AN OLD MAN'S TOY

Gravity at Work and Play in Einstein's Universe.
By A. Zee.
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By Marcia Bartusiak

EINSTEIN smiled. In 1955, on his 67th birthday, a neighbor presented the illustrious physicist with an odd, makeshift gift. A small brass ball, attached to a string, hung limply outside a metal cup. The string, after passing through the cup and down a pipe, was tied to a weak spring. The entire assembly was mounted atop a five-foot-long rod. The challenge, it was announced, was to figure out a way to pop the ball into the cup each and every time.

Einstein immediately recognized the trick: thrust the rod toward the ceiling and drop it, so that in free fall, with gravity's pull on the ball nullified, the spring could snap the ball into place without fail. Indeed, a similar musing, decades earlier, allowed Einstein, as Anthony Zee puts it, "to glimpse the profound mystery of gravity with its astonishing connection to space-time itself."

With this winsome anecdote, Mr. Zee begins his authoritative examination of nature's weakest force, the one we most take for granted. "No sooner had we come into existence," he writes in "An Old Man's Toy," "than we became aware of the downward pull of gravity, balanced by the buoyancy of the fluid inside our mothers' wombs. Yet we do not know gravity. . . . We know gravity by happenstance."

Sir Isaac Newton, of course, was the first to tame gravity. As the story goes, the fall of an apple allowed him to realize that the downward pull, so long a puzzle, obeyed a well-defined set of rules. Even more exciting, these laws were universal. The force that keeps our feet firmly planted on terra firma is the identical force that keeps the planets attracted to the sun. With Newton, humanity came to see that the same laws of physics govern both the heavens and the earth.

Einstein, however, turned gravity on its head, starting with one deceptively simple thought. "If a person falls freely," he realized in 1907, while still working as a lowly employee in a Swiss patent office, "he will not feel his own weight." From this strange inkling, and nearly 10 years of difficult reasoning, would come Einstein's revolutionary theory of general relativity, which intimately intertwines gravity with mass, energy, space and time.

Gravity was finally recognized for what it was: Massive objects are simply indenting space-time, so that people are attracted to the ground and planets are held in orbit by following the natural depressions in this "landscape" of space. Moreover, Einstein's equations brilliantly showed how the acceleration of an object can produce effects indistinguishable from gravity, an idea known as the equivalence principle. Mr. Zee aptly demonstrates how Einstein's work carried with it "a sense of the inevitable." This was a rare case in which the elegance of the theory captivated people. Many physicists were convinced of the truth of general relativity by the beauty of the mathematics before complete experimental proof was in.

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As in his earlier book, "Fearful Symmetry: The Search for Beauty in Modern Physics," Mr. Zee divides each of his chapters into a series of succinct segments, some only a few paragraphs long. The subheadings, often enticing and entertaining, include "Hedgehogs in the Early Universe," "After the Hot Parties," and, my favorite, "Once an Arnold Schwarzenegger," in which he describes the infinitesimal moment during the universe's infancy when gravity was the most powerful force around. Such a format is good for short, refreshing dips of reading over time. It's as if Mr. Zee is conducting an easygoing conversation with his audience, whom he envisions as the intellectually curious lay reader.

A professor with the Institute for Theoretical Physics at the University of California in Santa Barbara, where he ponders both gravity and the unification of the forces, Mr. Zee is a scientist who can clearly evoke the imagery hidden within a mathematical equation, treating some rather formidable material with enthusiasm and delight. "When my son Andrew was about four years old, he asked me whether gravity or Superman were stronger," recalls Mr. Zee. "Clearly, I replied, Superman's got to be stronger, since he can zip away from the earth's gravity at a moment's notice. But on second thought, is Superman strong enough to move galaxies around? Can Superman rein in the expansion of the whole universe?" Such personal reminiscences, as well as original analogies, are liberally sprinkled throughout the text.

Gravity, feeble as it is, becomes the most important force over expanses as vast as the universe. Hence, Mr. Zee appropriately devotes the bulk of his book to cosmological concerns. In this arena he sometimes writes more like an acquaintance of his material than one of its intimate associates, perhaps reflecting the fact that astrophysics is not his specialty. "The passion of the fundamental physicist," he confesses in his preface, "lies more with the mystery of why we fall than with the life of the universe." Cosmology is also a topic that has already been well mined by a host of books in recent years.

Yet what Mr. Zee offers is a new perspective — a physicist's distinct vision — that adds to the discussion, more than it repeats. "An Old Man's Toy" is a fitting companion to Mr. Zee's earlier book. Where "Fearful Symmetry" moved inward, focusing on modern physics's search for the fundamental tapestry whose weave reveals the varied forces and particles of nature, "An Old Man's Toy" joyfully springs outward to the universe at large.

On the discovery by Arno Penzias and Robert Wilson at Bell Laboratories of the sea of microwave photons left over from the Big Bang, Mr. Zee writes with wry, poetic humor: "Thus those mighty photons, once able to tear atomic nuclei apart with their bare hands, were reduced to portraits in aged frailty. Drifting through the eons and traveling the lengths of the universe, only to end up in New Jersey. What a fate, eh?"

These engaging monologues, alas, are distributed unevenly. Later in the book, for instance, readers are expected to consider such arcane concepts as "nonsymmetrical internal space" and theories of force involving many dimensions, not just the familiar three, with few comparative references to help them along.

Perhaps easy explanation is an insuperable task, what with physicists entering realms far removed from our daily experience. For Mr. Zee, who as a student switched from pure mathematics to physics, it's an ironic turn of events: "I told my math professor Ralph Fox that I was going into physics since I can't possibly visualize knots in high-dimensional spaces. Twenty years later, I am now struggling to visualize bizarre beasts in ten-dimensional space. Ralph would have liked that."

Mr. Zee leaves no cosmological stone — from the evolution of the Big Bang to the formation of galaxies — unturned, and sometimes his discussions can turn too brisk and technical. Yet, with his conversational approach, he manages to turn off the main road occasionally and wander down pathways loosely connected. He ponders why the sky is dark at night (hint: not because the sun goes down) and provides glimpses of some of astronomy's most notable figures, such as Milton Humason, a mule driver who hung around California's Mount Wilson observatory in the second decade of this century to court an engineer's daughter, only to become the observatory's most skillful galaxy surveyor.

In the end, the author returns from the far reaches of the cosmos to contemplate the latest views of physicists on gravity. This part is the book's most intriguing fare. He tantalizingly suggests that gravity may not be a fundamental force after all, but instead the manifestation of some deeper, underlying principle, a radical idea that Mr. Zee himself is working on. One wishes he had expanded on this all-too-brief section.

Answers may arrive when physicists at last find the means to marry gravity, a force whose tendrils span the width of the known universe, with the far tinier domain of quantum physics. Here, the idealists in theoretical physics are battling it out with the experimentalists.

SUPERSTRING theory, one of physics's hottest topics, hawks the idea that the ultimate bits of matter are not really pointlike particles but rather tiny, wiggling loops of string. Unfortunately, even the most powerful particle accelerators imaginable would be helpless in searching for these threadlike entities. Can beauty alone serve to convince once again, as it did with Einstein's theory?

Cracks are appearing. The standard models in theoretical physics could totter under the weight of what Mr. Zee calls the "biggest error in the history of physics": astronomical observations suggest that the cosmological constant — a sort of gauge of the energy in empty space — is nearly zero. On the other hand, particle physicists predict it should be, in Mr. Zee's words, "about 10^{123} times the maximum value that the astronomers tell us [it] can possibly have," a number so far removed from everyday experience that it defies description (10^{123} indicates 1 followed by 123 zeros; a trillion has only 12 zeros). After all, there are "only" some 10^{88} particles of light and matter in the entire cosmos. From such paradoxes, revolutions arise.

The difficulty physicists are having in joining gravity with the other forces in a unified theory suggests that there are more secrets to be discovered in the frightful clash of gravity with the quantum. If they succeed in our lifetime, we can hope that Mr. Zee will write "Toy II, the Sequel." □

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