PHOTOGRAPHS BY DAN WINTERS

$$\frac{H(as)\,a\,\sqrt{\frac{surfer^{1}}{snowboarder^{2}}}}{\left(\pm\frac{Who\ Lives}{in\ (a)\ Van}\right)} = \frac{\left(\frac{(Re)Written}{Ph(y)sics?}\right)}{Maybe}$$

BY EVAN RATLIFF

Garrett Lisi in Lake Tahoe with a model of E8.

EVEN TO A NONSCIENTIFIC OBSERVER LIKE ME, there are several obvious peculiarities about the life and work of Garrett Lisi. For instance, despite his being 40 years old and possessing a Ph.D. in theoretical physics, he has held few steady jobs—and those the likes of hiking guide and snowboarding instructor. An adventurer who's happiest when he's sliding down snow or waves, Lisi routinely follows a morning of surfing or boarding with an afternoon spent hunched at his laptop, puzzling over high-level mathematics. And he does it while leading a rootless, ascetic existence, sleeping on couches, house-sitting, or living in a van parked at Maui surf breaks.

Most peculiar of all, though, is that he's sitting in the dining room of his latest borrowed home on Lake Tahoe, explaining to me that he is not the next Albert Einstein. Only the most arrogant or deluded person would mention himself alongside the frizzy-haired former patent clerk. But Lisi appears neither. He seems "very sane," says John Baez, a mathematician at the University of California, Riverside. "Which is not exactly universal in people who are trying to crack the mysteries of physics."

A few weeks ago, Lisi posted an academic paper called "An Exceptionally Simple Theory of Everything" to arxiv.org, a site for scientists that's maintained by Cornell University. The paper outlined his attempt at a theory that would lay out the physics of the universe in one tidy package. For half a century, researchers have sought to reconcile gravity with the three forces that operate inside atoms, where gravity seems to hold no sway. (See "The Idiot's Guide to Incomprehensible Physics," page 104) No one—not even Einstein, who spent the later years of his life trying—has been able to explain how these four forces can coexist.

To understand fully Lisi's own hubristic stab at the problem requires a grasp of mathematics far beyond all but a handful of people, but the basic premise is that all physical forces and particles can be explained by mapping them onto an incredibly complex geometrical structure known as E_8. If Lisi is right, his theory would give an elegant shape to the physics of the cosmos, and E_8 would become as significant as $E=MC^2$. This would be a remarkable feat coming from any of the most accomplished physicists alive. Coming from a surf bum, it would be beyond extraordinary.

Lisi began presenting his theory at conferences last year, and many well-regarded physicists found it interesting, even plausible. So he posted the paper, hoping for feedback. And with that, he set off a rogue wave of hype and backlash that he's having a hard time riding. SURFER DUDE STUNS PHYSICISTS WITH THEORY OF EVERYTHING, thundered London's *Telegraph*. *Discover* magazine asked, COULD THE NEXT EINSTEIN BE A SURFER DUDE?

More than a few physicists, meanwhile, took to blogs to trash his idea. "A huge joke," one called it. "Nonsense," said another. Some reached for the ultimate scientific insult: "crackpot." More thorough critics argued that the E_8 model wouldn't be able to accommodate all the universe's particles.

Though Lisi has detractors, he also has his fans, those who like the idea that it's still possible for a maverick physics genius to exist. "I and other people think that the academic world suffers from not being more inclusive of people of this kind," says Lee Smolin, a highly regarded researcher at the Waterloo, Canada–based Perimeter Institute for Theoretical Physics, who has corresponded with Lisi. "We're not talking about a crackpot. He has a Ph.D. from a good graduate program, and his work is well within the bounds of good research."

The furor is still raging in November 2007, when I meet Lisi in Tahoe. He greets me in a pair of fluffy bear-paw slippers and has a slightly top-heavy surfer's physique, with wide shoulders and a thick neck. Having recently started shaving his head of its receding blond hair, he has a tendency to rub his scalp idly when he's thinking. And he's had a lot to ponder lately.

Lisi knows that by even addressing the Einstein comparison he risks coming off as a lunatic, but too many people have reached for the E-word for him to ignore it totally. "Yeah, I am a guy working on physics outside of academia," he says, shuffling his bear paws on the hardwood floor. "But I'm nowhere near Einstein's caliber. Certainly in terms of what I've accomplished, and also because this theory might be wrong. It's not a justified comparison."

Lisi requires little more to do his work than a laptop and an Internet connection.

There's nothing unusual about Lisi suggesting that he might be off target. Only one grand theoretical picture of reality can be correct, after all—both mathematically consistent and experimentally validated against the real world. All the rest are just scribblings on paper. What is truly peculiar is that this scientist hobo, a man who abandoned the security of academia to take his chances as a physics nomad, has any shot at all at being right.

LISI GREW UP IN SAN DIEGO, oscillating between riding waves and geeking out. When he was a kid, he says, "my mom could never get me off the beach," but by the time he reached adolescence, in the early eighties, he had forsaken the ocean for an Apple II, programming and designing video games in his bedroom. When his father, a probate attorney, gave him an old VW microbus at age 16, Lisi drifted back to the beach, turning his

body to surfing while his mind chased science.

"Math does come easily to me," he says, "but I was always much more interested in what theorems imply about the world than in proving them." While studying physics and mathematics as an undergrad at UCLA, he became obsessed with unraveling the machinery of the universe. Lisi was the top physics student in his graduating class and was accepted to several Ph.D. programs, including UC Berkeley, one of the world's finest. He chose UC San Diego for its funding offer and proximity to the surf, and lived for eight years with the beach as his backyard.

During the fourth year of his doctorate, Lisi uncovered what he thought might be the kind of deeper pattern he'd been seeking, though it was a bit outside the physics mainstream. It involved a mathematical anomaly that, he speculated, might explain certain properties of an electron. Soon thereafter, his adviser—Roger Dashen, an acclaimed theoretical physicist who had encouraged Lisi's research—died in front of Lisi during a seminar, of a massive heart attack. Devastated, Lisi suddenly found that "no one else was particularly interested in what I was doing." He finished his dissertation on a more conventional topic—hydraulic drag on dolphin skin—and abandoned his discovery as nothing more than a mathematical curiosity.

After earning his doctorate in mid-1999, Lisi glumly realized that postdoc research would require working on string theory, the dominant unifying idea in physics for the past decade. If you got into physics in the nineties looking for a theory of everything, string was the place to be. To skeptics, however, the theory had become a kind of mathematical Rube Goldberg machine, with strange parts and ideas welded on to keep it viable. Its researchers postulated the existence of half a dozen or more additional physical dimensions, folded up inside the ones we know about but well beyond our capacity for measurement. Lisi considers string theory "overly speculative." Even its proponents admit it might be impossible to confirm experimentally.

> "I've tried to make the rest of my life good enough that even if the physics theories don't work out, it wasn't a waste of time."

Like most theoretical physicists, Lisi requires few tools to do his work, which mostly entails reading, doing calculations, and just plain thinking. So, backed by a nest egg of Ph.D. stipend money he'd invested in Apple, he moved to Hawaii with a friend, Brandyn Webb—a computer scientist who shares his intellectual and independent streaks—to surf and contemplate physics on his own.

"There's an academic establishment that almost values conformity over ingenuity, and he wouldn't conform," says Stephen Applebaum, a doctoral classmate who now works for a medical-device company in San Diego. "He was certainly one of the most gifted people, but he hasn't always been the best at applying himself. Something really has to interest him."

Lisi and Webb became what Webb describes as "freelance perpetual grad students." They mixed serious research (Webb wrote computer-science algorithms while Lisi continued probing the universe) with a taste for adventure, exploring Maui's big waves on surf- and sailboards. Reichart Von Wolfsheild, a Maui-based computer scientist who has been Lisi's friend for nearly a decade, still chuckles when he recalls meeting the pair. Walking on the beach one afternoon, he saw two men with surfboards, deep in conversation. "Even at a distance," he says, "something suggested that these guys don't belong on the beach." As he approached, he noticed that one board was covered in arcane symbols:

$$\nabla^2\Psi = \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\Psi$$

For years, Lisi had been having a board shaper adorn his surfboards with the mathematical description for the propagation of waves.

"You meet certain people," Von Wolfsheild says, "and you realize instantly that you are going to be friends." He joined Lisi's growing circle of thrill seekers and intellectual enablers and was soon inviting him to house-sit at his home north of Lahaina, where Lisi could access the legendary breaks at Honolua Bay.

"I would never go out there," says Von Wolfsheild. "Garrett's got way more balls than I've got. He's happiest when he's falling down in water."

IN 2002, LISI SUCCUMBED to island fever and relocated to Breckenridge, Colorado, where he taught snowboarding. He rode an extra-long carving board and was known for bombing down slopes in a lab coat. Because he tends to think most clearly early in the day, which also happens to be when conditions are best for surfing and snowboarding, Lisi typically alternates mornings between recreation and work—the former a head-clearing jaunt that enables him to dive happily into the latter. It was in the shadow of the mountains that he began making progress on unifying gravity with the Standard Model, the collective name for the three subatomic forces and their interactions with matter.

Lisi's first significant insight came from an obscure formulation of gravity he found in a paper by Lee Smolin. Instead of viewing gravity, as Einstein had, in terms of how matter disrupts spacetime—the frequent analogy is a bowling ball on a trampoline—Smolin and two colleagues had revived an unusual description involving the connection between moving shapes. That's the kind of gravity a snowboarder can get behind. And by looking at it in this way, Lisi was able to combine gravity and the Standard Model into a crude geometric structure. "But," he says, "I didn't know what the heck it was."

Restless again, Lisi decided to head back to Maui in 2004, in true drifter style. Before leaving, he bought a white utility van, tore out the seats, and outfitted it with a sleeping platform, 12-volt shower pump, sink, stove, and surfboard storage. Around the same time, he started dating Crystal Baranyk, an artist he'd met online. "We were just starting to get to know one another," recalls Baranyk, who's been with Lisi for four years now. "He said, 'Do you want to go live in a van?' And I said, 'I guess I'll know if our relationship will work out, so better now than later.' " They shipped the van to Maui and lived wherever the surf took them.

In Maui, Lisi continued to explore the questions his Breckenridge insight had raised. But physics theories don't buy food, so he and Baranyk scraped together a piecemeal income. Lisi worked as a script consultant for a Hollywood sci-fi movie—still in development—involving spaceships with fusion drives. Von Wolfsheild hired him to create probability tables that predict payout rates for Las Vegas poker machines. Baranyk sold paintings and worked as a hiking guide. Lisi also took a job teaching introductory physics at a branch of the University of Hawaii.

Through it all, he stayed busy piling up adventures, many of which he gleefully chronicled on his Web site, sifter.org/~aglisi: kitesurfing on a skateboard; scaring off car strippers trying to steal parts from his van; hiding from park rangers looking to evict him and Baranyk; snapping his surfboard while diving through triple-

overhead swells and getting swept so far down the coast he had to hitchhike back, his face bloodied. One of his most enthusiastic posts is about getting his ass kicked in chess by a naked man on a life-size board, during one of his frequent visits to Burning Man.

"I've tried to make the rest of my life good enough that even if the physics theories don't work out," he says, "it wasn't a waste of time."

BY 2006 LISI WAS "damn near broke" and still lacked a cohesive theory. Then he heard that the Foundational Questions Institute, a U.S. group that funds theoretical research, was offering grants for research into "new frontiers" of physics. He threw together an application in a last-ditch effort to make good on seven years of solitary scribbling. A rejection, he mused on his Web site, "will probably really mean my work just isn't that good."

Instead, the institute selected Lisi's proposal, along with those of 29 other applicants from places like Harvard and MIT. Lisi was the only researcher not housed at a major university or institute.

"We never want to forget that Albert Einstein wasn't working in academia when he discovered the theory of relativity," says Max Tegmark, an MIT physicist and the institute's director. "It's important to gamble, because sometimes long shots can turn out to be home runs." Lisi got $77,000 for two years. Upon receiving his first research check in a decade, he bought the most valuable research tool he could think of: a new mountain bike.

He and Baranyk stashed their van in Maui and drifted to Tahoe, where friends loaned them a house above the lake. It was there, early last year, that Lisi stumbled onto his second significant insight. Up one morning reading mathematics blogs, he came across a posting by John Baez that described an elaborate, three-dimensional algebraic structure called E_8 that, when projected in two dimensions, looks like the world's most elegant Spirograph. E_8 is one of a number of complex symmetrical shapes discovered in the late 1800s. With 240 separate vertices, it is so complicated that it recently took a team of 18 mathematicians four years to do a formulation based on the E_8 equation.

Lisi studying wave theory in Hawaii.

> "Deep down, everybody wants to do what they want to be doing. But they feel that they can't. It just takes some sacrifices."

When Lisi saw Baez's posting, he realized instantly that E_8 matched the rough model he'd been building since Breckenridge. "It was the most stunning thing I could ever ask for," he says. "I walked around with my brain tickling, thinking, This is going to work."

He began doing the calculations to map some of the 226 known subatomic particles and forces, together with gravity, explicitly onto E_8. The math seemed to hold, at least for what are known as "first-generation" particles. (Most subatomic particles have three variations, called generations. First-generation particles make up everyday matter, while the others show up only at extraordinarily high energies.) When Lisi rotated the shape or added together its points, the mathematical results matched the properties already discovered at particle accelerators, where physicists bash matter together to test theories about forces and sub-particles. On the E_8 model, there were 20 points left over, perhaps representing particles yet to be discovered. An E_8 model of the universe, Lisi concluded, had the potential to be proved or disproved by the discovery of these unknown particles.

After communicating with several physicists, he went to an academic conference last June in Morelia, Mexico, and met Smolin. This was followed by a presentation at the Perimeter Institute, which is dedicated to nonestablishment physics research. "The talk was very clear, and he emphasized the open issues and the high-risk nature of things," says Smolin. "He knew he was putting forward something that, if correct, is highly interesting, but he did it cautiously and modestly." Buoyed by the reception, Lisi was stoked enough to post the paper online.

THE SHITSTORM BLEW IN the moment the paper hit the Web. First, the managers of arxiv.org recategorized Lisi's paper from the respectable "high energy" section to the "general" area, a graveyard for laymen and quacks. They subsequently returned it, but the shuffling foreshadowed difficulties to come. On November 15, an article appeared in *New Scientist,* a respected British science magazine, describing the paper and mentioning Lisi's unusual background. Within days, the story spiraled across the globe, from the *Daily News & Analysis* in Bombay to Fox News here.

The media explosion drew the attention of physics blogs devoted to disputes over the latest research. For many theoretical physicists, a lifetime's work on a theory—combined with a high danger of ending up wrong—necessitates serious emotional investment. So the decibel level of criticism, especially online, tends to start at 11.

Most of the broadsides simply echoed problems Lisi himself had admitted in the paper, like the incorporation of only first-generation particles. But some people simply waved it off. The truth is, most theoretical physicists can't be bothered to

CRYSTAL BARANYK

sort out Lisi's theory until he solves its problems.

"Lisi's paper seems to me to be pretty much nonsense," responded Sheldon Glashow, a Nobel Prize–winning physicist from Boston University, when I e-mailed him about Lisi. "I have no interest in discussing it or in enhancing the idiotic hoopla about it."

More sanguine researchers, however, argue that Lisi's approach is both intriguing and elegant, and that it lacks any glaring, fatal flaws. "No one has come up with a theory that works yet. It's the same for all of us," says John Donoghue, a theoretical physicist at the University of Massachusetts Amherst. "It's premature to canonize him but premature to say he's barking up the wrong tree."

Smolin has already posted a paper online building on Lisi's, offering a simpler way to formulate some of Lisi's math. "I don't see it as a finished theory," he says of Lisi's formulation. "I see it as some mathematical observations and then a proposal."

What's required to make it work, according to Lisi, is a combination of mathematical grunt work and a new insight or two. "The main problem is finding how the second and third generations work. If you try any of the obvious ways to make them fit, it doesn't work. So it has to be nonobvious." If he can solve that, E_8 would allow him to predict the properties of some of the 20 unknown particles. The ultimate proof, or disproof, could then come when the world's most powerful particle accelerator, the Large Hadron Collider, begins operating later this year in Switzerland. It is widely anticipated that the LHC will lead to the discovery of new subatomic particles, and string theorists are also betting on it to validate some of their ideas.

"Right now there is no experimental reason to have confidence in this theory—for the same reason that there is no experimental reason to have confidence in string theory," Lisi says. "Either the numbers that come out of the geometry are going to match up with these physical constants, or they are not. If they don't, then the theory is wrong. That's all there is to it."

BACK IN TAHOE, Lisi seems worn down by the attention. "It stresses me out that some people are very angry. I'm not used to having enemies," he says between slices of homemade pizza. "There is a lot of press saying, 'He is the next Einstein, he has solved everything!' It's probably bad for this theory, and for me personally, that it got this much attention."

Still, he admits to enjoying the encouraging e-mails. ("Nice work, man!" read one physics student's message. "I am trying to digest your theory right now . . . it's coming in focus slowly.") "Deep down, everybody wants to do what they want to be doing," Lisi says. "They just feel that they can't. So I think they find it kind of inspiring to see that it's possible. It just takes some sacrifices."

The next afternoon, Lisi suggests we go mountain biking on the Tahoe Rim Trail. Despite the early winter chill, he shows up wearing tropical-print boardshorts. He rides with a kind of fearless joy, tearing down the trail at questionable speeds, whooping as he weaves between boulders, and soon disappearing ahead. When I finally catch up, Lisi has paused to check out a sweeping view of the valley. "Not bad, eh?" he says. "It's doing things like this that keep me from ever wanting to have a real job."

Right or wrong, Lisi offers a different approach to work and ambition—one that is potentially more valuable than an improbable, inscrutable theory of everything. "To my perception, Lisi hasn't advanced the story," says MIT physicist Frank Wilczek, a Nobel Prize winner. "That said, I admire people who think for themselves and dare to take on reality directly rather than writing footnotes to fashionable literature. So I hope he keeps trying and inspires others."

For now, at least, Lisi is no longer working alone. Other researchers have taken up parts of the E_8 theory to investigate, and Lisi says he'd consider a temporary academic post—if it were near decent snow or surf. "I've gotten e-mails asking, 'Are you taking students?' " he says. "Well, come visit and I'll be happy to talk to you. But I'm not a degree-granting institution. And I don't want the surf breaks to get more crowded."

The danger of working out on the solitary edge of human thought, of course, is that the sharpest minds still need a check against self-delusion. Even the smoothest-seeming face can be plagued by hidden reefs. "It could be nature's big joke on me," Lisi says. "Sometimes we see patterns that aren't there. But it's certainly an adventure to think about. There aren't that many frontiers left in our world." o

SAN FRANCISCO–BASED EVAN RATLIFF IS A CONTRIBUTING EDITOR AT *WIRED*.

The Idiot's Guide to Incomprehensible Physics

Just nod and pretend you understand

GRAVITY

Gravity is the mysterious force that makes all objects with mass attract each other. It explains why apples fall from trees and why you can't dunk. Einstein ascribed it to a distortion of space-time, a theory that holds true as long as you're talking about "big" stuff—from snowflakes on up to the cosmos.

THE STANDARD MODEL

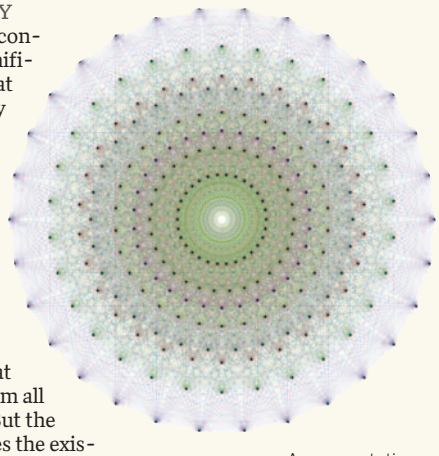
Gravity is too weak to explain the strong bonds between subatomic particles. Break gravity, you get NASA. Break the nucleus of an atom, you could get an atomic bomb. Researchers have defined three forces—electromagnetism, the strong force, and the weak force—that hold atoms together and regulate their decay. The catch is that the theory, known as the Standard Model, can't account for gravity.

STRING THEORY

This is the leading contender for grand unification, a theory that would bring gravity and the Standard Model together into one happy package. It holds that at the core of every subatomic particle there are much, much smaller vibrating entities called superstrings , and that their vibrations form all energy and mass. But the theory also assumes the existence of nine or more dimensions of space, a concept that, so far, renders much of it untestable.

E_8

With 248 individual coordinates, E_8 is one of the most complex symmetrical shapes possible. (Many equations can be mapped out geometrically, and if the math behind E_8 were written in newspaper type, it would cover an area the size of Manhattan.) Physicists routinely use shapes to construct theories and probe relationships. Garrett Lisi noticed similarities between the equations of E_8 and his own work on grand unification. By plotting particles and forces on various coordinates, he started generating potentially testable results that suggested an underlying mathematical structure to the universe.—JOE SPRING



A representation of E_8