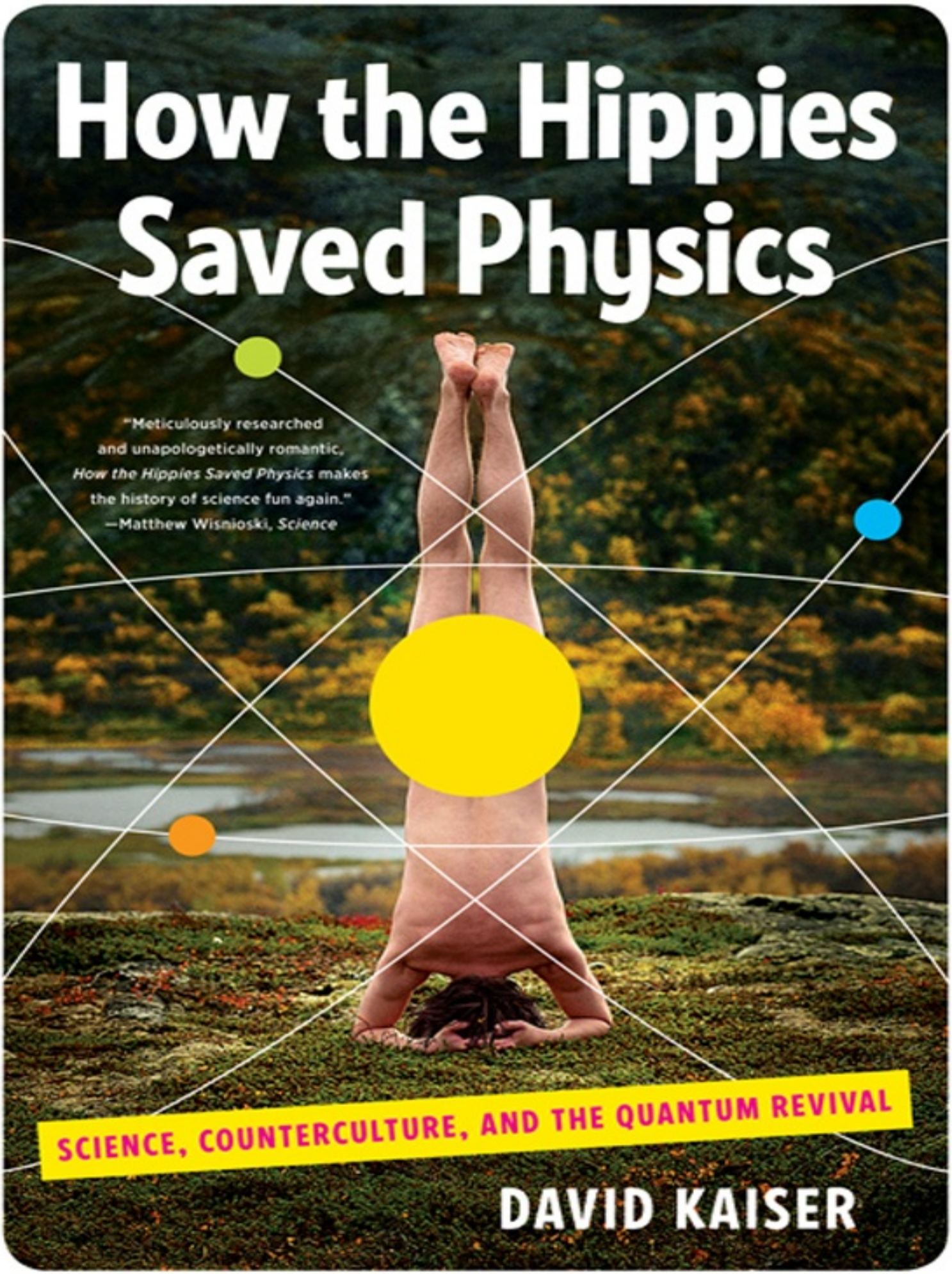
How the Hippies Saved Physics



"Meticulously researched and unapologetically romantic, *How the Hippies Saved Physics* makes the history of science fun again."
—Matthew Wisnioski, *Science*

SCIENCE, COUNTERCULTURE, AND THE QUANTUM REVIVAL

DAVID KAISER

SCIENCE, COUNTERCULTURE, AND THE QUANTUM REVIVAL

DAVID KAISER

W. W. Norton & Company
NEW YORK • LONDON

To the memory of my father, Richard A. Kaiser.
He was no hippie.

There must be thousands of young persons whose nervous systems were expanded and opened-up in the 1960's and who have now reached positions of competence in the sciences…. We expect the new wave of turned-on young mathematicians, physicists, and astronomers are more able to use their energized nervous systems as tools to provide new correlations between psychology and science.

—Timothy Leary, 1977

Table of Contents

Introduction

To most residents of Vienna, April 21, 2004, probably seemed like any other spring day in the Austrian capital. Students mulled over books in cafés; tourists delighted in the Hapsburg-era gardens museums, and opera houses; and businesspeople scurried through their appointments. Amid the bustl however, something magical happened. The city's mayor and the director of one of the city's largest banks collaborated on a breathtaking experiment. Working with physicists from the University of Vienna and a spin-off company, the mayor and banker performed the first electronic bank transfer using quantum cryptography. Specially prepared beams of light transmitted an unbreakable code—ar encryption key—between the bank's branch office and city hall. If anyone else had tried to listen in o the signal, the eavesdropping would have been detected easily and unambiguously. More important, any attempt to breach security would have destroyed the sought-after signal, scrambling it into harmless, random noise. With these safeguards in place, the mayor's money wire went through without a hitch.[1]

Three years later, residents of Geneva, Switzerland, participated in a similar feat. Government officials, in cooperation with their own local physicists, employed quantum encryption to protect the transmission of electronic votes cast in the Swiss national election. As in Vienna, the communication remained perfectly secure. The laws of physics had made sure of it.[2]

Advances like these belong to the fascinating, flourishing field of quantum information science. An amalgam of topics with funny-sounding names—quantum computing, quantum encryption, quantum teleportation—the field sounds more like *Star Trek* with each passing year. These days quantum information science sports a multi-billion-dollar research program, ten thousand published research articles, and a variety of device prototypes. The field has leaped to the cutting edge of physics, catapulted by palpable enthusiasm among research scientists, industrial partners, and government agencies around the world.[3] Breathless coverage of the field can be found everywhere from the *New York Times* and the *Wall Street Journal* to *Wired Magazine* and *BusinessWeek*.[4]

The tremendous excitement marks the tail end of a long-simmering Cinderella story. Long befo the huge budgets and dedicated teams, the field moldered on the scientific sidelines. To make the latest breakthroughs possible, researchers needed to grapple with quantum theory, physicists' famously successful (yet infamously strange) description of matter and energy at the atomic scale. The equations had been around since the 1920s. But figuring out how to *interpret* those equations, to parse the symbols in words and scrutinize just what they implied about the mysterious workings of th microworld—that interpretive task had long since fallen out of favor. During the middle decades of the twentieth century, most physicists recoiled from such philosophical labor. They treated the interpretation of quantum theory as a fringe topic, a fine leisure-time diversion for retired researcher in their dotage, perhaps, but not the sort of activity on which rising stars should spend their time. Thirty years ago, readers who were interested in the unsettled debates over the interpretation of quantum theory had to hunt in some out-of-the-way places. In 1979, some of the most extensive coverage appeared in an unpublished memorandum from the Central Intelligence Agency and a feature article in *Oui* magazine. The latter—no publication of the French embassy—was *Playboy*'s answer to *Penthouse*. Both items focused on work by physicists at the center of this story. The porn magazine's discussion was by far the better researched and more accurate of the two.[5]

Lost from view in today's hoopla is a story, equal parts inspiring and bizarre, of scientific

striving in the face of long odds. The intellectual bedrock of quantum information science—the ideas that undergird today's quantum-encrypted bank transfers and electronic voting—took form in a settin that couldn't have been more different from the ivory tower of academe or the citadels of business an politics. In fact, the breakthroughs in Vienna and Geneva ultimately owe their origins to the hazy, bong-filled excesses of the 1970s New Age movement. Many of the ideas that now occupy the core o quantum information science once found their home amid an anything-goes counterculture frenzy, a mishmash of spoon-bending psychics, Eastern mysticism, LSD trips, CIA spooks chasing mind-reading dreams, and comparable "Age of Aquarius" enthusiasms. For the better part of a decade, the concepts that would blossom into developments like quantum encryption were bandied about in late-night bull sessions and hawked by proponents of a burgeoning self-help movement—more snake oil than stock option.

The woolly pursuits of the 1970s hearkened back to an earlier way of doing physics and of being a physicist. The roots of quantum information science stretch all the way back to the golden age of theoretical physics of the 1920s and 1930s, when giants like Albert Einstein, Niels Bohr, Werner Heisenberg, and Erwin Schrödinger cobbled quantum mechanics together. From their earliest wranglings, they found themselves tangled up with all sorts of strange, counterintuitive notions. Man have become well-known catchphrases like "wave-particle duality," "Heisenberg's uncertainty principle," and "Schrödinger's cat." Each signaled that atom-sized objects could behave fantastically different from what our usual experience would suggest. To Einstein, Bohr, and the rest, it seemed axiomatic that progress could only be made by tackling these philosophical challenges head on. Manipulating equations for their own sake would never be enough.[6]

That style of doing physics did not last long. The clouds of fascism gathered quickly across Europe, scattering a once-tight community. The ensuing war engulfed physicists around the world. Torn from their prewar routines and thrust into projects of immediate, worldly significance—radar, the atomic bomb, and dozens of lesser-known gadgets—physicists' day-to-day activities in 1945 bor little resemblance to those of 1925. Over the next quarter century, Cold War imperatives shaped not just who received grants to pursue this or that problem; they left an indelible mark on the world of ideas, on what counted as "real" physics. Physicists in the United States adopted an aggressively pragmatic attitude. The equations of quantum mechanics had long since lost their novelty, even if their ultimate meaning still remained obscure. The pressing challenge became to put those equations to work. How much radiation would be emitted from a particular nuclear reaction? How would electr current flow through a transistor or a superconductor? As far as the postwar generation of physicists was concerned, their business was to calculate, not to daydream about philosophical chestnuts.[7]

Before the war, Einstein, Bohr, Heisenberg, and Schrödinger had held one model in mind for the aspiring physicist. A physicist should aim, above all, to be a *Kulturträger*—a bearer of culture—as comfortable reciting passages of Goethe's *Faust* from memory or admiring a Mozart sonata as jousting over the strange world of the quantum.[8] The physicists who came of age during and after World War II crafted a rather different identity for themselves. Watching their mentors stride throug the corridors of power, advising generals, lecturing politicians, and consulting for major industries, few sought to mimic the otherworldly, detached demeanor of the prewar days. Philosophical engagement with quantum theory, which had once seemed inseparable from working on quantum theory itself, rapidly fell out of fashion. Those few physicists who continued to wrestle with the seemingly outlandish features of quantum mechanics found their activity shoved ever more sharply t the margins.[9]

Before there could be a field like quantum information science—and long before demonstration

like those in Vienna and Geneva could even be imagined—a critical mass of researchers needed to embrace a different mode of doing physics once more. They had to incorporate philosophy, interpretation, even bald speculation back into their daily routine. Quantum physicists needed to daydream again.

Rarely can we date with any precision the ebbs and flows of scientists' research styles or intellectual approaches. Yet these transitions—the how's and why's behind major shifts in a scientific field's reigning questions and methods—have long held a special fascination for me. We see laid bare in these moments a messy alchemy, intermixing the world of institutions with the world of ideas. Brilliant insights and dazzling discoveries take their place alongside political decisions, funding battles, personal rivalries, and cultural cues. These many ingredients combine to make one agenda seem worth pursuing in a particular time and place—and worth teaching to students—while quietly eclipsing other questions or approaches that had beckoned with equal urgency only a few years earlie

In the case of the interpretation of quantum mechanics, which ultimately spawned quantum information science, we may detect just such a seismic shift in the 1970s. The physics profession in the United States suffered the lashings of a perfect storm between 1968 and 1972. Internal audits at the Department of Defense led to massive cutbacks on spending for basic research, which had financed, directly or indirectly, nearly all graduate training in physics for decades. Desperate for mor soldiers to feed the escalation of fighting in the Vietnam War, meanwhile, military planners began to revoke draft deferments for students—first for undergraduates in 1967, then, two years later, for graduate students as well—reversing twenty years of draft policies that had kept physics students in their classrooms. Across the country, the Cold War coalition between the Pentagon and the universities crumbled under wave after wave of teach-ins and sit-ins, ultimately lost in a tear gas fog Amid the turmoil, the nation's economy slid into "stagflation": rising inflation coupled with stagnan economic growth. All at once, physicists faced massive budget cuts, a plummeting job market, and vanishing student enrollments.[10]

As the Cold War nexus of institutions and ideas collapsed, other modes of being a physicist crep back in. The transition was neither smooth nor painless. Caught in the upheavals, a ragtag crew of young physicists banded together. Elizabeth Rauscher and George Weissmann, both graduate student in Berkeley, California, founded an informal discussion group in a fit of pique and frustration in May 1975. From their earliest years they had been captivated by books about the great revolutions of modern physics: relativity and quantum theory. They had entered the field with heads full of Einstein styled paradoxes; they, too, dreamed of tackling the deepest questions of space, time, and matter. Yet their formal training had offered none of that. By the time they entered graduate school, the watershe of World War II and the hyperpragmatism of the Cold War had long since shorn off any philosophica veneer from physics students' curricula. In place of grand thoughts, their classes taught them narrow skills: how to calculate this or that physical effect, rather than what those fancy equations might portend about the nature of reality.

The two students had ties to the Theoretical Physics Division of the Lawrence Berkeley Laboratory, a sprawling national laboratory nestled in the Berkeley hills. They decided to do for themselves what their teachers and textbooks had not. Reserving a big seminar room at the lab, they established an open-door policy: anyone interested in the interpretation of quantum theory was welcome to attend their weekly meetings, joining the others around the large circular table for free-ranging discussions. They continued to meet, week in and week out, over the next three and a half years. They called themselves the "Fundamental Fysiks Group."

Their informal brainstorming sessions quickly filled up with like-minded seekers. Most membe

of the Fundamental Fysiks Group found themselves on the periphery of the discipline for reasons beyond their immediate control. Although they held PhDs from elite universities like Columbia, the University of California at Los Angeles, and Stanford, their prospects had dried up or their situations had become untenable with the bust of the early 1970s. Adrift in a sea of professional uncertainty, the young physicists made their way to Berkeley. Finding themselves with time on their hands and questions they still wanted to pursue, they gravitated toward Rauscher and Weissmann's group. They met on Friday afternoons at 4 P.M.—an informal cap to the week—and the spirited chatter often spilled late into the night at a favorite pizza parlor or Indian restaurant near campus.

The group's intense, unstructured brainstorming sessions planted seeds that would eventually flower into today's field of quantum information science; they helped make possible a world in which bankers and politicians shield their most critical missives with quantum encryption. Along the way, members of the Fundamental Fysiks Group, together with parallel efforts from a few other isolated physicists, contributed to a sea change in how we think about information, communication, computation, and the subtle workings of the microworld.

Despite the significance of quantum information science today, the Fundamental Fysiks Group's contributions lie buried still, overlooked or forgotten in physicists' collective consciousness. The group's elision from the annals of history is not entirely surprising. On the face of it, they seemed least likely to play any special role at all. Indeed, from today's vantage point it may seem shocking that anything of lasting value could have come from the hothouse of psychedelic drugs, transcendental meditation, consciousness expansion, psychic mind-reading, and spiritualist séances in which several members dabbled with such evident glee. History can be funny that way.

While the physics profession foundered, members of the Fundamental Fysiks Group emerged as the full-color public face of the "new physics" avant-garde. Hovering on the margins of mainstream physics, they managed to parlay their interest into a widespread cultural phenomenon. They cultivated a new set of generous patrons, ranging from the Central Intelligence Agency to self-made entrepreneurs like Werner Erhard, guru of the fast-expanding "human potential movement." With money pouring in from these untraditional sources, the Fundamental Fysiks Group carved out new institutional niches in which to pursue their big-picture discussions. Most important became the Esalen Institute in Big Sur, California, fabled incubator of all things New Age. For years on end, members of the group organized workshops and conferences, freely mixing the latest countercultural delights—everything from psychedelics like LSD to Eastern mysticism and psychic mind-reading—with a heavy dose of quantum physics.

To many journalists at the time, the Fundamental Fysiks Group seemed too good to be true. What better reflection of the times than to see physicists grappling with the problems of consciousness, mysticism, and the paranormal? The earliest coverage showed up in underground arenas dedicated to celebrating, not just reporting, the latest countercultural twists and turns. On the heels of his critically acclaimed films *The Godfather* and *American Graffiti*, for example, filmmaker Francis Ford Coppola bought the fledgling *City of San Francisco* magazine. One of its earliest issues after Coppola's renovation devoted a two-page spread to several core members of the Fundamental Fysiks Group, focusing on how the "new physicists" were busy "going into trances, working at telepathy, [and] dipping into their subconscious in experiments toward psychic mobility," all the better to understand subtle quantum effects.[11] A few months later some members of the group heard from Timothy Leary, the former Harvard psychology professor turned poster boy for New Age antics and all things psychedelic. At the time Leary was still in a California jail on drug charges, though he had hardly stopped working. Together with novelist and counterculture icon Ken Kesey (of *One Flew Over the*

Cuckoo's Nest and "Merry Pranksters" fame, and the inventor of the "Electric Kool-Aid Acid Tests") Leary was busy editing a special issue of the quirky Bay Area magazine *Spit in the Ocean*, and he wa eager to publish some of the far-out essays that the hippie physicists had submitted.[12] Soon after that one of the core members of the Fundamental Fysiks Group, Jack Sarfatti, showed up on the cover of *North Beach Magazine*, another San Francisco niche publication, in full guru mode: framed by a poster of Einstein and holding a copy of physicist George Gamow's autobiography, *My World Line*. When novelist and Beat generation hipster Herb Gold composed his memoirs of life among the likes of Allen Ginsberg and William S. Burroughs, the first off-scale personality to appear in the narrative was Sarfatti, holding forth on quantum physics in the Caffe Trieste, North Beach, San Francisco.[13] (Fig. I.1.)

The media coverage was by no means limited to these "tuned-in" venues. *Time* magazine ran a cover story about "The Psychics" with ample space devoted to Fundamental Fysiks Group participants. *Newsweek* covered the group a few years later. *California Living Magazine* ran a long story about the "*New* new physics," complete with head shots of several group members. In May 197 the group's Jack Sarfatti shared the podium with eccentric architect Buckminster Fuller and "five-stages-of-grief" psychiatrist Elisabeth Kübler-Ross as a keynote speaker at a "humanistic psychology conference. Not long after that, the *San Francisco Chronicle* devoted a half-page article to Sarfatti, depicted as the latest in a long line of "eccentric geniuses" to set up shop in the city's bohemian Nort Beach area. Even newspapers as far away as the *New Hampshire Sunday News* covered the group's intellectual peregrinations. Virtually overnight, members of the informal discussion group had become counterculture darlings.[14]

FIGURE I.1. **The "new physicists" as counterculture darlings.** *Left* **(standing, left to right): Jack Sarfatti, Saul-Paul Sirag, Nick Herbert; (kneeling) Fred Alan Wolf, ca. 1975.** *Right***: Jack Sarfat as the eccentric genius of North Beach, 1979. (***Left***, courtesy Fred Alan Wolf;** *right***, photograph by Robert L. Jones, courtesy Robert L. Jones and Jack Sarfatti.)**

One might be tempted to dismiss the Fundamental Fysiks Group and its antics as just one more fring phenomenon: a colorful reminder of tie-dyed life in the 1970s, perhaps, but of little lasting significance. After all, as a sociologist observed as early as 1976, members of the group consistently posed questions and acknowledged experiences that would have "served to label the participants as mentally deranged" only a few years earlier.[15] Surely some *cordon sanitaire* separated the group fro "real" physics.

When other sociologists turned attention to the Fundamental Fysiks Group—and related outcroppings of activity, such as studies of "plant empathy" or the international spoon-bending fad inspired by the apparently psychic feats of Israeli performer Uri Geller—they, too, framed the matter in terms of "demarcation."[16] The eminent philosopher Sir Karl Popper introduced the demarcation problem in the middle decades of the twentieth century: how do scientists draw boundaries between legitimate science and something else? The issue had little to do with truth or falsity. Popper readily acknowledged that many of today's scientific convictions will wind up as tomorrow's forgotten missteps. Popper was after something else, some set of criteria with which to distinguish proper scientific investigation from unscientific efforts. He had some searing examples in mind. As a young man he had experienced the convulsions that wracked daily life in his native Austria in the wake of World War I. The troubled times had inspired all manner of dogmatisms. He sought some means of separating Marxism, psychoanalysis, and astrology from the canons of scientific inquiry. What made the pursuit of those topics distinct from, say, Einstein's relativity?[17]

Since Popper's day, philosophers have spilled much ink in pursuit of those elusive demarcation criteria. Yet sociologists have countered with case after case, showing that scientists make judgments and draw boundaries in ways that rarely stack up with the philosophers' rarefied notions. Who is to say where the line should be drawn in any given instance? Popper's progeny never could establish an Maginot Line of legitimacy, some set of factors that might reliably separate real science from the imposter projects that had so exercised the great philosopher.[18]

The demarcation problem becomes acute in the case of the Fundamental Fysiks Group. Try as w might, we cannot cleave off the group or its activities from the "real" physics of the day. Many of the members' activities placed them on one end of a spectrum, to be sure. But no hard-and-fast dividing line separated them from legitimate—even illustrious—science. Members of the Fundamental Fysiks Group were entangled with mainstream physics on multiple levels, including people, patronage, and intellectual payoff. The group's marginal position and its multiple interactions with mainstream physics provide a unique view onto what it meant to do physics during the turbulent 1970s.

The hippie physicists of the Fundamental Fysiks Group help us map still larger transitions in American culture, beyond the shifting fortunes of physics. A few journalists in San Francisco and Ne York City coined the term "hippie" in the mid-1960s, searching for some way to describe the rising youth culture that was mutating beyond the "hipsters" of the 1950s Beat generation. With the media attention came the first waves of pushback. As California's then-governor Ronald Reagan put it in 1967, after the hippie scene in San Francisco's Haight-Ashbury district had become a national obsession, a hippie was someone "who dresses like Tarzan, has hair like Jane, and smells like Cheetah."[19] Reagan's quip lumped together groups whom scholars have recently labored to distinguish, often with Jesuitical precision. The left-leaning hippie movement, for example, had an uneasy relationship with the "New Left," the campus-based liberal and increasingly radical political movement associated with the Students for a Democratic Society and (ultimately) the Weather Underground. Members of the New Left aimed at organized political intervention, inspired by the civil rights movement and stoked by the escalation of the Vietnam War. The campus radicals often looked with dismay on their hippie counterculture cousins, for whom political organizations of any stripe seemed so very unhip. While the political types signed petitions and planned rallies, most hippies sought to "drop out."[20]

The hippie counterculture sported a playful worship of youth, spontaneity, and "authenticity," a personal striving often facilitated by heavy use of psychedelic drugs. LSD, synthesized in a Swiss lab in the late 1930s, was first outlawed in the United States in 1966; possession of the drug was bumped up to a felony offense in 1968. Until that time, the psychedelic had fascinated straight-laced chemists

and psychologists as well as long-haired hippies. The Central Intelligence Agency and the U.S. Army sponsored research on effects of LSD at government laboratories and reputable research universities throughout the 1940s and 1950s. Along with psychedelics enthusiast Ken Kesey, for example, the physicist Nick Herbert, who would become a founding member of the Fundamental Fysiks Group, wa introduced to LSD by psychologists at Stanford University.[21] Only later, over the course of the 1960s did the drug seep into wider circulation among hordes of "tuned-in" youth. Long after the drug had been criminalized, LSD and other psychedelics, like psilocybin (from "magic mushrooms"), remaine staple elements of the hippie counterculture.[22]

New Age enthusiasms had also been mixed up in the hippies' heady brew right from the start: everything from Eastern mysticism to extrasensory perception (ESP), unidentified flying objects (UFOs), Tarot card reading, and more. Research on LSD during the 1950s was often reported in parapsychology journals in between articles on mind-reading and reincarnation.[23] Americans' awareness of Eastern religions and healing practices, such as acupuncture, grew sharply following 1965 revisions to U.S. immigration law, after which immigration from Asia soared (having previousl been capped by tight quotas).[24] Some of the earliest underground tabloids of the budding counterculture—newspapers like the *Oracle*, peddled in San Francisco's Haight-Ashbury neighborhood beginning in 1966—featured news about yoga, astrology, and the occult alongside information on where to score the most potent psychedelic drugs.[25] According to close observers, the hippie counterculture and New Age movements in the United States had fused by the early 1970s, achieving a critical mass, self-awareness, and no shortage of critics.[26] Even so, the boundaries of the counterculture remained porous. One analyst likened it to a medieval crusade, a "procession constantly in flux, acquiring and losing members all along the route of march."[27]

The inherent tensions that historians have begun to identify within the hippie counterculture—leftist but not "New Left," curious about the workings of the world but tempted by psychedelic escapism—help explain the wide range of followers whom the Fundamental Fysiks Group inspired. Their efforts attracted equally fervent support from stalwarts of the military-industrial complex as from storied cultivators of flower power, from the Central Intelligence Agency, the Pentagon, and defense-contractor laboratories like the Stanford Research Institute to the Esalen Institute. Members of the Fundamental Fysiks Group exemplified these tensions themselves. Many threw themselves headlong into the New Age alchemy, even as they pursued serious questions at the heart of quantum theory. They shifted easily from weapons laboratories to communes, universities to ashrams.[28]

All the while, members of the Fundamental Fysiks Group pioneered a flood of publications abou the new physics and its broader implications. Many sold handsomely; some netted national awards. Best known today are such cultural icons as *The Tao of Physics* (1975) by physicist and group membe Fritjof Capra and *The Dancing Wu Li Masters* (1979) by the writer Gary Zukav, at the time an avid participant in the Fundamental Fysiks Group's discussions and roommate of one of its founding members. The group also experimented with alternate ways to spread their message, inspired by and modeled on the counterculture's underground press.[29] The group's efforts helped to bring sustained attention to the interpretation of quantum mechanics back into the classroom. And in a few critical instances, their work instigated major breakthroughs that—with hindsight—we may now recognize a laying crucial groundwork for quantum information science.

The group of hippies who formed the Fundamental Fysiks Group saved physics in three ways. First concerned style or method. They self-consciously opened up space again for freewheeling speculatio for the kind of spirited philosophical engagement with fundamental physics that the Cold War decad

had dampened. More than most of their generation, they sought to recapture the big-picture search fo meaning that had driven their heroes—Einstein, Bohr, Heisenberg, and Schrödinger—and to smuggle that mode of doing physics back into their daily routine.

Second, members of the Fundamental Fysiks Group latched onto a topic, known as "Bell's theorem," and rescued it from a decade of unrelenting obscurity. The theorem, named for the fiery Irish physicist John S. Bell, stipulated that quantum objects that had once interacted would retain some strange link or connection, even after they had moved arbitrarily far apart from each other. Bell used words like "nonlocality" and "entanglement" to describe his result. To many group members, th phenomenon seemed equally evocative of Buddhist teachings. As one group member put it in 1976, "Bell's theorem gives precise physical content to the mystic motto, 'we are all one.'"[30] Working in various genres and media, the Fundamental Fysiks Group grappled with Bell's theorem and quantum entanglement. They struggled to make sense of it, test out its limits, and see what it might imply. In the process, they forced a few of their physicist peers to pay attention to the topic, jousting with them over its ultimate implications. From these battles, quantum information science was born.

Bell's theorem and quantum entanglement seemed to suggest that one could use quantum theory to act at a distance, instantly. Nudge a particle here and its partner would instantaneously dance over there, regardless of whether it was nanometers or light-years away. But Einstein's relativity forbade any force or influence to travel faster than the speed of light. The Fundamental Fysiks Group pushed relentlessly on that boundary, the seemingly weak joint in the architecture of all we know about how the universe hangs together. They had many motivations. One was dogged pursuit of the big metaphysical questions, the constant refrain of "how could the world *work* that way?" But there was more. If faster-than-light signaling were possible (perhaps even inevitable), then physicists would need to broaden the discipline to include even larger questions. Was action at a distance really so different from clairvoyance, psychokinesis, or the Eastern mystics' emphasis on holism? Those were the stakes, at least as the Fundamental Fysiks Group saw them. Sitting in the Bay Area, as the counterculture and New Age movements burst into technicolor bloom, the deep mysteries of quantum physics reflected all-new hues.[31]

The hippie physicists' concerted push on Bell's theorem and quantum entanglement instigated major breakthroughs—the third way they saved physics. The most important became known as the "no-cloning theorem," a new insight into quantum theory that emerged from spirited efforts to wrestl with hypothetical machines dreamed up by members of the Fundamental Fysiks Group. Akin to Heisenberg's famous uncertainty principle, the no-cloning theorem stipulates that it is impossible to produce perfect copies (or "clones") of an unknown or arbitrary quantum state. Efforts to copy the fragile quantum state necessarily alter it. The fact that unknown quantum states—like the beams of light fired down long fiber-optics cables in the Vienna and Geneva demonstrations—cannot be copie is what stops eavesdroppers in their tracks. Unlike ordinary signals, to which one might surreptitious listen, quantum-encrypted communications simply cannot be tapped without destroying the desired signal. The no-cloning theorem thus gives force to quantum encryption: it provides the mechanism b which bank transfers and election results can be transmitted with perfect security. That much is well known among today's physicists and aficionados of quantum information science; the latest textbook often feature the result in their opening pages.[32] Less well known is that the no-cloning theorem emerged directly from the Fundamental Fysiks Group's tireless efforts—at once earnest and zany—t explore whether Bell's theorem and quantum entanglement might unlock the secrets of mental telepathy and extrasensory perception, or even enable contact with spirits of the dead.

Hence the brashness of my title, *How the Hippies Saved Physics*. Readers may well note a tinge of the same bravado, equal parts ironic and defiant, that animated Thomas Cahill's well-known study

How the Irish Saved Civilization.[33] The similarity is by design. Both books examine moments of gre instability and decay in reigning institutions: the Roman empire on one hand, Cold War institutions physics research on the other. In both accounts, an unlikely group of underdogs and castaways kept t torch of learning aflame, nursing a body of scholarship and a set of questions until the mainstream h recovered sufficiently to appreciate their importance and build on them again. That which required saving was "Western civilization" in Cahill's case; it was a commitment to deep questioning of quantum reality in mine. Cahill casts the Irish monks of the Middle Ages in twin roles: both as cultivators of Europe's lost heritage and as effective missionaries, replanting the seeds of learning throughout the Continent. This book focuses on down-and-out hippie physicists, whose passion for physics and for the big questions at the heart of quantum theory was implacable. They demonstrated impressive tenacity in the face of professional hardships; their zeal to share their findings and spread the word was unflappable.

Several critics of Cahill's account have rightly pointed out that the role of the medieval Irish is easily exaggerated. Other groups at the time proved equally adept at squirreling away the intellectual riches of Greece and Rome, tending to them, building upon them, and helping to replenish the stocks of learning throughout the European continent at a propitious moment.[34] So too with the physicists a the center of this story. By no means were the individuals upon whom I focus unique. Other outcroppings of like-minded investigators existed, and at times the various groups found each other and interacted.

Yet the Fundamental Fysiks Group—an ensemble cast from the start—played what can only be considered an outsized role. The ratio of their ambitious participation to the humbleness of their professional situation was especially striking. They weren't just chasing new gadgets, though they certainly had these in mind and even marched a few steps down the patent-filing road. Their goal remained far more grand: changing an entire worldview. I find this mismatch between their soaring intellectual aspirations and their modest professional platform especially captivating. That they have left any mark at all—attenuated to be sure, and largely unrecognized amid today's breathtaking successes—should give current researchers, toiling in relative obscurity, some modicum of comfort. Members of the Fundamental Fysiks Group threw themselves into their investigations with gusto, keeping spirits high and enjoying every last minute of their quest. Surely there is a lesson in that.

Chapter 1

“Shut Up and Calculate”

> It was very different, when the masters of the science sought immortality and power; such views although futile, were grand: but now the scene had changed. The ambition of the inquirer seeme to limit itself to the annihilation of those visions on which my interest in science was chiefly founded. I was required to exchange chimeras of boundless grandeur for realities of little worth.
>
> **—Victor Frankenstein, character in Mary Shelley’s Frankenstein**

In the spring of 1974, a most unusual meeting took place. Two physicists—Fred Alan Wolf and Jack Sarfatti, who would soon become charter members of the Fundamental Fysiks Group—sat down with Werner Erhard in the lobby of the Ritz Hotel in Paris. Erhard, one of the leading exponents of the “human potential movement,” was at the top of his game. His *est* workshops (“Erhard Seminars Training”), forerunner of today’s self-help and personal-growth industry, had already grossed several million dollars and boosted Erhard to worldwide celebrity.[1] He had asked Wolf and Sarfatti to meet with him because he was fascinated by the way physicists attacked complicated and counterintuitive problems with rigor.[2]

The meeting did not get off to an auspicious start. Sarfatti felt restless, uninterested in the meeting; he had never heard of Erhard. Erhard’s gaudy outfit, accessorized by a beautiful female admirer hanging on his sleeve, put Sarfatti off even more. Sarfatti asked what Erhard did. Erhard grinned and replied, “I make people happy.” It was more than Sarfatti could take. Itching to leave, he said in a strong Brooklyn accent, “I think you’re an asshole.” As Sarfatti remembers it, Erhard rose from his chair—smile stretching from ear to ear—embraced Sarfatti right there in the hotel lobby, and said, “I am going to give you money.” Without knowing it, Sarfatti had used one of the catchphrases associated with Erhard’s sprawling self-help venture. Soon the money began to flow: thousands of dollars, all from this most eager new patron of quantum physics.[3]

Erhard was not the first to seek enlightenment from the strange subject of quantum theory. Even more than relativity—with its talk of shrinking meter sticks, slowing clocks, and twins who age at different rates—quantum mechanics is a science of the bizarre. Particles tunnel through walls. Cats become trapped, half dead and half alive. Objects separated light-years apart retain telepathic links with one another. The seeming solidity of the world evaporates into a cloud of likelihoods. Long before Erhard, Wolf, or Sarfatti had arrived on the scene, the world’s leading physicists had struggled to come to grips with quantum theory, to tease out just what it might mean. Many of their ideas sounded no less peculiar than the half-formed inklings that inspired Erhard on that fateful spring day.

Quantum mechanics emerged over the first quarter of the twentieth century, honed primarily by Europeans working in the leading centers of theoretical physics: Göttingen, Munich, Copenhagen, Cambridge. Most of its creators—towering figures like Niels Bohr, Werner Heisenberg, and Erwin Schrödinger—famously argued that quantum mechanics was first and foremost a new way of thinking. Ideas that had guided scientists for centuries were to be cast aside. Bohr constantly spoke of the