Who Ordered the Muon?

THE HUNTING OF THE QUARK
A True Story of Modern Physics.
By Michael Riordan.
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By Marcia Bartusiak

BLAME Democritus. In the fifth century B.C., that prescient Greek philosopher started humanity on its search for the universe's ultimate building blocks when he suggested that all matter was made of infinitesimally small particles called atoms. In 1897, the British physicist J. J. Thomson complicated the issue when he discovered the first subatomic particle, the electron. Later, others recognized the proton and neutron. As atom smashers grew in the next few decades, myriads of ephemeral particles appeared in the debris, a veritable Greek alphabet soup of lambdas, sigmas and pions. "Who ordered that?" exclaimed the theorist Isidor I. Rabi when the muon was identified.

Confusion reigned until 1963, when the physicists Murray Gell-Mann and George Zweig independently surmised that many particles in this vast array were actually composites, each a different combination of smaller, more fundamental constituents. Mr. Zweig called these tiny entities "aces." Mr. Gell-Mann, on the other hand, in a fit of whimsy not unusual for particle theorists, labeled them "quorks" but slightly altered the spelling when he came across a passage in James Joyce's "Finnegans Wake": "Three quarks for Muster Mark!" Today quarks come in six "flavors" — up, down, strange, charm, top and bottom — a collection that allows complexity to be replaced with a wondrous simplicity. That was Mr. Gell-Mann's genius, writes Michael Riordan in "The Hunting of the Quark": "He could look at a pile of coal and see only diamonds."

Yet physicists were very reluctant to embrace these gems. It is now generally forgotten that the brilliant idea of Mr. Gell-Mann and Mr. Zweig was just one of a bewildering variety of theories then being advocated as the most basic form of matter. "It is a small miracle," Mr. Riordan notes, "that particle physicists could ever agree on one interpretation."

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Indeed, they were often swayed by trends. In the 1960's, the most fashionable theory was the bootstrap model, which declared that there were no fundamental particles, only an ever-percolating stew of mass energy. Sometimes this stew could taste like a proton, at other times a neutron; it was a nuclear democracy. Within such an egalitarian atmosphere, the concept of quarks was not greeted with open arms. Mr. Gell-Mann, in fact, thought of his creations as mere mathematical abstractions. To ascribe quarks material essence was heresy, a reflection of the eternal conflict between idealism and materialism. But the tide eventually shifted, partly because the supreme materialist of physics, Richard Feynman of the California Institute of Technology, a man once described as the Groucho Marx of physics, turned the quest for nuclear substructure into a cause célèbre.

Many books on the 20th-century revolution in particle physics focus on the startling new notions introduced. Not as much attention is paid to those who dirtied their hands, nursing crotchety accelerator instruments, in order to prove the conjectures. Mr. Riordan, a physicist affiliated with the Stanford Linear Accelerator Center, presents an authoritative account of this less-told tale. A veteran quark-stalker himself, he deftly combines his technical expertise with a journalistic flair, personally acquainting us with many of the men and women who joined in the hunt. "Although most of us then perceived it only dimly, if at all," he says, "we had been soldiers in a classic scientific revolution."

After a brisk and dutiful summary of particle physics in the first half of this century, Mr. Riordan hits his stride when he enters more familiar territory, particularly the pioneering explorations conducted in the late 60's and early 70's at the Stanford Linear Accelerator, "the knife that sliced open the subnuclear world." It was here, with Mr. Riordan participating as a graduate student, that the first hints of a quark's existence were uncovered, and on a machine that was considered second-rate at the time.

According to Mr. Riordan, he and his colleagues were like blind men playing billiards. Experimentalists couldn't hope to "see" a quark — forever trapped in a subnuclear prison — but they could search for its distinctive signature amid particle ratios, scaling violations and energy plateaus. Proof would come in the way an electron, hurtled down a narrow tube miles long at speeds near that of light, slammed into a proton and recoiled from the fateful collision.

Mr. Riordan provides us with a riveting climax when he recounts how two research teams — one at Brookhaven National Laboratory on Long Island, the other at Stanford — in a photo finish snared the most valuable catch of the era: the J/psi, a particle that cornered the elusive fourth quark, charm. Here are the missed opportunities, blind alleys and intense rivalries that almost always precede a triumph — and a Nobel Prize, for the American physicists Burton Richter and Samuel C. C. Ting.

FOR those fluent in the language of this esoteric field, "The Hunting of the Quark" is a cogent and lively portrayal of the varied tests that finally led to acceptance of the quark as a bona fide particle. Mr. Riordan has a knack for the original analogy: probability waves in quantum mechanics are compared to crime waves, while the creation of particles out of nothingness, a standard trick of the microcosm, is likened to a grand case of embezzlement.

For the uninitiated, however, the author's casual references to current algebras, Feynman parameters and broken symmetries can be overwhelming at times. Readers who are unfamiliar with such jargon will assuredly flounder, perhaps because particle physicists must deal with certain ideas — for example, Planck's constant, fractional electric charge and an uncertainty principle — that have no equivalents in our everyday world. The objects they study, Mr. Riordan points out, "are quirky at best; if you try to examine one too closely, it leaps away from your scrutiny. Objectivity evaporates into a mystical sigh." Yet even with this difficulty, Mr. Riordan enables us to behold exactly how physicists work and the tortuous paths that experimentalists must travel to gain just a scrap of insight into the puzzling laws of nature.

Revolutions are never tidy. Mr. Riordan admits the possibility that deeper investigations into the heart of matter — the "cosmic onion," as he puts it — may go on endlessly. Faint whispers of something called a preon, an even smaller hypothetical building block, can already be heard in physics department corridors. What has Democritus wrought? ■

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