Einstein’s Grand Quest for a Unified Theory

By Tim Folger

Einstein was at the Institute for Advanced Study in Princeton, New Jersey. Yet both men were outsiders of a sort. In his later years, Einstein had become increasingly isolated from the mainstream physics community, refusing to embrace the strange but powerful theory of quantum mechanics—with its particles that are also waves and that transform simply because they’re observed. Nature, he argued, couldn’t be so perverse.

So for nearly 30 years he had pursued what most physicists considered a quixotic goal: the creation of a unified field theory to describe all the forces of nature.

That was the occasion for Moffat’s letter. He thought he could offer Einstein some constructive criticism. “I wrote him to say that I wasn’t happy about what he was doing,” Moffat recalls. There was nothing unusual about this. Plenty of people sent letters to Einstein, not all of them rational. But in Moffat’s case something unexpected happened: Einstein wrote back.

“Dear Mr. Moffat,” the reply began. “Our situation is the following. We are standing in front of a closed box which we cannot open, and we try hard to discover what is and what is not in it.” That closed box is the universe, of course, and no one had done more to pry off the lid than Einstein. Yet in the eyes of nearly all his colleagues he had contributed almost nothing of importance to physics for almost 20 years.

Were they right? Did he squander his genius by chasing vainly after an ultimate theory? That is the conventional view. But at least a few physicists now argue that Einstein was far ahead of his time, raising questions that will challenge researchers for decades.

“It’s often said that Einstein wasted his time later in life,” Moffat, who went on to become a theoretical physicist, says. “This of course is erroneous. Einstein never wasted his time.”

EINSTEIN’S SPLIT WITH MAINSTREAM PHYSICS came at the very height of his career. In 1927, when he was 48, the world’s leading physicists gathered at a conference in Brussels to
pose an infinite range. Einstein wasn’t alone in wanting to know what he was saying. “Einstein was confiding his problems in his office at Princeton,” physicist Carlo Rovelli says, “and a lot of physicists didn’t care about deep questions. They left the deep questions to Einstein.”

In 1939 the physicist J. Robert Oppenheimer used the theory of general relativity to show in detail how black holes could form. Yet Einstein conceived that he wouldn’t live to complete his theory. “I have locked myself into quite hopeless scientific problems,” Einstein wrote near the end of his life. “I have remained estranged from the society here.”

Einstein’s office at Princeton (left). “He was so always interested in deep questions,” physicist Carlo Rovelli says, “and a lot of physicists didn’t care about deep questions. They left the deep questions to Einstein.”

Einstein didn’t live to complete his theory. His work was not without promise at first. He was attempting to unite the force of gravity—which he had successfully described in his general theory of relativity—with the force of electromagnetism, and the two forces are similar in many ways. The strength of both, for instance, is inversely proportional to the square of the distance between two bodies, and both have an infinite range. Einstein wasn’t alone in his conviction that he could solve the problem of gravity-level material in about a year, then he moved on to professional physics journals. “I got hold of some of Einstein’s papers and decided that there was some weakness in what he was doing,” he says. “So I wrote two papers and sent them to him at Princeton. I never thought I’d hear anything from him.”

Einstein conceded that Moffat had a point. They went on to exchange several letters over the next six months, inspiring Moffat to pursue a career in physics. Although he lacked all formal training in the field, Moffat mentioned his interest in Einstein’s work. “He got very angry,” Moffat remembers. “He started shouting at me for his bad. He said Einstein was a fool. I was quite overwhelmed.”

What most enraged Schrödinger was that he, too, a decade earlier, had tried to develop a unified theory with an approach very similar to Einstein’s. But he had abandoned the effort when it became apparent to him that he was getting nowhere. He couldn’t tolerate Einstein’s refusal to do the same.

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Moffat went on to be accepted into the graduate program in physics at Cambridge University, thanks in part to Schrödinger’s strong recommendation. In 1958, he became the first student in the 800-year history of the school to earn his Ph.D. without...
first completing an undergraduate degree. Moffat now works at the Perimeter Institute near Toronto, Ontario—an iconoclastic veteran among some of the world’s best and bravest young physicists. If he was first drawn to Einstein by his mistakes, he now believes the old man may have been on the right path after all. He just started down it a few decades too soon.

In the 1930s, when Einstein began his work on the unified field theory, physicists believed that there were only two universal forces that the theory would have to unite: gravity and electromagnetism. They have since learned that there are two other fundamental forces as well: a strong force that binds atomic nuclei and a weak force that governs radioactive decay. “Einstein defined what later became a fundamental problem in physics,” says Carlo Rovelli, a theoretical physicist at the University of the Mediterranean in Marseille, France. “But he was missing an ingredient.”

These days Einstein’s once-lonely quest engages thousands of physicists around the world, most of them string theorists. While their work is grounded in quantum mechanics, it relies heavily on some of the same components that Einstein used. According to string theory, the fundamental constituents of the physical world are not pointlike particles, but infinitesimal, one-dimensional loops, or strings. All the particles and forces in the universe arise from these strings vibrating at different frequencies. But here’s the catch, and no doubt it would have made Einstein smile: The strings need 11 dimensions in which to vibrate. And these extra dimensions are described by essentially the same mathematics that Einstein used in his own five-dimensional unified field theory.

Moffat is not so sure that string theory is an improvement on Einstein’s ideas. But for much of the past decade he has returned to the theory that Einstein was working on when he died—the same one that prompted his fatal letter. Moffat argues that the mathematics Einstein hoped would describe electromagnetism in his unified field theory gives rise, instead, to a slight repulsion that a third star, unobserved as yet, is disturbing the orbit. But Moffat doesn’t think so. In his modified version of Einstein’s later theory, the gravitational pull between the two stars is weakened just enough to slow the stars’ orbits down a bit. By his new calculations, the precession agrees exactly with observations.

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Two thousand light-years from Earth, for instance, two young blue stars in a system called DI Herculis whirl about each other every 10.52 days. Their paths shift slightly from one orbit to the next—a phenomenon known as precession—but when astronomers use general relativity to predict this shift, their answers are off by a factor of four. Most astronomers believe that a third star, unobserved as yet, is disturbing the orbit. But Moffat doesn’t think so. In his modified version of Einstein’s later theory, the gravitational pull between the two stars is weakened just enough to slow the stars’ orbits down a bit. By his new calculations, the precession agrees exactly with observations.

There’s no small historical irony to all this. One of the first rigorous tests of general relativity was an observation of the precession of Mercury’s orbit around the sun. Before Einstein, most astronomers assumed, as with DI Herculis, that a third body would make the orbit conform to Newton’s equations. Some even claimed to have observed the mystery planet and have named it Vulcan. Einstein’s general theory of relativity made the third planet unnecessary.

Could the third star in DI Herculis turn out to be as illusory as Vulcan? If so, it would be very big news indeed. Moffat claims that his theory would eliminate the need for dark matter and dark energy—two phenomena, as yet undetected, that physicists have invoked to account for the motions of galaxies and expansion of the universe. It’s a long shot, Moffat says, but Einstein’s last theory may have some life in it yet.