INTRODUCTION TO THE CLASSICAL THEORY OF PARTICLES AND FIELDS

Note de lecture

Introduction to the Classical Theory of Particles and Fields, Boris Kosyakov, XIV + 479 pp. Springer, Heidelberg, 2007. Hardcover. Price: 139.95 euro.

This volume is intended to be an introduction to modern field theory for advanced undergraduate and graduate students. The book is restricted to classical theory in Minkowski space-time which is the subject of many already existing texts. However the reader will be surprised how many new aspects are still there which were not touched upon in the standard courses. Particular attention has been given to conceptual aspects of field theory, accurate definitions of basic physical notions, and thorough analysis of exact solutions to the equations of motion for interacting systems. Two theories covered by the book in great detail are the Maxwell–Lorentz electrodynamics and Yang–Mills–Wong theory.

The author deliberately excluded gravitation from consideration. This restricts his argument to the simplest relativistic geometry of Minkowski space-time. Is this selection of the subject matter a robust stand? Phenomenologically, the best strategy to be followed is to combine examination of electromagnetism and gravity, because both have definite domains of their classical manifestations, directly observed in macroscopic experiment. However, the advance of gauge theories in the 1970s made it clear that electrodynamics blends well with just the Yang–Mills theory, both stemming from a single dynamical paradigm—the theory of gauge interactions. Three of the four fundamental forces are mediated by gauge fields: electromagnetic, weak, and strong. The fourth fundamental force, gravitation, differs radically from those three both in conceptual and mathematical respects. It is therefore quite reasonable to begin with gauge fields in their simplest incarnation if we are to understand how they are actually structured.

In chapters 1–5, and 7, the main body of the Maxwell–Lorentz and Yang–Mills–Wong theories is developed, and the rest of the book, stretching over chapters 6 and 8–10, focuses on the self-interaction problem. Kosyakov's *Introduction* covers an impressively large scope of topics and includes many (above 300) instructive problems. For example, considerable space is given to symmetries (ranging from the traditional Poincaré invariance via gauge invariance and reparametrizations, to duality and conformal symmetries, which are rare in the existing literature) and their associated conservation laws and Noether identities. Most of the common standard results in relativistic mechanics and gauge field theory are covered in a very lucid manner. Of particular interest is the basic idea of the last chapter: "To comprehend electrodynamics as a whole, one should view it from different perspectives in a wider context". To this purpose, it is necessary to generalize the principles underlying mechanics and electrodynamics. *Introduction* is the only text I have seen which offers such careful analysis of this branchy subject.

The professional field theorists will enjoy a refreshing treatment of self-interaction in the Maxwell–Lorentz and Yang–Mills theories. Self-interaction is a central problem of the book. The discussion relies heavily on refined key notions: the rearrangement of the initial degrees of freedom appearing in the Lagrangian, dressed particles, and spontaneous symmetry deformation.

The book will certainly attract the interest of philosophers of science. During the 20th century their attention was occupied by revolutionary events in physics, which followed so fast one after another: Relativity, Quantum Mechanics, Quantum Electrodynamics, Standard Model, Grand Unification, Strings, Dark Energy. There comes a time to clear debris and try to gain a deeper insight into what is presently known as "classical physics". The reader will find that familiar notions and facts are not all that sharply defined and conclusively established. Among concepts on which the book has been pondered are the inertial frames of reference, standard time scale, mass, charge, and electromagnetic field. It transpires that Newton's first law is entirely valid only for a certain class of mechanical objects (Galilean particles), while Newton's second law in its original formulation requires no modification: it should be only embedded in the four-dimensional geometry of Minkowski space. The dynamical law for the electromagnetic field appears here in a quite marvelous way. Kosyakov shows that some of the structure of Maxwell's equations is dictated by the geometrical features of our universe, in particular the fact that there are three space dimensions. The residual information translates into four assumptions: locality, linearity, the extended action–reaction principle, and lack of magnetic monopoles.

Kosyakov's historical remarks are very much to the point. The bibliography contains some 400 written out in full major references.

In summary, this is a useful introductory and reference work which can be recommended to students studying the fundamentals of classical field theory. Specialists will also enjoy many original derivations and discussion of subtle points of Maxwell–Lorentz electrodynamics and gauge theories with classical particle sources.

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