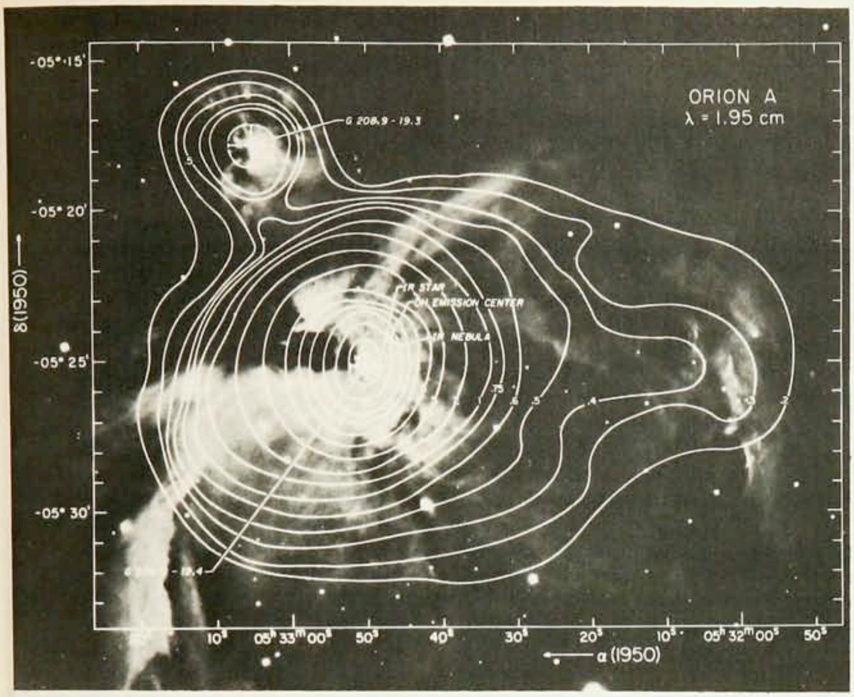

Radio map of a portion of the Orion Nebula that is a probable site of star formation. This type of region is described in *Stellar Formation* by V. C. Reddish. (photograph: NRAO)

stars into the spiral arms is the most obvious structural feature of spiral galaxies. Reddish summarizes the density wave theory for the origin of spiral arms. According to this theory the spiral-arm structure does not wholly share the differential rotation of the mass of clouds and stars. It is likely that shock waves produced by the movement of density waves through galactic clouds are effective in compressing them sufficiently that some become unstable against gravitational contraction or collapse.

The book contains a discussion of how the evolution of galaxies is influenced by the birth and death of stars. The integrated properties of spiral, elliptical and irregular galaxies indicate that star formation proceeds at different rates in different types of galaxies. In the case of elliptical galaxies, most star formation appears to have taken place during the initial collapse of the protogalaxy. The formation of numerous low-mass stars has apparently been preceded by the formation and explosion by supernova outburst of a large number of massive stars.

Interstellar grains and molecules must play very important roles in the process of star formation. Reddish has made numerous research contributions to this field and has been particularly interested in understanding the effects of interstellar grains. The book describes much of this work. Its principal shortcoming is its lack of a systematic discussion of interstellar molecules.

The reader who has some background in astronomy will find the book an interesting and very useful introduction to research in the field of star formation.

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Fundamentals of Quantum Mechanics

V. A. Fock
368 pp. Mir, Moscow, 1978 (Imported Publications, Chicago, Illinois)
(first Russian ed., 1932). $7.50

This book, translated by Eugene Yankovsky from the greatly augmented 1976 Russian edition, should be valuable to those who like or need lengthy mathematical derivations of properties of spherical harmonics and of radial functions used in one-electron wave mechanics. The book covers several of the topics one expects in an introduction to quantum mechanics and a few valuable additional topics, but the omission of other important fundamentals of quantum mechanics makes the title of the book somewhat pretentious.

Considering Vladimir Fock's own outstanding contribution to the theory of second quantization,[1] it is somewhat disappointing that this book merely mentions this subject without elaboration on the second to the last page. Also, after a discussion of Dirac's relativistic wave mechanics in the last part of the book, positron theory is merely mentioned in its original primitive form using holes in a sea of negative-energy electrons, ignoring the progress made since then.[2] Fock's introduction of the Dirac equation itself is as axiomatic as Dirac's and lacks the elegance and pursuasiveness of the method based on considerations of covariance found in H. A. Kramers's book on quantum theory.[3] The author's discussion of the many-electron problem does state a few of the important results of multiplet theory, but as the book does not justify these statements by either derivation or application, a student reader without prior knowledge of the topic would remain confused. For instance, Fock uses the spin permutation operators P_{ij} in a formula for the square of the total spin without explaining or even mentioning that $P_{ij} = (1/2)(\sigma_i \cdot \sigma_j + 1)$. The vector model is once mentioned by name, but never explained. Again, Kramers's book gives a far better introduction for all of this.

Fock's discussion of perturbation theory for stationary states goes beyond what is found in most English texts by discussing the zeroth-order wave functions to be used for first-order calculation of the perturbed energy levels in the case of two adjacent unperturbed energy levels.[4] He also discusses the Stark effect and the wave functions for valence electrons and for cores or closed shells, with a brief mention of the Hartree–Fock equations. However, the book does not discuss time-dependent perturbation theory at all, so that he bases the selection rules for spectral lines completely upon semiclassical radiation theory, while the discussion of scattering is very brief and incomplete.

Fock tries to discuss the meaning of the wave function. Here it is most disturbing that he does not discuss at all the density matrix formalism introduced by John von Neumann.[5] As quantum-mechanical states describe probability distributions, it is usually said that they describe ensembles. Fock notes that for each different quantity Q measured on particles or systems in a given quantum state ψ, there is a separate ensemble (say $E_Q(\psi)$). While ψ describes all measurements that are "potentially possible," each of these $E_Q(\psi)$ describes "the accomplished" of a particular choice of Q. Most people would conclude that Fock's ensembles $E_Q(\psi)$ are simply subensembles of what they would call the ensemble $E(\psi)$ described by ψ. Fock's claim that this ensemble $E(\psi)$ would not exist then merely means that his definition of an ensemble somehow is narrower than the definition of an ensemble used by those who define $E(\psi)$ as the union of all the author's $E_Q(\psi)$ with common ψ, so that this seeming difference in language. Fock, however, concludes without further justification that "a wave function describes the state of only one particle . . . and must be interpreted on the basis of the potential possibility of certain results being obtained in experiments (measurements) with the particle." (page 231) He does not explain how this conclusion would follow from his own preceding discussion, or even how one would measure for only one particle a potential possibility expressed by a probability distribution. Instead of concluding that ψ describes for each potentially possible an ensemble $E(\psi)$, he continues that "a quantum object cannot be an element of a statistical ensemble."

What is worse, Fock does not even warn the reader that most quantum-mechanical states (or preparations of states of physical systems) are not describable by any wave function or state vector at all;[6] as in von Neumann's sense most states are not "pure" but "mixed states" describable only by density matrices. The confusion is further increased by the use of the label "mixed state" for a pure state described by a superposition of wave functions on page 230. The author's tacit assumption that all states would be describable by wave functions also leads him to the assumption that necessarily normalization of wave function must be conserved, so that for ψ there should always exist a unitary evolution operator. This misunderstanding (in which he is not alone) means a tacit denial of the existence of physical systems that are not closed systems.[7]

As I already mentioned, Fock's book gives a lot of mathematics for some fundamental topics. One strong point of the book is its emphasis on similarities between the results of Schrödinger's theory and of classical theory, and between the results of Dirac's theory and Pauli's spin theory. However, many derivations are unnecessarily lengthy and can be much abbreviated by use of different methods. Compare, for instance, the 6 ½-page derivation of the radial Dirac equation starting on page 321, with the 1 ½-page derivation given on page 322 in L. I. Schiff, *Quantum Mechanics* (McGraw-Hill, New York, 1949).

Fock defines p_r as $i\hbar\partial/\partial r$ (which is not Hermitian when operating on conventionally normalized wave functions). His equation (6.42) on page 253, however, is valid only if p_r in it is understood to mean the Hermitian operator $-i\hbar[\partial/\partial r + 1/r]$ called $p_r{}'$ by Fock on his page 165. This error would not have occurred, if equation (6.42) would have been derived by the half-page-or-less derivation found in other books, instead of by Fock's five-page derivation on pages 248–253. He sometimes writes ψ for what others would called $r\psi$, and sometimes fails to indicate where a transformation is made from the one ψ to the other. Somewhere between pages 323 and 325 such a change of ψ must have taken place, or many later formulas would be incorrect. On the positive side, some readers may like Fock's use of "proper differentials" for avoiding explicit Dirac delta-functions in the discussion of the continuous spectrum.

The English of the translation by Yankovsky generally is good, except for the utilization of the verb *build* for *construct* when speaking of mathematical expressions and (on the last 50 pages) the use of *exclude* for *eliminate.*

To sum it up, this book belongs in libraries where it may serve as a reference book for properties of some functions often used in applications of wave mechanics. Those already familiar with wave mechanics might learn a few additional things from it. As a textbook for a starter course in wave mechanics for physics students, however, it would be a poor substitute of other books available, as beginning students may well become lost in some of the mathematical derivations.

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2. See for instance, A. S. Wightman and S. S. Schweber, Phys. Rev. **98**, 812 (1955).
3. H. A. Kramers, *Hand and Jahrbuch der chemischen Physik* **1**/II, Akademische Verlagsgesellschaft, Leipzig (1938) or H. A. Kramers, *Quantum Mechanics*, North-Holland, Amsterdam (1956).
4. These wave functions are found also in A., S. Davydov, *Quantum Mechanics*, Pergamon, Oxford (1965).
5. J. von Neumann, Göttinger Nachrichten **1927**, 1, 245, 273 and D. ter Haar, Rep. Prog. Phys. **24**, 304 (1961).
6. See F. J. Belinfante, Int. J. Quantum Chem. **17**, 1 (1980).
7. See F. J. Belinfante, *Measurements and Time Reversal in Objective Quantum Theory*, Pergamon, Oxford (1975).

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book note

Table of Integrals, Series and Products: Corrected and Enlarged Edition. 1160 pp. I. S. Gradsteyn, I. M. Ryshik. Academic, New York, 1980. $19.50

The first Russian editions of this massive tome predate World War II; the first English edition (prepared from the fourth Russian) came out in 1965. Much has changed in that time. Where the earlier versions were intended to help scientists and engineers find analytical solutions to problems often involving complicated series of special functions, high-speed computers now find numerical solutions to these problems directly. Alan Jeffrey, professor of engineering mathematics at the University of Newcastle-upon-Tyne, has revised and enlarged the earlier edition to meet these changing needs. The emphasis on series is somewhat reduced and new material has been added: chapters on vectors, matrices and determinants, on inequalities and on integral transforms. The major part of the work is still the huge table of integrals (900 pages), but the new material should make the book useful for both traditional, analytic solutions as well as for complex problems for which one needs to be able to estimate the properties of solutions instead of finding them outright. —TVF

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