

In Search of Uncertainty

Is finding a Theory of Everything an impossible task? For cosmologist Janna Levin, the idea that we might never have all the answers isn't all that depressing.

by SCOTT DODD



FQXi Awardee: Janna Levin, Barnard College of Columbia University

June 8, 2007

A Theory of Everything is often described as the Holy Grail of modern physics. Stephen Hawking talked about it as “reading the mind of God.”

Think of it: A way of understanding the world that links the two greatest achievements of 20th century physics – General Relativity and quantum mechanics – and reveals the fundamental nature of the universe. We could at last understand what the universe is made of, how it works, maybe even what it's doing here in the first place.

Some truths are ultimately forever elusive.

- Janna Levin

Physicist and FQXi Awardee Janna Levin, who spends her time puzzling over the minds of madmen, is willing to spoil the party and explore the idea that a Theory of Everything – or TOE – may be impossible to find.

More precisely, Levin doesn't think a unifying theory is beyond our ken. In fact, she thinks that, in time, we may be able to understand most things about the cosmos. But she also embraces the disconcerting idea that there may be something fundamental built into the very nature of the universe that makes it impossible to know absolutely everything about it.

Confused? Relax. In the end, it all comes down to math.

It's My Party

Levin, an author and professor of astronomy and physics at Barnard College of Columbia University in New York, writes in a way that manages to fill mathematics – seemingly the most detached and analytical of subjects – with a profound sense of melancholy.

Her debut book, *How the Universe Got Its Spots*, written as a diary for her mother, opens with the very un-cheery line: “Some of the great mathematicians killed themselves.”

Levin's theme of melancholy and mania reappears in the title of her most recent effort: *A Madman Dreams of Turing Machines*, a novel (although she took great pains to make it true to life) about early 20th century mathematicians – and madmen – Kurt Gödel and Alan Turing.

Gödel, a paranoid schizophrenic, starved himself to death because he feared his food was poisoned. Turing, after being chemically castrated for his homosexuality, committed suicide. Not the sunniest of topics.

Levin found herself drawn to Gödel and Turing out of sympathy for their ability to get lost in their work – and their willingness to explore fundamental limits to knowledge. When she learned of their depressing ends, it only made her more intrigued. “It was sort of like a sore tooth that you pry at relentlessly,” Levin said.

Despite soulful eyes, Levin's outward disposition couldn't be further from the subjects she chooses to write about. “I'm sort of chipper, actually,” she acknowledges, flouncing her pigtailed and tucking her legs under her as she sits. When New York's Secret Science Club invited her for a talk at Union Hall in Brooklyn recently, they wrote her a theme song, “Cosmic Girl,” and served a signature drink in her honor, the “Time Warp.”

“I didn't actually drink the Time Warp,” she says. “Unless I did and I don't remember.”

Party Poopers

Gödel and Turing did their most important work in a scientific era that Levin compares to physics today. Mathemati-

cians had made great strides – so great that one of the field's leaders, David Hilbert, believed it was on the verge of solving the greatest puzzles of all. Hilbert, at the International Congress of Mathematicians in 1928, challenged his colleagues to address the final problems underlying the foundations of mathematics – a challenge similar to the modern-day search by physicists for a TOE.



EXPLORING UNCERTAINTY
Janna Levin

Gödel instead showed that Hilbert was wrong, that there were statements within mathematics that could never be proven true or false. Turing, the father of computer science, took Gödel's work a step further, showing that there are numbers that can never be calculated. For example, some numbers are random, just a decimal point and an infinite list of digits so unknowable that determining what comes next might as well be up to the toss of a coin.

Decades later, working for IBM, Gregory Chaitin, a mathematician and member of the FQXi Scientific Advisory

Panel, offered even more evidence that the vast majority of numbers are, in fact, random. “There’s a limit to what we can know, even about something as simple as numbers themselves,” Levin explains. “That puts me in an uncomfortable place, and I think that’s why I thought so much about these two characters.”

Levin wondered if Gödel and Turing’s mathematical conclusions might contain a message about the nature of the cosmos, as well. “Some truths are ultimately forever elusive,” Levin says. What if that’s as true for physics as it is for mathematics?

Curfews and Other Constraints

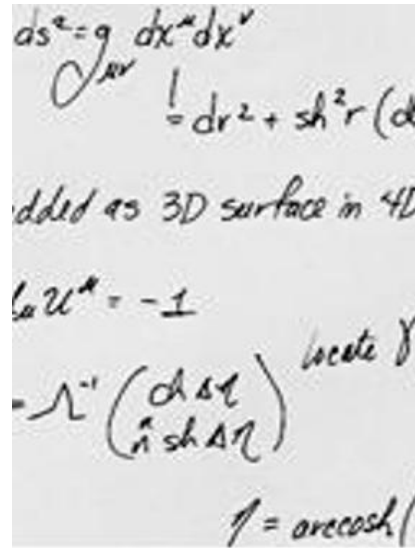
Limits aren’t necessarily a bad thing in Levin’s view. Proposing a fundamental speed limit for light led Albert Einstein to his theories of relativity. Werner Heisenberg’s uncertainty principle became the cornerstone of quantum mechanics. So, maybe confronting the limits of mathematical incompleteness could lead to a better understanding of physics’ most sought-after theory – and whether it can even exist.

The originality and offbeat nature of Levin’s proposal won a \$28,611 grant from FQXi. Levin has been working on her ideas with Seth Lloyd, a pioneer of quantum computing, professor of mechanical engineering at the Massachusetts Institute of Technology, and FQXi Member. (His first feasible model of a quantum computer looks like a beer keg.)

Lloyd has some radical ideas of his own. “I believe that the entire universe is just one huge honking quantum computer,” he says. In his view, the laws of physics are simply the programs the ultra-

computer is running, and the output is everything that exists – including us.

Like the Mac or the PC on your desk, Lloyd says, the giant universal computer is bound to have unpredictable elements, or bugs. On a universal scale, bugs result in unexpected or unexplainable permutations – much like Turing’s incomputable numbers, with their wholly random digits. So even if there is a TOE, Lloyd says, there might be no way of finding it.



THEORY OF EVERYTHING

Can there be one?

“I just barged into his office one day to tell him I wanted to work on this,” Levin says, reminiscing about how she and Lloyd spent hours throwing out ideas and jotting down formulas on a whiteboard. That first encounter has served as the model for their current collaboration. “We have these outbursts where we just talk, talk, talk,

talk, talk. We’ll both be whizzing for a couple of days afterward.”

Hangover Cures

Levin hopes that their ideas will get others in the physics world whizzing, as well – although she also worries a bit about the reaction. She has already discussed her ideas with Columbia colleague and fellow FQXi Awardee Brian Greene, one of the leading proponents of superstring theory, the leading candidate for a Theory of Everything. The two of them go back and forth about the ideas of knowability.

“It doesn’t mean that string theory is wrong or that there will never be a theory of unification” that brings together gravity and quantum mechanics, Levin says. “Both of us wonder whether or not any theory will answer everything.” Even if string theory proves successful at uniting the fundamental forces of physics, she says, it might remain incomplete.

Lloyd, for his part, says – almost gleefully – that he’s sure that any TOE will lack the desired level of finality. If Greene is right, for example, and all the fundamental particles of the universe are composed of super-tiny vibrating strings, who is to say that those strings aren’t composed of something even smaller?

“You can essentially prove that you can’t know whether there’s something deeper or not,” Lloyd says. “That’s just the way life is.”

That’s bound to be a depressing thought for some physicists. For Levin, it just makes sense. It seems her universe wouldn’t be complete without a little melancholy built into the equation.