Experimental clues have yet to produce a 'tsunami moment' that provides a glimpse beyond the equations of particle physics formulated in the 1970s. But physicists are hoping for something bizarre.

Physics awaits new options as Standard Model idles

For most of us, any physics is new physics.

Having stopped paying attention somewhere back around "for every action there is an equal and opposite reaction" or the discovery that you can make sparks by shuffling your feet on the carpet and then touching a doorknob (or another person), we amateurs respond with the same glazed mixture of wonder and incredulity to the latest abilities of computer chips or the expansion of the universe.

For us, the world is constant naïve novelty. The same cannot be said for professional physicists, the ultimate insiders.

Forget the lifetime tenure, the travel, the six-figure book contracts—what professional physicists live for is the tsunami moment when they know something that nobody else has ever known, the revelatory flash of a new glimpse into the workings of what Stephen Hawking, the Cambridge University cosmologist, called "the Mind of God."

Alas, God, as reflected in the known laws of physics, hasn't gotten any smarter since the 1970s. It was then that particle physicists put the finishing touches on the Standard Model, a collection of theories describing all the physical forces except gravity.

They have been stuck in that model, like birds in a gilded cage, ever since. The Standard Model agrees with every experiment that has been performed since. But it doesn't say anything about the most familiar force of all, gravity. Nor does it explain why the universe is matter instead of antimatter, or why we believe there are such things as space and time.

"Is there physics beyond the Standard Model?" runs the refrain often repeated by David Gross, the director of the Kavli Institute for Theoretical Physics and a co-winner of the 2004 Nobel Prize for his part in constructing this mathematical edifice.

Physicists presume that the answer is yes, that some more overarching theory should explain these and other mysteries. But lacking any loose ends to grab hold of, no discrepancies from the predictions wrung from the Standard Model, they have no experimental clues as to what that theory might be.

Every once in a while there is a hint of progress and revolution in the air—new physics that would impress the professional as well as awe the layman—like a faint jingle of music drawing you down the street. You briefly feel young and limitless. You feel as if you might walk past an open window and hear "Sgt. Pepper's Lonely Hearts Club Band" playing again.

Then the feeling vanishes. It happened this spring when two teams of physicists at Fermilab succeeded in measuring a particularly odd schizophrenic particle, known as the strange neutral *B* meson, that flips back and forth between being itself and its own opposite antiparticle three trillion times a second. Weird as that behavior is, it was right on the money as predicted by the Standard Model.

"Our real hope was for something bizarre," admitted Young-Kee Kim of the University of Chicago and a spokeswoman for one of the Fermilab teams. In an email message later, Dr. Kim said that she was undaunted. "We are explorers," she said, "and I cannot imagine how exciting it will be when we get even one step closer to true nature!! This belief and this desire is so huge that we will never give up."

Physicists have high hopes that some new physics will begin to reveal itself when they fire up the world's largest particle accelerator, the Large Hadron Collider at CERN outside Geneva in November next year, although the laboratory just announced that the accelerator would not be running at full strength, colliding protons with seven trillion electronvolts of energy, until 2008. If the physicists are lucky, in addition to the last piece of the Standard Model, a character known as the Higgs boson, new particles not produced since the big bang could eventually come spitting out.

Now you may think that the last thing the world needs is a new elementary particle with another cute annoying name, and physicists agree. What's exciting about the particles, they say, are not the particles, but the new laws of nature they manifest. If you are of a certain rock 'n' roll age, you might not think the universe needs any new laws either.

Unlike, say, in the tax code, however, in physics new laws are more elegant and economical than the ones they replace. For the last century they have usually involved new symmetries that

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nature seems sworn to uphold—things that don't change when we view the universe from different perspectives.

Physicists have one more symmetry card to play, a concept known as supersymmetry. If this notion is right, there is a whole new population of particles, so-called superpartners to the ones we already know and puzzle about waiting to be discovered.

The problem is that according to some versions of supersymmetry, the effects of these particles, if not the particles themselves, should already be showing up in delicate experiments like the flip-flopping meson. There are thousands of versions of supersymmetry, but the fact that nothing has shown up yet has caused "a growing tension in the field," said Nima Arkani-Hamed, a particle theorist at Harvard.

Dr. Arkani-Hamed admitted, "My nightmare is that we see nothing at all besides the Higgs," in the new collider.

Meanwhile, something bizarre really has shown up. It just hasn't been in a form that physicists can test and play with. Eight years ago two teams of astronomers discovered that the expansion of the universe was speeding up, in defiance of cosmic gravity and of what might be left of common sense. The universe apparently is its own antigravity machine.

That might be weird enough, and deserving of tabloid headlines, except it apparently happened before. New studies reported last spring of relic radio waves left over from the waning days of the big bang have reinforced, but not yet conclusively proved, the idea that a violent antigravitational force known colloquially as inflation held sway in the first moments of time, stretching and bubbling the cosmos into roughly the shape we see today.

Whatever bubbled and stretched the cosmos is beyond the ken of the Standard Model. Inflation is new physics, Sean Carroll of the University of Chicago explained in a recent email message, adding, "Anything other than inflation would be even newer physics!"

So, yes, there is new physics out there. The question is whether it will ever be put together into the neat mathematical package that would have impressed Einstein.

It may be asking too much of a theory of physics to explain the world. I don't expect physicists to tell me the meaning of life, I just want something to tell my kid.

In words that still haunt me, Lee Smolin, a physicist at the Perimeter Institute for Theoretical Physics in Ontario, once wrote, "When a child asks, 'What is the world?' we literally have nothing to tell her."

Some theorists think they have an answer, namely that the world is made up of tiny vibrating strings. As of now, however, there is scant evidence other than the beauty of their equations that the string theorists are right.

My own daughter, Mira, just turned 4 and she is not asking me what the world is made of, quite yet. I've managed to keep ahead of her so far, if only by reading a page ahead in the dinosaur books that occupy bedtime, but the time is coming when she will be calling me and the world's physicists to account.

When she does, I would like to have something to tell her, and myself.

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