BIBLIOGRAPHY

Encyclopedia of theoretical physics

M. I. Koganov

Usp. Fiz. Nauk **145**, 349–354 (February 1985)

Physics is one of the most dynamic sciences. Accumulating and selecting knowledge, it advances into unknown fields constructing instruments and creating methods of investigation, formulating new concepts and approaches. Theoretical physics changes, possibly, more rapidly than experimental physics. Improvement in development of mathematical apparatus of the theory takes place continuously, such abstract branches of mathematics become involved that it becomes ever more difficult for one man to know all theoretical physics. One has to state sadly that the time of the encyclopedists (even in the specially restricted sence of this word) has gone by: theoretical physicists from different fields have a hard time understanding each other. Under these conditions the existence of the "Course of Theoretical Physics" in its design and in fact embracing the whole theoretical physics becomes a most important fact of scientific life.

Several generations of physicists studied using "Landau and Lifshitz", and not only studied, but continuously used the course in their daily (creative and educational) activity. It is difficult to name other books on theoretical physics which can with equal justification be granted the "title" of a reference. And at the same time there was always a feeling that there is no complete course of theoretical physics. How many times was it that each one of us on encountering one of those problems which later found their way into other volumes thought longingly: "if only 'kinetics' (or 'theory of the condensed state') . . . " would be published. And now (since 1979) there does exist a complete "Course of Theoretical Physics" by Landau and Lifshitz. This titanic project planned by L. D. Landau more than forty years ago has now been completed by E. M. Lifshitz together with L. P. Pitaevskiĭ in 1979 with the publication of the X volume of the course—"Physical Kinetics". This does not mean that work on the course has ceased. In 1982 a second edition of "Electrodynamics of Continuous Media" revised and augmented by E. M. Lifshitz and L. P. Pitaevskiĭ has been published. A new edition of "Hydrodynamics" is in preparation.

The complete course consists of ten volumes published at different times[1]:

I—Mechanics 1973 (1958).
II—Field Theory—1973 (1941).
III—Quantum Mechanics (nonrelativistic theory)—1974 (1948).
IV—Quantum Electrodynamics[2]—(1968).

[1]Cf., "Physical Kinetics", p. 10. The years of publication of the first editions are shown in parentheses.

[2]Written by V. B. Berestetskiĭ, E. M. Lifshitz, and L. P. Pitaevskiĭ.

E. M. Lifshitz, L. D. Landau (1940's)

V—Statistical Physics, Part 1—1976 (1938—Classical Statistics; 1951—Classical and Quantum Statistics).
VI—Mechanics of Continuous Media—1953 (1944, Hydrodynamics will be published separately in 1985).
VII—Theory of Elasticity—1965.
VIII—Electrodynamics of Continuous Media—1982 (1958).
IX—Statistical Physics, Part 2 (Theory of the Condensed State)—1978.
X—Physical Kinetics—1979.

In 1932 Landau moved to Khar'kov, becoming the Head of the Theoretical Division of the Ukrainian Physico-Technical Institute (UPTI) and the Department of Theoretical Physics in the Physico-Mechanical Faculty of the Institute of Mechanics and Machine Building. He was full of ideas which became incorporated in his brilliant papers of those years. He dreamed of restructuring the teaching of physics in its entirety. Already in Leningrad with the participation of N. Bronshteĭn he made the first outline of the future "Statistical Physics". " . . . in Khar'kov the idea was born and the realization began of the program of compiling a complete course on theoretical physics and a course of gen-

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eral physics" (E. M. Lifshitz "Lev Davidovich Landau" in the collected works of L. D. Landau.—Nauka, M.,—Vol. 2, p. 432). "Not limiting himself to the development only of programs, he gave lectures on theoretical physics for the scientific members of the UPTI, and for students of the Physico-Mechanical Faculty" (*ibid.*, p. 431). The early chapters of the Course were written on the basis of lecture notes. Who of the young men (in 1932 Landau was 24 years old!) did not dream "of great deeds . . . of glory"? One is not overwhelmed by the grand scale of the plans, one is overwhelmed by the fact that they have been carried out! Of course, Landau "was . . . a truly outstanding teacher, a teacher by vocation. In this respect, perhaps, it is permissable to compare Landau with his own teacher—Niels Bohr" (*ibid.*, p. 431). But one should also not forget the fact that in Khar'kov in the early 1930's L. D. Landau began to work together with E. M. Lifshitz. It is precisely at that time that the combination of words "Landau and Lifshitz" so familiar to all physicists and displayed on one of the title pages of the Course originated.

The Course of Theoretical Physics lacks a preface common to the whole course in which the principles on which the course was structured would be formulated. And in a certain sense this circumstance corresponds to the spirit of the Course—to "tackle the task" from the very first lines. I think that one of the guiding ideas for structuring the Course of Theoretical Physics consists of arriving by the shortest path to the solution of specific problems without getting bogged down in arguments and the laying of foundations. Theoretical physics, as propounded by Landau and Lifshitz, is a science which enables one to answer concrete questions: how to calculate the cross-section of some process, to evaluate the damping of sound or to determine the equation of state. But the Course is by no means just a handbook of mathematical methods. The whole exposition is based on physical concepts, either general ones (such as conservation laws) or model ones (ideal gas, collisionless plasma, a strictly periodic crystal, etc.). However, in reading the Course there arises (or is enhanced) the understanding of the fact that there is no theoretical physics, and that there cannot be any, without a rigorous mathematical apparatus. Estimates, suggestive arguments are needed specifically as suggestive arguments, utilizing which one can construct a rigorous theory whose result must necessarily be a formula (or a curve) relating physical quantities. If in the initial formulations the authors have indulged in a certain deliberate haste[3] (in any event: essentially, the fundamental equations of any physical theory cannot be derived, they are a mathematical distillation of our experience), then later in going on to the development of the theory the authors are rigorous and very punctilious, although nowhere (over the whole Course) do they indulge in purely mathematical "epsilontics" taking the point of view (with perfect justification) that the aim of theoretical physics is not to prove existence theorems for solutions, but to obtain the solutions directly. The solutions can often be obtained by following different paths. It seems to me that the authors always find the *natural* path to a solution; the results obtained do not leave the reader with the feeling of mystical horror which arises in reading many modern books in which the result "appears" after a number of nebulous statements. The reader of the Course of Theoretical Physics having provided himself with pen and paper (one cannot proceed *without* this!) can, by following the authors, carry out the whole calculation, learning "along the way" methods which without any doubt will be useful to him in his independent work.

The amazing feature of the Course is the selection of material. Almost everything contained within the ten volumes appears to be without any doubt necessary. But do they contain everything that is necessary? Are there any omissions? I think that there are. Very likely each specialist in a particular specific field will find them without any trouble. For example, it seems to me that in Volumes IX and X semiconductors should have been included along with metals (normal and superconducting). Within these same volumes it would have been appropriate to have chapters on disordered systems, etc. The omissions in "Kinetics" (kinetics of magnetic processes and passage of charged particles through matter) have been noted by the authors as "two obvious defects" (vol. X, p. 9). But still, if one criticizes the selection of material then one is more likely to do so because there is too much material rather than because some specific item is missing. As the authors assert with justification in the Preface to Vol. X, " . . . this book is a part of a course on theoretical physics and by no means lays any claim to be a course on solid state theory". This phrase might be inserted in the preface to any one of the volumes simply by replacing the name of the discipline.

Comparing the content of the books in different editions one begins to understand how difficult it is to leave something out of the Course. The second edition of "Electrodynamics of Continuous Media" exceeds the first edition by 100 pages. Without any doubt the authors understood that it would have been desirable to "reduce" the book to its initial dimensions, but, apparently, they could not bring themselves to it . . . It is easy to understand them. Even our (the readers') concepts of what theoretical physics consists (what is the content of this so comprehensive a concept) is created to a large extent precisely by the Course of Theoretical Physics by Landau and Lifshitz. And in the case of the authors?—all the more so . . .

The Course of Theoretical Physics by Landau and Lifshitz has been internationally acclaimed: it has been translated into six languages (English, German, French, Japanese, Italian, and Hungarian). The Course has been translated in its entirety; in yet another ten languages (Spanish, Portuguese, Serbo-Croatian, Rumanian, Polish, Bulgarian, Chinese, Vietnamese, Greek, and Hindi) individual volumes have been published; the two volumes of the Short course on theoretical physics that have been published have been translated into English, German, Spanish, and Slovak languages.

The Course has, as the saying goes, an "excellent press". Here are several excerpts from reviews.[4]

[3]Cf.: §2 in vol. I, ch. 1 (particularily §7) in vol. III, §8 in vol. V, and others.

[4]The translator was unable to locate the original reviews. Therefore the following quotations retranslated from the Russian text will inevitably differ in detail from the original passages.

Field theory

"The revised second edition of this irreplaceable work does not require a new discussion: this is the standard authority in the given field. But it is of interest to think a bit about its style and to attempt to discover the secret of its success. It consists, apparently, in the uncompromising simplicity, clarity, and precision of the text. Everything that can be clearly formulated, has been written down explicitly in a sequence of pure short phrases. The mathematical argument together with the physical laws on which it is based are presented so clearly that it appears that the logic itself carries us with it" (J. M. Ziman, 1963).

"The strict beauty of the smooth flow of rigorous mathematical deductions has been purchased at a high price. It in fact reduces to turning the natural development of the subject upside down. I know from our discussions in the good old days that for Landau his "Ingres' violin" has been his belief that the whole of physics can be encompassed by the monumental principle of least action. As far as I can judge, this is the leading idea strictly followed throughout the whole Course, and we can see the results" (L. Rosenfeld, 1952).

"The authors begin by formulating the theory of relativity in terms of the principle of least action. This somewhat abstract approach to the subject is maintained throughout the whole book" (C. Holbrow, 1962).

Relativistic quantum mechanics

"The nine volumes of the Course of Theoretical Physics associated with the names of Landau and Lifshitz occupy a unique place in the literature on theoretical physics and both because of their style and content have no rivals. The great accomplishment of the three authors of the present volume is the fact that they have written a book on the most difficult of all the fields of theoretical physics which deserves to stand in the same rank with the other volumes. If one remembers that this was done without Landau's direct influence, this achievement appears to deserve particular commendation" (E. Squires, 1971).

Quantum mechanics

"I think that this is, probably, the best of the presently existing courses on quantum mechanics . . . It encompasses artistic charm in its details. Someone has discovered the secret of what induces the best men in science to write textbooks" (A. Salam, 1959).

"It is just in the last semester, once again after a long interruption, that I gave a course on quantum mechanics, and already at the first glance at your book I could establish how carefully the material was selected and arranged, and how impressive is the exposition in all its details . . . I admire yours and Lifshitz's ability to work which give you the strength to write such books" (W. Heisenberg, 1959). (From a letter)

"From the many manuals on physics the Landau and Lifshitz series on theoretical physics has exerted and continues to exert a deep influence on the physics community. The authors have accomplished a remarkable feat, by having covered almost the whole theoretical physics in an authoritative manner in a remarkably easily readable series of volumes. The mastery of the subject which the authors exhibit is reflected in the inimitable manner in which these books are written" ("J. de Physique", 1978).

Electrodynamics of continuous media

"As the successive volumes of this monumental work appear in English translation the exact measure of its grandeur becomes ever more evident. One can only repeat again and again that in our time there is nothing with which this can be compared—not only in its breadth of coverage, but in its conceptual unity" (N. Kemmer, 1961).

"The titles of the volumes in this series cover a tremendous range of subjects, and it appears that there is very little in physics about which the authors are not very well informed. The volume on the electrodynamics of continuous media creates the impression of a truly remarkable degree of mastery by the authors of this subject" (B. Chirgwin, "Nature", 1961).

Physical kinetics

"I seriously doubt that at the present time there are in the whole world many physicists who would not have in their personal libraries at least several volumes of the Course of Theoretical Physics by Landau and Lifshitz. There are many reasons for the tremendous popularity of these books: the wide range of subjects, the presentation of the material in a clear and definitely 'nonpedestrian' form . . . and particularly in the fact that if someone has some subtle question concerning anything in physics he will most likely find this question discussed and answered somewhere in the Landau-Lifshitz books. The present volume "Physical Kinetics", the last volume in this series, is characterized by all the positive qualities mentioned above . . . This is an excellent book and I can recommend it enthusiastically" (J. Dorfman, 1983).

The aim of the present note does not include an analysis of specific methods of presentation, although many of them evoke sincere admiration. However, one should recall that the principles of presenting the most important sections of theoretical physics were being created in the process of writing the Course. For the first time the course on mechanics [5)] is constructed starting from the principle of least action, and the conservation laws are deduced from symmetry considerations; for the first time the presentation of field theory is based on the theory of relativity, and of statistical physics on the Gibbs method. Even the fact that "statistics and thermodynamics form a unified whole" had to be explained to the readers by the authors who added that "all concepts and quantities of thermodynamics follow most naturally, simply and rigorously from the concepts of statistics" (cf., vol. V, "From the Preface to previous editions", dated 1937–1939).

A special place is occupied by "Electrodynamics of Continuous Media". It seems to me that this book has creat-

[5)]In essence, it is specifically in the Course by Landau and Lifshitz that mechanics has become a chapter in theoretical physics. Until then there was in existence theoretical mechanics of a mathematical nature, and mechanics as a section of physics.

ed a new section of theoretical physics. This field (as a section of theoretical physics) simply did not exist! I would like to call attention to two quotations. From the Preface to the first edition (1956): "In writing this book we encountered considerable difficulties associated with the necessity of making some sort of a selection from the available tremendous material . . .". And from the Preface to the second edition (1981): "The selection of material was made at the time in such a manner that in fact it (with very insignificant exceptions) has not become outdated even by now"(!).

Having in mind the use of the Course as an educational resource in theoretical physics I would like to make some comments and to express some wishes.

Unfortunately the publication of the "Short Course on Theoretical Physics" has ceased (the second book—"Quantum Mechanics" was published in 1972). Perhaps each volume should be provided with a list of sections which could be omitted on first reading (even the "Landau minimum" contains such a list). In each volume there is a brief subject index, which "complements the Table of Contents of the book without repeating it. The index includes terms and concepts which are not reflected directly in the Table of Contents". Of course, a subject index is an aid in the search for the required material. The Course lacks a subject index to the whole series of volumes (perhaps it should be published in the form of a separate volume—an appendix?!). The next wish is addressed not to the authors but to the users themselves. It seems to me that it would be very important to write and to publish methodological developments of the basic theoretical physics disciplines presented in the physics faculties of universities and in physico-technical institutes. The program cannot encompass all the material making up the content of the Landau-Lifshitz Course. The lecturer has to make a selection or to use other books. The level of instruction in theoretical physics will be raised if methodological aids would be developed (and, of course, published)—a kind of guide over the course containing not only a list of selected sections (in accordance with the program), but also an explanation of the difficult passages, an indication of what part of the material is to be presented in lectures and what part is offered for individual study. In effect the problems in the Course are a direct extension of the sections. They are practically all provided with solutions (perhaps the solution is presented somewhat more concisely than the main text). The importance of the role played by completely independent work—solution of a problem without being prompted is well known. A methodological teaching aid should be prepared formulating problems for independent solution by the student and indicating when (following the presentation of what subject) they should be assigned. And, finally, the last wish. It refers to those who use the Course of Theoretical Physics in reading (or studying) special disciplines—plasma physics, solid state physics, etc. In my opinion one should boldly introduce into the programs and the corresponding methodological outlines material from the Landau-Lifshitz Course. My experience shows that in presenting a special discipline reference to the Course of Theoretical Physics makes the presentation not only deeper but also, if one can say so, more "all-embracing". The use of the Course teaches conciseness of presentation which economizes time and makes possible to present (from general points of view) much specific material.

In concluding this review I wish to congratulate E. M. Lifshitz and L. P. Pitaevskiĭ and the readers with the completion of the Course of Theoretical Physics. This is a most important event in the life of world science. I am confident that work on new editions will continue and the revised volumes (first of all—"Hydrodynamics") will take their place on the desks of theoretical physicists.

February 21 was the seventieth birthday of Academician Evgeniĭ Mikhaĭlovich Lifshitz.

His fundamental papers on ferromagnetism, on the theory of phase transitions of the II kind, on superfluid helium, on cosmology, on calculation of forces acting between condensed bodies—have placed E. M. Lifshitz among the most prominent theoretical physicists of the world.

An infinite amount of effort, energy, and lively interest has been devoted by E. M. Lifshitz to JETP. All the actively working physicists know how uncompromisingly Evgeniĭ Mikhaĭlovich directs our oldest physics journal, maintaining it with all the resources at his command at its high, truly world-class level.

The Course of Theoretical Physics by Landau and Lifshitz is the lifetime work of Evgeniĭ Mikhaĭlovich.

Evgeniĭ Mikhaĭlovich celebrates his anniversary with his productive powers in excellent form. Knowing his strong distaste for high-sounding phrases and pompous outpourings of words we restrict ourselves to wishing him to remain for a long time hale and hearty and actively working.

Translated by: G. M. Volkoff, Editor of Sov. Phys. Usp., who joins The Editorial Board in their good wishes.