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A Scientist Takes On Gravity

By DENNIS OVERBYE

It's hard to imagine a more fundamental and ubiquitous aspect of life on the Earth than gravity, from the moment you first took a step and fell on your diapered bottom to the slow terminal sagging of flesh and dreams.

But what if it's all an illusion, a sort of cosmic frill, or a side effect of something else going on at deeper levels of reality?

So says Erik Verlinde, 48, a respected string theorist and professor of physics at the University of Amsterdam, whose contention that gravity is indeed an illusion has caused a continuing ruckus among physicists, or at least among those who profess to understand it. Reversing the logic of 300 years of science, he argued in a recent paper, titled "On the Origin of Gravity and the Laws of Newton," that gravity is a consequence of the venerable laws of thermodynamics, which describe the behavior of heat and gases.

"For me gravity doesn't exist," said Dr. Verlinde, who was recently in the United States to explain himself. Not that he can't fall down, but Dr. Verlinde is among a number of physicists who say that science has been looking at gravity the wrong way and that there is something more basic, from which gravity "emerges," the way stock markets emerge from the collective behavior of individual investors or that elasticity emerges from the mechanics of atoms.

Looking at gravity from this angle, they say, could shed light on some of the vexing cosmic issues of the day, like the dark energy, a kind of anti-gravity that seems to be speeding up the expansion of the universe, or the dark matter that is supposedly needed to hold galaxies together.

Dr. Verlinde's argument turns on something you could call the "bad hair day" theory of gravity.

It goes something like this: your hair frizzles in the heat and humidity, because there are more ways for your hair to be curled than to be straight, and nature likes options. So it takes a force to pull hair straight and eliminate nature's options. Forget curved space or the spooky attraction at a distance described by Isaac Newton's equations well enough to let us navigate the rings of Saturn, the force we call gravity is simply a byproduct of nature's propensity to maximize disorder.

Some of the best physicists in the world say they don't understand Dr. Verlinde's paper, and many are outright skeptical. But some of those very same physicists say he has provided a fresh perspective on some of the deepest questions in science, namely why space, time and gravity exist at all — even if he has not yet answered them.

"Some people have said it can't be right, others that it's right and we already knew it — that it's right and profound, right and trivial," Andrew Strominger, a string theorist at Harvard said.

"What you have to say," he went on, "is that it has inspired a lot of interesting discussions. It's just a very interesting collection of ideas that touch on things we most profoundly do not understand about our universe. That's why I liked it."

Dr. Verlinde is not an obvious candidate to go off the deep end. He and his brother Herman, a Princeton professor, are celebrated twins known more for their mastery of the mathematics of hard-core string theory than for philosophic flights.

Born in Woudenberg, in the Netherlands, in 1962, the brothers got early inspiration from a pair of 1970s television shows about particle physics and black holes. "I was completely captured," Dr. Verlinde recalled. He and his brother obtained Ph.D's from the University of Utrecht together in 1988 and then went to Princeton, Erik to the Institute for Advanced Study and Herman to the university. After bouncing back and forth across the ocean, they got tenure at Princeton. And, they married and divorced sisters. Erik left Princeton for Amsterdam to be near his children.

He made his first big splash as a graduate student when he invented Verlinde Algebra and the Verlinde formula, which are important in string theory, the so-called theory of everything, which posits that the world is made of tiny wriggling strings.

You might wonder why a string theorist is interested in Newton's equations. After all Newton was overturned a century ago by Einstein, who explained gravity as warps in the geometry of space-time, and who some theorists think could be overturned in turn by string theorists.

Over the last 30 years gravity has been "undressed," in Dr. Verlinde's words, as a fundamental force.

This disrobing began in the 1970s with the discovery by Jacob Bekenstein of the Hebrew University of Jerusalem and Stephen Hawking of Cambridge University, among others, of a mysterious connection between black holes and thermodynamics, culminating in Dr. Hawking's discovery in 1974 that when quantum effects are taken into account black holes would glow and eventually explode.

In a provocative calculation in 1995, Ted Jacobson, a theorist from the University of Maryland, showed that given a few of these holographic ideas, Einstein's equations of general relativity are just a another way of stating the laws of thermodynamics.

Those exploding black holes (at least in theory — none has ever been observed) lit up a new strangeness of nature. Black holes, in effect, are holograms — like the 3-D images you see on bank cards. All the information about what has been lost inside them is encoded on their surfaces. Physicists have been wondering ever since how this "holographic principle" — that we are all maybe just shadows on a distant wall — applies to the universe and where it came from.

In one striking example of a holographic universe, Juan Maldacena of the Institute for Advanced Study constructed a mathematical model of a "soup can" universe, where what happened inside the can, including gravity, is encoded in the label on the outside of the can, where there was no gravity, as well as one less spatial dimension. If dimensions don't matter and gravity doesn't matter, how real can they be?

Lee Smolin, a quantum gravity theorist at the Perimeter Institute for Theoretical Physics, called Dr. Jacobson's paper "one of the most important papers of the last 20 years."

But it received little attention at first, said Thanu Padmanabhan of the Inter-University Center for Astronomy and Astrophysics in Pune, India, who has taken up the subject of "emergent gravity" in several papers over the last few years. Dr. Padmanabhan said that the connection to thermodynamics went deeper that just Einstein's equations to other theories of gravity. "Gravity," he said recently in a talk at the Perimeter Institute, "is the thermodynamic limit of the statistical mechanics of "atoms of space-time."

Dr. Verlinde said he had read Dr. Jacobson's paper many times over the years but that nobody seemed to have gotten the message. People were still talking about gravity as a fundamental force. "Clearly we have to take these analogies seriously, but somehow no one does," he complained.

His paper, posted to the physics archive in January, resembles Dr. Jacobson's in many ways, but Dr. Verlinde bristles when people say he has added nothing new to Dr. Jacobson's analysis. What is new, he said, is the idea that differences in entropy can be the driving mechanism behind gravity, that gravity is, as he puts it an "entropic force."

That inspiration came to him courtesy of a thief.

As he was about to go home from a vacation in the south of France last summer, a thief broke into his room and stole his laptop, his keys, his passport, everything. "I had to stay a week longer," he said, "I got this idea."

Up the beach, his brother got a series of e-mail messages first saying that he had to stay longer, then that he had a new idea and finally, on the third day, that he knew how to derive Newton's laws from first principles, at which point Herman recalled thinking, "What's going on here? What has he been drinking?"

When they talked the next day it all made more sense, at least to Herman. "It's interesting," Herman said, "how having to change plans can lead to different thoughts."

Think of the universe as a box of scrabble letters. There is only one way to have the letters arranged to spell out the Gettysburg Address, but an astronomical number of ways to have them spell nonsense. Shake the box and it will tend toward nonsense, disorder will increase and information will be lost as the letters shuffle toward their most probable configurations. Could this be gravity?

As a metaphor for how this would work, Dr. Verlinde used the example of a polymer — a strand of DNA, say, a noodle or a hair — curling up.

“It took me two months to understand polymers,” he said.

The resulting paper, as Dr. Verlinde himself admits, is a little vague.

“This is not the basis of a theory,” Dr. Verlinde explained. “I don’t pretend this to be a theory. People should read the words I am saying opposed to the details of equations.”

Dr. Padmanabhan said that he could see little difference between Dr. Verlinde’s and Dr. Jacobson’s papers and that the new element of an entropic force lacked mathematical rigor. “I doubt whether these ideas will stand the test of time,” he wrote in an e-mail message from India. Dr. Jacobson said he couldn’t make sense of it.

John Schwarz of the California Institute of Technology, one of the fathers of string theory, said the paper was “very provocative.” Dr. Smolin called it, “very interesting and also very incomplete.”

At a workshop in Texas in the spring, Raphael Bousso of the University of California, Berkeley, was asked to lead a discussion on the paper.

“The end result was that everyone else didn’t understand it either, including people who initially thought that did make some sense to them,” he said in an e-mail message.

“In any case, Erik’s paper has drawn attention to what is genuinely a deep and important question, and that’s a good thing,” Dr. Bousso went on, “I just don’t think we know any better how this actually works after Erik’s paper. There are a lot of follow-up papers, but unlike Erik, they don’t even understand the problem.”

The Verlinde brothers are now trying to recast these ideas in more technical terms of string theory, and Erik has been on the road a bit, traveling in May to the Perimeter Institute and Stony Brook University on Long Island, stumping for the end of gravity. Michael Douglas, a professor at Stony Brook, described Dr. Verlinde’s work as “a set of ideas that resonates with the community, adding, “everyone is waiting to see if this can be made more precise.”

Until then the jury of Dr. Verlinde’s peers will still be out.

Over lunch in New York, Dr. Verlinde ruminated over his experiences of the last six months. He said he had simply surrendered to his intuition. “When this idea came to me, I was really excited and euphoric even,” Dr. Verlinde said. “It’s not often you get a chance to say something new about Newton’s laws. I don’t see immediately that I am wrong. That’s enough to go ahead.”

He said friends had encouraged him to stick his neck out and that he had no regrets. “If I am proven wrong, something has been learned anyway. Ignoring it would have been the worst thing.”

The next day Dr. Verlinde gave a more technical talk to a bunch of physicists in the city. He recalled that someone had told him the other day that the unfolding story of gravity was like the emperor’s new clothes.

“We’ve known for a long time gravity doesn’t exist,” Dr. Verlinde said, “It’s time to yell it.”