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Physics in Perspective

Book Reviews

David Kaiser, *How the Hippies Saved Physics: Science, Counterculture, and the Quantum Revival*, New York: W. W. Norton and Co., 2011, 416 pages, $17.95 (paperback).

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Quoting Ronald Reagan, author David Kaiser, in *How the Hippies Saved Physics: Science, Counterculture, and the Quantum Revival*, defines a hippie as "one who dresses like Tarzan, has hair like Jane, and smells like Cheetah." He augments Reagan's definition of a hippie as one who also uses LSD. Given these definitions, perhaps fortunately and with some poetic license, he is a little vague about which of his many players meet this definition and qualify as "true" hippies. Later on, he relaxes these definitions and generalizes his definition of hippie further to include all members of Lawrence Berkeley Laboratory's "Fundamental Fysiks Group" (FFG). In his final chapter, "Ideas and Institutions in the Quantum Revival," Kaiser praises the FFG and notes its similarity to a group named the "Olympia Academy," founded by Einstein to discuss electrodynamics and early atomic theories. The book centers on the activities of the FFG's members, and especially those of the more bohemian among them.

The FFG was a weekly seminar group at Lawrence Berkeley Laboratory (LBL, now Lawrence Berkeley National Laboratory). It was organized in 1975 by Elizabeth Rauscher and George Weissman, both graduate students of LBL physicist and University of California, Berkeley (UCB) physics professor Geoffrey Chew. Other founding members (non LBL/UCB employees) included Jack Sarfatti, Fred Allan Wolf, Saul-Paul Sirag, Nick Herbert, Fritjof Capra, and Gary Zukav. Brief biographies of these members are given in chapter 3, "Entanglements."

The FFG was formed to discuss various "fringe" subjects in physics. These subjects included Bell's theorem and its experimental tests, the foundations of quantum mechanics, quantum entanglement, and the quantum measurement problem. A fascination with Bell's theorem was promoted as a primary motivation behind the formation of this group. Kaiser appears to tacitly adopt as an "honorary hippie" anyone who studied Bell's theorem and its implications during this era, whether or not they were FFG members at the time, and whether or not they got

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haircuts, took showers, or ever used LSD. It is noteworthy that whereas these physics subjects were considered “fringe” in the 1970s, they are now mainstream. Kaiser discusses some of the reasons behind their fringe nature in his chapters 1 and 2, “Shut Up and Calculate” and “Spooky Action at a Distance.”

In 1975, I was working as a postdoc at LBL and the UCB Physics Department and was finishing a series of four different experiments testing Bell’s inequality and photon particle-like behavior and sub-Poissonian statistics. Chapter 3 describes some of that work, and how I had earlier in 1969 devised and proposed the first experimental test of Bell’s theorem while working with collaborators Mike Horne, Abner Shimony, and Dick Holt (aka CHSH). In 1974 Mike Horne and I formulated the first loophole-free Bell inequality (the CH inequality) and had showed that it constrained all theories of physics based on local realism. (Unfortunately Kaiser omits the name of Stuart Freedman, the UCB PhD student who collaborated with me in performing the first experimental test of the CHSH Bell inequality.) Given my background, Elizabeth Rauscher frequently visited my lab and invited me to attend the FFG’s seminar series and join the group. She also invited two other LBL physicists, Henry Stapp and Philippe Eberhard, who were also studying Bell’s theorem. She assured us that strict scientific rigor would be required for all proceedings of the group. At the end of 1975, I left LBL, UCB, and the FFG to go to the Lawrence Livermore National Laboratory to work on magnetic confinement–controlled fusion. Thus, I was associated with the FFG for less than a year. My brief association with the group nonetheless gave me unique insights into its operation, allowing me to confirm some of Kaiser’s careful reporting and meticulous documentation.

Another subject discussed by the FFG was human consciousness. Consciousness had earlier been linked to the quantum measurement problem by the so-called Wigner’s friend paradox, wherein Eugene Wigner replaced Schrödinger’s cat with a conscious human observer. Rather than killing the observer (like the cat), the observer was left alive and queried about what it was like to be in a quantum superposition. Wigner used this situation to argue that consciousness is essential to von Neumann’s wave-function collapse. I note, in passing, that Schrödinger’s cat and Wigner’s friend really are at the crux of the quantum measurement problem, in which the associated transition of a system from a pure state to a statistical mixture, as required by a “measurement,” is still not understood if one assumes quantum mechanics to be universally correct. But I digress.

As time progressed (mostly after I left), various FFG members insisted on the further inclusion of other “fringe” subjects less directly related to physics. Scientific rigor sadly began to decline. These subjects included parapsychology, extrasensory perception and remote viewing, psycho-kinesis, and Eastern mysticism. Kaiser notes, "To many group members, the phenomenon [of quantum entanglement] seemed equally evocative of Buddhist teachings" (xxiv), and quotes Nick Herbert as saying "Bell's theorem gives precise physical content to the mystic motto, 'we are all one.'" Kaiser claims that "for most members of the group, Bell-style nonlocality seemed tailor-made to explain curious occultlike action at a distance" (65). My personal recollection, however, is that, while I was present, we "honorary hippies" were never really part of Kaiser's "most members" and preferred to look beyond the occult and Buddhist teaching for explanations of Bell-style nonlocality. However, given Elizabeth Rauscher's promise, we were still open to listening to the arguments and experimental bases for these alternative viewpoints.

The FFG's activities followed two parallel but intertwined narratives in Kaiser's account. In what I will call the "physics narrative," Kaiser argued in favor of the book's title—that the "hippies saved physics." In what I will call the "pseudo-physics narrative," some FFG members (especially Sarfatti) argued in favor of the legitimacy, indeed even for the primacy, of more fringe subjects.

The physics narrative is described mostly in chapter 9, "From FLASH to Quantum Encryption." It starts with Sarfatti's proposed modification of my Bell's theorem test experimental configuration. Sarfatti thereby attempted to produce a faster-than-light communications scheme based on two-photon entanglement. Its operation immediately appeared to violate special relativity. Its flaw was quickly found by "honorary hippies" Henry Stapp and Philippe Eberhard, who produced a first version of what is now known as the quantum no-cloning theorem.

Following the demise of Sarfatti's scheme, FFG member Nick Herbert proposed a much-improved configuration for attempted faster-than-light communication, which he named FLASH (First Laser Amplified Superluminal Hookup). Herbert's configuration was also a modification of my Bell's inequality test experimental configuration. In Herbert's FLASH proposal, a laser gain tube is added to one side of the experiment, which then produces a burst of identical copies of a photon emitted by the source. That photon burst is then entangled with the photon on the opposite side of the experiment. Various polarization states are to be measured on either side of the experiment. Herbert claimed to produce faster-than-light communication via prescribed manipulations of the experiment's polarizers.

Herbert's was much more difficult to debunk than Sarfatti's. It relied on the assertion that, in the stimulated emission process (fundamental to the operation of a laser), the stimulated photon emitted by an excited atom is identical to the stimulating photon. Herbert's idea provoked some difficult, even confounding, questions regarding some poorly understood physics of quantum entanglement and of the stimulated emission process. Chapter 9 describes a heated debate among its various reviewers and referees, including Henry Stapp, Philippe Eberhard, Bill Wootters, Wojciech Zurek, John Wheeler, Dennis Dieks, GianCarlo Ghirardi, and Tullio Weber. Most argued in terms of the quantum no-cloning theorem, and/or produced new versions of the theorem. Subsequently, Leonard Mandel and Roy Glauber entered the controversy and discovered a second reason why it would not work. They argued that spontaneous emission noise emitted by the laser gain tube would interfere with the stimulated emission signal so that superluminal communication is not possible.

Kaiser maintains that the resolution of the evident paradox underlying Herbert's FLASH communicator provides a missing but critical element for an idea offered by Stephen Wiesner with his so-called quantum money. (Wiesner, although not an FFG member, is described as a "true" hippie.) Wiesner's efforts further inspired works by Charles Bennett, Gilles Brassard, and Artur Ekert on quantum encryption. These latter three gentlemen subsequently demonstrated that additional modifications to apparatus designed for a Bell's inequality experimental test can be used for provably secure quantum-encrypted communication.

Chapters 3 through 8 describe the "pseudo-physics" narrative. It was promoted mostly by Sarfatti and Capra, who argued strongly in favor of the legitimacy of occult subjects like parapsychology and attempted to link them to quantum entanglement. Much of this narrative describes hippie physicist con artists (including one convicted murderer) hustling other non-scientific con artists, or hustling the otherwise scientifically gullible (including government agencies), and correspondingly bartering pseudoscience for monetary gain and/or for perceived national security, spiritual fulfillment, and/or enlightenment. As part of the various cons, FFG members tried to link poorly understood aspects of quantum mechanics with Eastern mysticism, parapsychology, psychokinesis, and paranormal phenomena. In an alliance with the group's private funding agents, that list of subjects was extended to include human spirituality and the human potential movement (recall the mystic motto, "we are all one"). Kaiser describes in chapter 5 how in 1977, mostly at Jack Sarfatti's and Fritjoff Capra's urging, the FFG reformed itself into the Physical Consciousness Research Group (PCRG) and filed articles of incorporation in order to handle the flow of money.

Some of the US government's funding agencies being hustled for money included the CIA, DIA, DARPA, NSA, and NASA. Indeed, Jack Sarfatti offered his faster-than-light communications scheme to try to hustle money for a revolutionary communication system with far-reaching military applications. Following the demise of his scheme, he continued to argue for the use of entangled photons as part of Reagan's "Star Wars" missile defense initiative, which, in turn, was subsequently proven to be a colossal con in its own right. Physicist John Wheeler eventually intervened and pretty much halted the flow of government money. Nonetheless, Kaiser notes that gullible representatives of the NSA and DIA continued to worry about America's "parapsychology gap" with the Soviet Union. They allegedly continued to follow the group's activities, long after these scams ended, through an undercover agent named George Koopman.

The book describes how, after Sarfatti was exposed as a hustler of government agencies, he turned to private organizations and wealthy benefactors for funding. He struck pay dirt with patrons including Werner Erhard, the Esalen Institute, Erhard Sensitivity Training (EST) and its associated human potential movement, and Arthur Young and his Institute for the Study of Consciousness. One trick used for achieving respectability was to use the spectacular natural mineral hot springs bohemian resort setting of the Esalen Institute on Big Sur to lure additional "honorary hippie" physicists to quantum-mechanics discussion group conferences.

The book describes the FFG's (and PCRG's) interaction with magician/con artist Uri Geller (and with his stage manager Andrija Puharich), who performed off-the-shelf stage-magic illusions masquerading as a new form of quantum/psychic mysticism. Geller was publicly debunked by "The Amazing Randi," but not by the FFG. Indeed, some FFG members seemed to want to believe his "magic." (Geller would never survive on Penn and Teller's current TV program "Fool Us.") Two other promoters of paranormal activity, Harold Puthoff and Russell Targ, were also reviewed by the group, and indeed were embraced as potential partners by Sarfatti and other members. This case is probably better characterized as self-delusion, coupled with inadequate statistical analyses of claimed paranormal observations, rather than outright fraud.

Chapter 6, "Spreading and (Selling) the Word" describes Ira Einhorn (described as a "true" hippie) who acted as "publisher" of works by Sarfatti, Wolf, Rauscher, and Herbert via photocopied and mailed preprints. A side story in this chapter describes how Einhorn brutally murdered his girlfriend, Holly Maddux, stuffed her body into a steamer trunk to decompose, and was discovered and arrested. He was defended by future senator Arlen Specter, who obtained Einhorn's release on bail. Einhorn jumped bail and fled to France. He was eventually located by Interpol. Following a complicated process involving French President Jacques Chirac, Secretary of State Madeleine Albright, and Attorney General Janet Reno, Einhorn was extradited. The added complexity evidently involved an international plea bargain, since extradition from European countries for capital offenses is not allowed. Einhorn was finally convicted in a celebrity trial and sentenced to lifetime imprisonment with no possibility of parole.

In chapter 7, “Zen and the Art of Textbook Writing,” Kaiser describes the literary activities of some of the other group members, who authored a series of popular books wherein Eastern mysticism was linked to the “organicism or holism implied by quantum interconnectedness.” These books include Nick Herbert’s *Quantum Reality*, Fritjof Capra’s controversial best seller *The Tao of Physics*, and Gary Zukav’s *The Dancing Wu Li Masters*. Although these books do promote the importance of Bell’s theorem and of its associated experimental tests, Kaiser and I both believe that their linkage of these subjects to Eastern mysticism and other subjects is neither justified nor proven. Capra’s book, while entertaining and evidently appealing to general non-scientific audiences, should not be considered as a valid physics reference for college physics courses. Zen textbook writing is appropriately classed as part of Kaiser’s pseudo-physics narrative.

In his introduction, Kaiser lists three ways in which “hippies” saved physics. First, “They self-consciously opened up space again for freewheeling speculation for the kind of spirited philosophical engagement with fundamental physics that the Cold War decades had dampened.” Unfortunately, the “freewheeling speculation and philosophical engagement with fundamental physics” described in the pseudo-physics narrative should be given little credit for any resulting “salvation of physics.” As far as I can tell, no evidence was ever presented by or to the group to forge any solid links between quantum phenomena and the fringe, occultlike subjects, including consciousness, beyond the above-mentioned link from the Wigner’s friend thought experiment. By contrast, Herbert’s “freewheeling speculation” in the physics narrative about his FLASH communicator did lead to useful outcomes.

Second, Kaiser’s suggests that “members of the Fundamental Fysiks Group latched onto a topic known as ‘Bell’s theorem’ and rescued it from a decade of unrelenting obscurity.” If one includes Kaiser’s extended definition of “hippie” to include “honorary hippies,” and extends the time period to include well before the formation of the FFG, then member activity can be credited for rescuing Bell’s theorem and thereby contributing to said “salvation of physics.”

Ironically, the most important way, Kaiser’s third, in which “hippies saved physics” was the no-cloning theorem that fostered the very practical application of entanglement to quantum encryption by ensuring its security, for which the US Department of Defense and Central Intelligence Agency correspondingly have rewarded the physics community with more funding for research in this area.

In summary, I admit to a strong bias towards Kaiser’s physics narrative and against his pseudo-physics narrative. Kaiser’s case that “the hippies saved physics” is supported by his physics narrative, depending upon who you include as “hippies.” On the other hand, it is badly tarnished by his pseudo-physics narrative. But then, I am not much of a fan of Eastern mysticism. From an alternative viewpoint, the book might be viewed as a useful "how to" manual for the newly burgeoning scientific con artist industry that pervades today's government and business.

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Massimiliano Badino, *The Bumpy Road: Max Planck from Radiation Theory to the Quantum (1896–1906)*, Cham: Springer, 2015, 112 pages, €51.99 (softcover).

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Max Planck's introduction of the quantum hypothesis is one of the most interesting episodes in the history of physics. His discovery occurred at the end of a decade that Massimiliano Badino describes in his book as travelling on a bumpy road consisting of theoretical speculations and experiments in physics. This road has been the subject of strong disagreements among historian of science, whereas physicists have paid little attention to it. The standard story in most physics textbooks is that Planck was concerned that, according to the classical equipartition theorem, the total energy of black-body radiation contained in a cavity is infinite. But this divergence was first pointed out by Lord Rayleigh, whereas Planck was not aware of this problem, as Martin Klein showed.[1] Planck's main interest was to derive the second law of thermodynamics from the laws of classical mechanics and electromagnetism. Taking advantage of Gustav Kirchoff's observation that the spectrum of black-body radiation is a universal function independent of the nature of its source, Planck's first step was to obtain a thermodynamic relation for a source in thermal equilibrium with this radiation consisting of an ensemble of microscopic Hertzian oscillators with variable frequency. Applying a formula introduced by Wien that fitted the high frequency end of this radiation, Planck obtained an expression for the mean energy of these oscillators.

The measurements of black-body radiation were being made by careful experiments at the Physikalisch Technische Reichsanstalt (PTR) which became the center for infrared radiation studies in Berlin during the nineteenth century. But near the end of the century, it was discovered that Wien's distribution did not fit new data at lower frequencies and higher temperatures that had been previously measured. At this point, it appeared that Planck's approach had failed, but soon he obtained a new distribution formula by an *interpolation* procedure based on his

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previous application of the relation between entropy and energy for a system in thermal equilibrium. Remarkably, his new result fitted very well both the new as well as the earlier experimental results. But Planck became concerned that his successful radiation formula was based on purely phenomenological arguments—based only on fitting experimental data—and that it required a basis in some fundamental physics. For this purpose, he turned to Boltzmann's seminal 1877 paper on the *statistical* approach to the second law of thermodynamics and the origin of entropy that Planck had rejected previously.[2]

Badino devotes the first four fifths of his book to Planck's failed approach and presents his successful approach only in the last twenty pages. Unfortunately, his book also does not contain a synopsis of Planck's bumpy road such as the one outlined above, and instead provides incomprehensible (to this reviewer) diagrams with boxes and arrows (pp. 58 and 87) to summarize his approach. Moreover, Badino fails to explain how Planck arrived at his most important achievement, namely, the *correct* black-body formula that now bears his name. He states that working on the new experimental data provided to him by Heinrich Rubens (an experimentalist at the PTR), "Planck found out that the radiation intensity as a function of the temperature and the wavelength was represented by the new law, Eq. 42" (p. 89), but a description of how Planck obtained this fundamental result is lacking. Instead, on the next page, Badino quotes Planck's new formula for the second derivative of the entropy with respect to the energy, which he developed to account also for the new low-temperature data at the PTR, but again without describing how Planck obtained it and in particular without indicating that it was this new relation that led Planck directly to his correct formula for black-body radiation. In fact, the constants α and β that appear in Planck's new second derivative of the entropy correspond to Boltzmann's constant k, and $h\nu$ respectively, where h is Planck's constant, and ν is the frequency of the Hertzian oscillators, which lead to the constants that appear in Planck's new law, Eq. 42, namely, $c_1 = 8\pi hc$ and $c_2 = hc/k$, where c is the velocity of light.

On the next page, Badino makes the remarkable claim that in his 1877 paper Boltzmann had not written the relation for which he is most famous, namely that the entropy is proportional to the logarithm of the number of configurations of the ensemble of his model for a molecular gas. Actually, chapter V of Boltzmann's paper is entitled "The relationship of entropy to what I have described as the distribution probability," and his Eq. (61) contains *explicitly* this relation for his molecular gas. Boltzmann's paper does not contain the generalization of his fundamental relation for any distribution of equally probable states, engraved on his tomb in the well-known form, $S = k \log W$, where S is the entropy and W is the *maximum* number of configurations of any system in thermal equilibrium. Yet

Baldino claims that W is the "state probability," which is incorrect, because a probability function has to be less that unity. Actually, Planck assumed that W represented the *total number* of equally probable configurations of his oscillators, instead of the *maximum number* of those configurations. It can be shown, however, that in the limit of large numbers of configurations these two quantities for W are the same, which explains why Planck recovered his correct black-body formula from Boltzmann's statistical considerations.

There are several good accounts of Planck's epochal discovery of discreteness in the physics of the microcosm, but Badino's book is not one of them.

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