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★**The thermodynamics of quantum Yang-Mills theory.**

Theory and applications.

*World Scientific Publishing Co. Pte. Ltd., Hackensack, NJ, 2012. xviii+461 pp.*

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There is no doubt that gauge theories have dominated the last 50 years of theoretical physics, at least as far as ‘experimentally accessible’ theoretical physics is concerned. They include the best known and tested models for the mathematical description of the fundamental interactions known in nature—only gravity has difficulties fitting into this scheme.

Gauge field theories have an impressive number of ‘ramifications’. Their applications cover an impressive number of fields, from pure mathematics to economics.

On the parallel side, finite temperature (or thermal) field theories have also attracted a lot of attention. Finite temperature field theories can be conveniently described in terms of ‘conventional’ quantum field theories by an analytic continuation to the Euclidean time  $t \rightarrow i\tau$ , followed by a  $\tau$  compactification, the inverse of the period being the temperature.

The subject of the present book is precisely the intersection of the above two subjects: thermodynamics of quantum Yang-Mills theory. It is an exotic subject, in the sense that it is not much studied. This is one of the few books on the matter.

Thermodynamics deals with the world of many particles; it deals with averages that are more reliable when larger numbers of particles are considered. On the other hand, very naively one could think that Yang-Mills theories deal with particles that either: (a) cannot be freely observed in nature (in the case of the  $SU(3)$  gauge theory of strong interactions) or (b) are extraordinarily rare at our scales (in the case of the electroweak model). So, at first these two subjects seem ‘at odds’ with each other. This is not true: the conventional Standard Model describes *one* of the possible phases of Yang-Mills theory, and different phases occur at different temperatures, so the thermodynamics of Yang-Mills theories studies how the different phases of gauge theories evolve with temperature (or energy). It is not incidental that this subject plays a crucial role in astroparticle physics and cosmology, where energies and temperatures span over large scales.

The author is very competent in this field. He has conducted a lot of research in this subject and published important contributions. Unfortunately the matter is as fascinating as it is difficult, in the sense that it requires a lot of prerequisites to be understood. One should be able to handle capably—just to begin—gauge field theory, non-perturbative methods, finite temperature field theory and phase transitions. This is not an easy task, and this is, in my opinion, the key to understanding the greatest value of this book: it drives the reader into an impressive number of different (and difficult) subjects. It is unusual to find so many different subjects in a single source. This is done in Part I, where in seven chapters the author describes many aspects of Yang-Mills theories: classical and quantal (perturbative) theory, finite temperature theory, non-perturbative solutions (Euclidean or not), and all three phases of the theory (deconfining, preconfining and confining). At the end

of each chapter there is a collection of problems and a list of references dedicated to the specific chapter.

Part II of the book contains the last three chapters, which describe mainly astrophysical and cosmological applications. These last chapters do not have problems.

Chapters 5 to 10 largely rely on research papers written in the last few years. This means that if on the one hand the matter is an active area of research and very up-to-date, on the other hand it will not be presented at an 'elementary' level. This is not an easy book. It is more of a research book, so do not expect to find an easy textbook. Fortunately every chapter has many references to guide the reader through the literature of the specific subject. To whom is this book addressed? Certainly to graduate students and researchers willing to undertake a journey into this fascinating subject.

Reviewed by *Giuseppe Nardelli*

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