the neutron, and each is more than 1,835 times as massive as the electron.

These values, like all the others making up the spec sheet of the universe, seem so arbitrary. Yet if they had been slightly different, theorists tell us, the universe would not have given rise to intelligent life.

Rejecting the possibility that this was nothing more than a lucky accident, physicists have been looking for some underlying principle — a compelling explanation for why everything could only have unfolded in this particular way.

That is not how we ordinarily think of human history, where for the want of a hanging chad we might be living in a very different geopolitical world. With every event, forking paths of possibilities branch out into the future. Pick one of the multitude that didn't become real, and you might have the plot for a good counterfactual novel.

In Philip K. Dick's "The Man in the High Castle," the United States loses World War II and is divided down the middle, with the East occupied by Nazi Germany and the West by Japan. Other writers have started with the premise that the Black Death wiped out Europe in medieval times, leaving (in various versions) Islam, the Ottomans, the Persians, the Aztecs and the Iroquois as contending superpowers.

In a satirical essay published in 1930, speculating on the ramifications of a Confederate victory in the Civil War, Winston Churchill wrote of the

fascination people have for "the tiny things, the sharp agate points, on which the ponderous balance of destiny turns."

With a slight suspension of disbelief, we can imagine what it would be like if John F. Kennedy had lived out his presidency. But physics isn't played that way: If a number called alpha, which governs the strength of electromagnetism, were infinitesimally larger or smaller, stars could not have formed, leaving a lifeless void.

Alpha's value seems no more predictable than digits randomly spit out by a lottery machine: 0.0072973525698. One of the greatest mysteries of physics, the physicist Richard Feynman called it, "a magic number that comes to us with no understanding by man."

Other values, like the mass of the Higgs, or the strength of the force that binds together the cores of atoms, appear to be just as finely tuned. Bump the dials just barely, and nothing like our universe could exist.

There are several ways to react to this existential dilemma. We can take a cue from the author Douglas Adams and relish the idea that life, the universe and everything are a grand cosmic fluke. If the universal settings were slightly different, we wouldn't be here considering the mystery. This is a version of what has come to be called the "weak anthropic principle."

Taking a more mystical turn are adepts of another doctrine: the strong anthropic principle. Drawing on a controversial interpretation of quantum theory, they propose an Escher-like symbiosis. The universe gives rise to conscious observers, who in turn conjure the universe into existence by the dint of their constant gaze.

Finally there are followers of a middle path, who seek to prove that the universe is not accidental but inevitable, with its set of defining numbers as constrained and mutually consistent as the solution to a Sudoku puzzle.

That was the goal of string theory when it rose to prominence three decades ago. The mathematics, with its extra dimensions and pretzel geometries, was so mesmerizing that the theory seemed almost certain to be true — a tightly woven description, when ultimately deciphered, of a universe just like our own.

Instead, string theory spiraled off in another direction, predicting a whole multitude of other universes, each with a different physics and each unobservable except for our own. Maybe some of the other universes have spawned different kinds of conscious beings, made from something other

than atoms and just as puzzled (in some unfathomable equivalent of puzzlement) as we are.

Or maybe the whole multiverse thing is just an elaborate way of saying that there are endless ways that this Universe (singular and with a capital U) might have unfolded — counterfactual histories, no more real than a hypothetical Earth on which the Mayans ally with the Incas to fight a thermonuclear war against beings on the moon.

For years now theorists have been torn between those who reject the multiverse as "a cop-out of infinite proportions," as Natalie Wolchover and Peter Byrne wrote last year in Quanta, and those who insist the idea is too powerful to be wrong, even if there is no way to verify that any of the other universes exist.

Plenty of multiverse skeptics remain open to some version of string theory, one that doesn't require redefining what counts as real. Maybe, lurking still hidden in the thicket, is a magic equation, showing that this universe is, after all, the only one that can be.