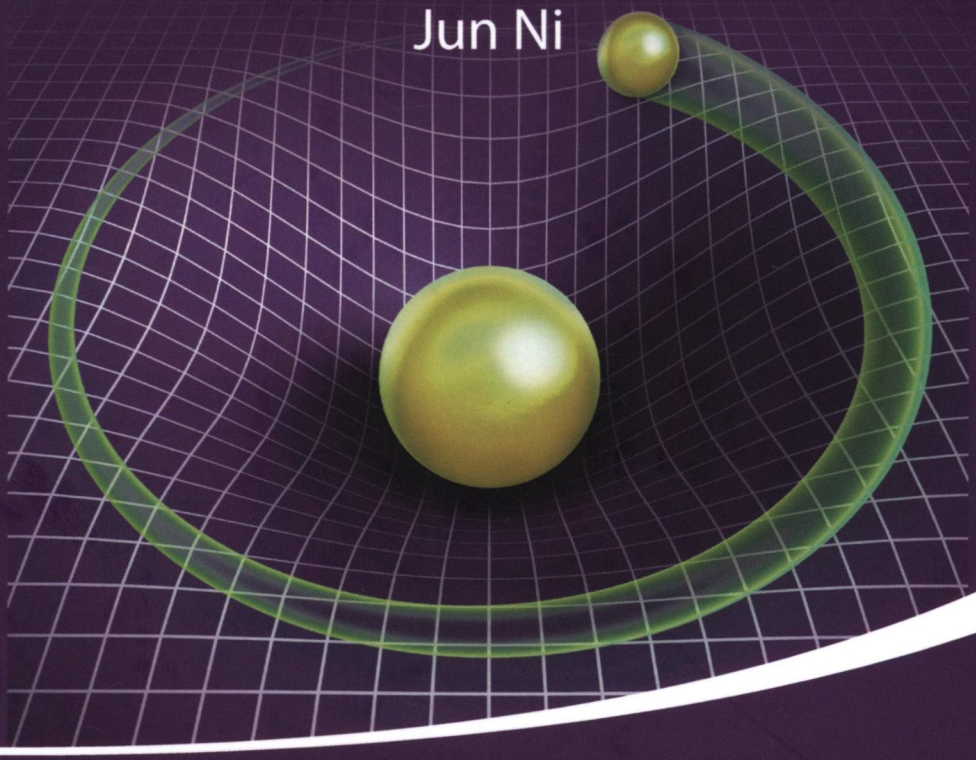
TSINGHUA
Report and Review in
Physics Vol. 3

PRINCIPLES OF PHYSICS

From Quantum Field Theory to Classical Mechanics

Second Edition

Jun Ni



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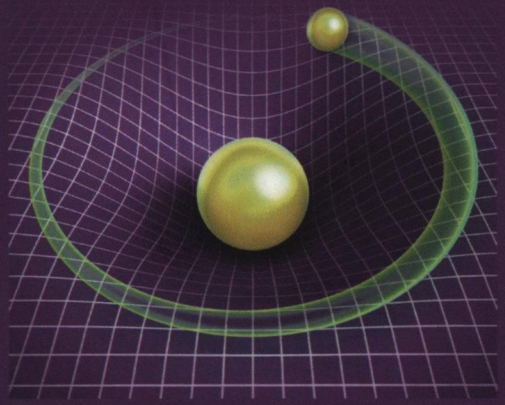

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Review of the First Edition:

"The book is highly recommended as a reference for advanced graduate students and scholars involved in modern physics research. The perspective obtained from sequential derivation and presentation of topics, from quantum to macro-scales, enables the reader with an increased understanding of the topics so described."

Contemporary Physics

This book starts from a set of common basic principles to establish the basic formalisms of all disciplines of fundamental physics, including quantum field theory, quantum mechanics, statistical mechanics, thermodynamics, general relativity, electromagnetism, and classical mechanics. Instead of the traditional pedagogic way, the author arranges the subjects and formalisms in a logical order, i.e. all the formulas are derived from the formulas before them. The formalisms are also kept self-contained. Most mathematical tools are given in the appendices. Although this book covers all the disciplines of fundamental physics, it contains only a single volume because the contents are kept concise and treated as an integrated entity, which is consistent with the motto that simplicity is beauty, unification is beauty, and thus physics is beauty.

This can be used as an advanced textbook for graduate students. It is also suitable for physicists who wish to have an overview of fundamental physics.

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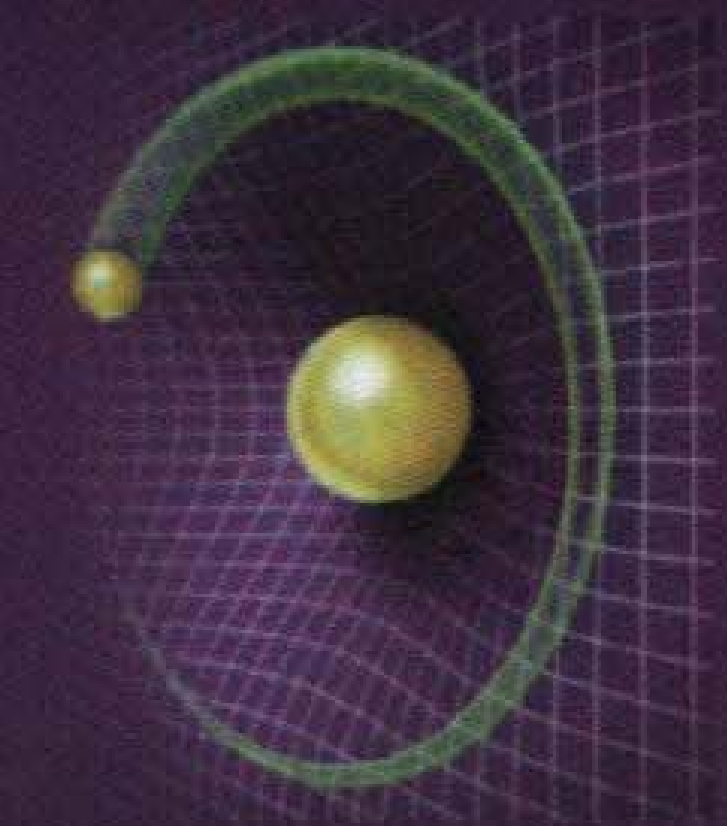

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Vol. 1 Möbius Inversion in Physics
by Nanxian Chen

Vol. 2 Principles of Physics:
From Quantum Field Theory to Classical Mechanics
by Jun Ni

Vol. 3 Principles of Physics:
From Quantum Field Theory to Classical Mechanics (Second Edition)
by Jun Ni

To my daughter Ruyan

Preface

During the 20th century, physics experienced a rapid expansion. A general theoretical physics curriculum now consists of a collection of separate courses labeled as classical mechanics, electrodynamics, quantum mechanics, statistical mechanics, quantum field theory, general relativity, etc., with each course taught with a different book. I consider there to be a need to write a book which is compact and merge these courses into one single unified course. This book is an attempt to realize this aim. In writing this book, I focus on two purposes. (1) Historically, physics is established from classical mechanics to quantum mechanics, from quantum mechanics to quantum field theory, from thermodynamics to statistical mechanics, from Newtonian gravity to general relativity. However, a more logical presentation is from quantum field theory to classical mechanics, from the physics principles on microscopic scale to physics on macroscopic scale. In this book, I try to achieve this by elucidating the physics from quantum field theory to classical mechanics from a set of common basic principles in a unified way. (2) Physics is considered as an experimental science. This view, however, is being changed. In the history of physics, there are two epic heroes: Newton and Einstein. They represent two epochs in physics. In the Newtonian epoch, physical laws are deduced from the experimental observations. People were amazed that the observed physical laws can be described accurately by mathematical equations. At the same time, it is reasonable to ask why the nature should obey the physical laws described by the mathematical equations. After wondering how accurately the nature obeys the gravitational law that the gravitational force is proportional to the inverse square of the distance, one would ask why it is not operated in other ways. Einstein created a new epoch by deducing physical laws not merely from experiments but also from principles such as simplicity,

symmetry and other understandable credos. From the view of Einstein, physical laws should be natural and simple. It is my belief that all physical laws should be understandable. In this book, I endeavor to establish the physical formalisms based on the basic principles that are as simple and understandable as possible.

The book covers all the disciplines of fundamental physics, including quantum field theory, quantum mechanics, statistical mechanics, thermodynamics, general relativity, electromagnetism, and classical mechanics. Instead of the traditional pedagogic way, the subjects and formalisms are arranged in a logical order, i.e. all the formulas are derived from the formulas before them. Also all the formalisms are kept self-contained, i.e. the derivations of all the physical formulas appeared in this book can be found in this book. Most mathematic tools are also given in the appendices. Although this book covers all the disciplines of fundamental physics, the book is compact and has only about 400 pages because the contents are kept concise and treated as an integrated entity. In this book, the main emphasis is the basic formalisms of physics. The topics on applications and approximation methods are kept minimum and are selected based on the generality and importance. Still it was not easy when some important topics had to be omitted. Since it is impossible to provide an exhaustive bibliography, I list only the related textbooks and monographs that I am familiar with. I apologize to the authors whose books have not been included unintentionally.

This book may be used as an advanced textbook by graduate students. It is also suitable for physicists who wish to have an overview of the fundamental physics.

I am grateful to all my colleagues and students for the inspirations and help. I would also like to express my gratitude to World Scientific for the help in publishing this book.

Jun Ni
August 8, 2013
Tsinghua, Beijing

Preface to the second edition

In this edition, the whole frame and style of the book remain unchanged. However, there are some modifications on the derivations of important equations. For example, I have used the new way to derive the Euler-Lagrange equation. There is also expansion on the contents of the book. I have made significant expansion on the parts of quantum electrodynamics, classical electrodynamics and special relativity, which makes the contents of the book more complete and self-contained. Quantum electrodynamics plays an important part in the bridge from quantum field theory to quantum mechanics. I hope these additions could better achieve the purpose of the book. I have also rewritten a few parts of the book and corrected the errors in the first edition.

Jun Ni
April 15, 2017
Tsinghua, Beijing

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