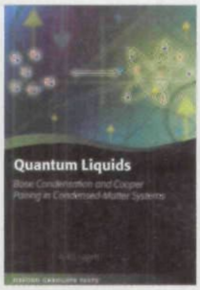
assorted exotic systems.



Not that Leggett, a 2003 Nobel laureate in physics and MacArthur Professor at the University of Illinois at Urbana-Champaign, would ever use the words "macroscopic quantum coherence": He devotes much of the first two introductory chapters to explaining why he rejects the now-classic description in terms of coherent states and favors instead the narrower idea of off-diagonal long-range order. In so doing, he explicitly rejects the connection of coherence with broken gauge symmetry that eventually led to the electroweak theory; but more seriously, the words "Goldstone boson" do not appear in reference to the phonons and collective modes in helium, nor does the question of why they do not appear in superconductors. Because the Bardeen-Cooper-Schrieffer (BCS) theory has always been viewed as the poster child for the concept of broken symmetry, Leggett's refusal to look in those directions warrants questioning—and all the more in a work of reference.

The early chapters of the book also divagate on a number of questions that seem out of place in a text at this level. For instance, is it at all relevant that "there is no proof of the existence of Bose–Einstein condensation in any physical system" (page 46). If there were "proof" of nonexistence, it would be the premises of the proof that would be questioned, not the physics of liquid helium.

For graduate students who want a thorough grounding in some of the most fundamental aspects of quantum fluids—such as statistical mechanics in a rotating container, the Landau–Silin approach to metals, the dynamical theory of the dielectric constant of metals, and the theory of Feshbach resonances in dilute gases—*Quantum Liquids* would be very useful. And for those of us who have specialized in a particular branch of the field and need updating on the marvelous things that have been done with cold atoms or on the beautiful details of the liquid ^{3}He story, the book is a wonderfully informative source. Each of the four chapters on the classic, well-understood cases of liquid ^{4}He, Bose alkali gases, superconductivity, and liquid ^{3}He is full of small gems of insight, typical of Leggett's finical style.

But from time to time it seems as if the author has distorted or ignored history. One wonders if Henry Hall and Joe Vinen would have been happy being dropped from the history of quantized vorticity in superfluid ^{4}He. In the chapter on classical superconductivity, John Rowell is not mentioned in connection with the Josephson effect. And perhaps I might have earned some credit for the formalism in section 5.8, the one using time-reverse pairing. In addition, the entire and crucially important subject of flux lattices, flux pinning, and creep and flow is postponed to a cursory inclusion in the chapter on cuprates. The omission of the flux lattice and flow properties constitutes a serious incompleteness in a learning tool.

For my specialty, the cuprates, I had hoped to see a thoughtful, if idiosyncratic, treatment like those in the previous chapters; instead, the coverage in chapter 7 does not actually reflect the modern state of the subject. Again, Leggett's characteristic viewpoint comes into play: He says, in effect, that some may believe that the Hubbard model is useful—but he doesn't, offering no explanation (page 332). Yet Leggett is not finicky about the mathematically questionable basis of the antiferromagnetic spin-fluctuation theory. Another example: A long-ago paper by one of his close colleagues, Myron Salomon, shows that the transition is always of x–y character—that is, into a fluctuating paired liquid—which invalidates the naive Jeff Tallon phase diagrams that Leggett uses.

In a few paragraphs in chapter 8, Leggett dismisses the large field of organic superconductors. He does not mention established data that demonstrate the coincidence of a Mott transition in an organic material with that in an antiferromagnetic superconductor, nor does he mention the demonstrations of triplet superconductivity in organics. Instead, the subject is dismissed as "probably phonon-motivated" (page 352) despite the myriad evidences for Mott–Hubbard physics. Leggett at least admits that the heavy-fermion superconductors are likely to have exotic order parameters and an electronic mechanism, but his long-term love affair with antiferromagnetic spin fluctuations continues. Superconductivity in Sr_2RuO_4, whose order parameter so closely resembles that of his favorite ^{3}He, is given a brief mention. Except for a final note on the BCS–BEC crossover, all of chapter 8 is cursory and out of date.

In summary, *Quantum Liquids* is a book that many condensed-matter theorists can read with profit. But because the text is so selective and occasionally misleading in parts, I would question its use as a comprehensive textbook for graduate students.

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Concepts of Simultaneity
From Antiquity to Einstein and Beyond

Max Jammer
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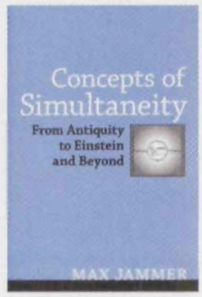
All physicists know that something important happened to the concept of simultaneity in 1905. But most are unaware that in the past 100 years a feud has developed over whether the simultaneity of distant events in a given reference frame is fact or convention.



Max Jammer, a professor emeritus of physics and former president at Bar-Ilan University in Israel, has written various books, including three classics published by Harvard University Press: *Concepts of Space: The History of Theories of Space in Physics* (1954), *Concepts of Force: A Study in Foundations of Dynamics* (1957), and *Concepts of Mass in Classical and Modern Physics* (1961). Since the last of the three was first published more than 40 years ago, one might be curious as to whether his new book, *Concepts of Simultaneity: From Antiquity to Einstein and Beyond*, is as good as the rest.

Jammer discusses notions of simultaneity in various contexts, including Egyptian hieroglyphs, Aristotle's works, and the tenseless Hopi language. Early philosophers criticized astrology by addressing the simultaneity of distant events. For example, Sextus Empiricus challenged the Chaldean method of casting horoscopes at birth: An astrologer on high ground waited to hear a gong when a woman gave birth, but because of the sound delay, the astrologer did not note the position of the stars at exactly the moment of birth. St. Augustine of Hippo denounced astrology by arguing that even though two women at distant places were known to have given birth at the same time because messengers dispatched from each birthplace met midway between the two, the children still had distinct lives.

Coincidentally, Albert Einstein's

method of determining simultaneity resembled that of St. Augustine. Thus Jammer highlights various precursors to the modern conception of simultaneity. For example, the scholastics discussed whether there exists only one time. Since 1676, Ole Rømer's demonstration that the speed of light is finite revealed that the constellations as we see them are illusions—not the real, simultaneous positions of stars. Later, in the early 18th century, Gottfried Leibniz ascribed logical priority to simultaneity over other notions of time. Then in 1905 Einstein showed that the simultaneity of distant events varies among inertial systems in relative motion. That relativity of time entailed a new physics.

Yet even in a single system, Einstein established simultaneity as a matter of *convention* by freely stipulating that the speed of light is equal in opposite directions. Most physicists think instead that the equal speed of light in all directions is a matter of fact. Some seem repulsed by the idea that the foundations of physics involve key elements that are not set empirically. Simultaneity is central to special relativity. So, some people might think that simultaneity as essentially a convention would lead to, as Jammer puts it, "disastrous consequences for the philosophical understanding and epistemological status of physics and with it of the whole of modern science."

Thus physicists and philosophers have contrived various proposals to prove the isotropy of the speed of light. Those include clocks coupled mechanically by rigid shafts, infinitely slow clock transport, observations of Jupiter's moons, and the use of galvanometers, cavity microwave resonance, and optical interference as sources of measurement. Such methods, however, have suffered refutations and retractions as critics have shown that they involve tacit assumptions equivalent to the standard simultaneity convention. Hence, John Norton once compared this persistent quest to the search for a perpetual motion machine.

In 1970 John Winnie derived a relativistic kinematics independent of the assumption that light speed is isotropic and showed that the theory shares identical experimental consequences with special relativity. Jammer expertly clarifies questions of symmetry and transitivity of nonstandard synchronisms. Meanwhile, some writers have advanced various nonempirical arguments based on simplicity and on causal theories of time to attempt to refute the claim that simultaneity is a convention. Various writers, even Jammer, have criticized such arguments, though Jammer cites a couple of arguments that he does not refute. He actually achieves the tone of an impartial scholar, which is much preferable to that of an impatient and biased judge. He treats conventionality as an unresolved, fundamentally important issue in physics.

The author also analyzes simultaneity in the context of the general theory of relativity. He points out that in a general system of reference it is impossible to globally define simultaneity between any two events. Thus a key concept that sprouted special relativity lost its general validity in the later theory.

Concepts of Simultaneity excels at clearly explaining subtle but important issues. The book is incisive and valuable; it will appeal not only to historians and philosophers of physics but also to physicists drawn to the elements of special relativity. It is indeed as good as Jammer's earlier classics. Physicists used to have no comprehensive resource for catching up on the thought-provoking literature on simultaneity. Now they do.

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