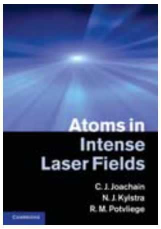


quarter-century of research has led to new VUV light sources and to attosecond science, which explores the time scale of correlated electronic motion in atoms and molecules. Scientists now understand much of the underlying physics responsible for the two phenomena related to VUV light production—high-harmonic generation (HHG) and above-threshold ionization (ATI). As a result, interest has turned to light-source applications of HHG; attosecond pulses; and strong-field studies in atoms, molecules, solids, and plasmas.

*Atoms in Intense Laser Fields* explains the underlying physics and theoretical techniques needed to advance the work. Authors Charles Joachain, Niels Kylstra, and Robert Potvliege have made numerous contributions to the theory of atoms and strong fields and have collaborated in the past. Joachain, in particular, has written several other textbooks and monographs on quantum mechanics and electron–atom collisions.

Previous books on the topic have not covered the history and status of strong-field atomic theory so well and so completely. *Theoretical Femtosecond Physics: Atoms and Molecules in Strong Laser Fields* by Frank Grossmann (Springer, 2008; reviewed in PHYSICS TODAY, November 2009, page 54) comes closest, but it is written at an advanced-undergraduate to beginning-graduate level, so it leaves out many of the more specialized methods used to carry out calculations. Other books on the subject are several years old, so this updated work is needed.

*Atoms in Intense Laser Fields* is a well-organized text. Part 1 summarizes the field in two chapters, introducing the history and importance of the subject with simple concepts and basic equations. The first chapter describes the experiments; the second chapter, on theory, lays out the elementary framework of HHG and ATI. The core of the book is part 2, chapters 3–7. Here the authors develop the concepts needed to perform calculations and interpret observations of strong-field phenomena. The chapters cover methods for solving Schrödinger's equation for an atom in a strong laser field. Examples of standard tools for that task include Crank–Nicolson and split-operator methods, quantum defect theory, and Floquet theory. The authors describe and develop the major theoretical approaches for strong-field physics, laser–atom physics, and electron–atom collisions, covering theories introduced by Farhad Faisal, Maciej Lewenstein, Howard Reiss, and others. This book does not assume that the reader is a student of advanced theory, but it goes well beyond the usual elementary discussions of the single-electron systems hydrogen and $H_2^+$.

Whereas part 1 developed a more intuitive and qualitative understanding of strong-field concepts in atomic physics, part 2 is more formal and mathematical. Chapter 4, on Floquet theory, describes many aspects of dressed states and helps to establish a basis for comparing different computational approaches. The dressed-state approach is quite useful for situations in which the laser wavelength and intensity are both slowly varying, but it is less useful for subcycle phenomena that have dominated recent work in attosecond science. In chapter 5 the authors describe methods to integrate the time-dependent Schrödinger equation and compare direct integration to Floquet results in several examples. They also cover the highly successful single-active-electron model and provide a good discussion of its strengths and weaknesses.

Part 2 concludes with a pair of chapters that discuss the low-frequency and high-frequency regimes in strong-field photoionization. Low-frequency phenomena include above-threshold ionization, in which the energy scale is not set by the photon energy but rather by the ponderomotive or quiver energy of electrons. Particularly noteworthy is the high-frequency, high-intensity regime, which has led to predictions of such exotic phenomena as high-frequency stabilization. Recent developments that use few-cycle pulses could have been discussed more in this section, particularly since the strong-field community has largely embraced few-cycle pulses and subcycle attosecond physics in the past decade.

Part 3, chapters 8–10, applies the results of parts 1 and 2 to three characteristic strong-field phenomena: multiphoton ionization, HHG, and laser-assisted electron scattering. Those chapters also include full discussions of attosecond pulses, multiphoton-induced multiple ionization, and the state of theoretical understanding in those areas.

Overall, *Atoms in Intense Laser Fields* is an excellent introduction to the phenomena and methods of strong-field, laser–atom physics. Despite its few shortcomings, the book is a solid exposition of the central discoveries and theoretical concepts that form the foundation of the field.

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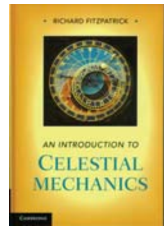
## An Introduction to Celestial Mechanics

Richard Fitzpatrick
Cambridge U. Press, New York, 2012.
\$65.00 (288 pp.).
ISBN 978-1-107-02381-9

Celestial mechanics is a venerable discipline more than two centuries old. It demonstrated stunning early victories, including the discovery of Neptune in 1846, and is now expanding into new areas such as exoplanetary research and solar-system evolution and navigation. Prior to the present generation of researchers, most techniques in the field were presented in essentially the same language that Leonhard Euler, Joseph Louis Lagrange, and Pierre Simon Laplace used at the turn of the 19th century: one that is incredibly and unnecessarily opaque.




Some textbook authors have attempted to make the field more approachable and understandable. Progress has been slow, but notable attempts include Dirk Brouwer and Gerald Clemence's *Methods of Celestial Mechanics* (Academic Press, 1961) and Carl Murray and Stanley Dermott's *Solar System Dynamics* (Cambridge University Press, 1999). But despite those efforts, a gap has long existed between material available for teaching the simple laws of Keplerian orbits and material for teaching the range of topics covered in existing advanced texts, including the three-body problem, secular perturbation theory, libration, and spin–orbit coupling.

*An Introduction to Celestial Mechanics* by University of Texas at Austin physics professor Richard Fitzpatrick aims to bridge that gap. His goal is to provide a textbook for the undergraduate or first-year graduate student who has seen derivations of Kepler's laws but needs to understand more complicated systems and deeper derivations based on Lagrangian and more sophisticated techniques. Fitzpatrick's text is excellent and makes a significant, though incomplete, improvement in presenting celestial mechanics to undergraduates.

Fitzpatrick's exposition is relatively flawless in its execution, but it could go further in offering more intuition for some of the results derived. The three-body problem is a good example. When I teach it to upper-level physics undergraduates, I motivate the derivation of the rotating pseudopotential results regarding Lagrange points by giving a "sneak peek" expressed in terms of a force formalism. That's useful, and it's easy to do. Then I show that results using pseudopotentials are more comprehensive and more generally applicable.

*An Introduction to Celestial Mechanics* is a valuable addition to the pedagogy of the field and has perhaps the clearest exposition of any celestial mechanics text for upper-level undergraduate students. For some students, Fitzpatrick will be approaching perfection. But for many others his text will need to be supplemented in parts with preparatory material. Instructors will need to be alert to how much extra motivation their classes will require.

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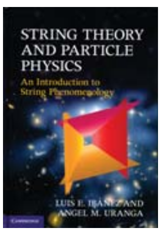
*New York*

## String Theory and Particle Physics

### An Introduction to String Phenomenology

Luis E. Ibáñez and Angel M. Uranga
Cambridge U. Press, New York, 2012.
$80.00 (673 pp.).
ISBN 978-0-521-51752-2

The field of string phenomenology has two aspects to it. One is to establish that the string theory's low-energy effective actions yield solutions that are stable, break supersymmetry, have a cosmological constant that is at least tunable to the observed value, and give rise to viable and testable predictions that do not depend strongly on the tuning. The other aspect is to demonstrate that the standard model actually exists in string theory: If it doesn't, the effective actions' solutions—whether or not they meet the criteria specified above—don't correspond to the real world. Although string-theory-derived models that resemble the standard model have appeared in the literature since the late 1980s, it is fair to say that a completely satisfactory construction, particularly when the first aspect is incorporated, has not yet been achieved.




*String Theory and Particle Physics: An Introduction to String Phenomenology* touches on the first aspect but focuses on the second, "model-building" side. The latter requires a thorough understanding of the full machinery of string theory, and authors Luis Ibáñez and Angel Uranga have done an excellent job of presenting that machinery in a clear and readable fashion. Both authors are distinguished researchers with a long history of important contributions to the field of string phenomenology. Ibáñez's contributions go back to the early 1980s when he and others pioneered the field of supersymmetry and supergravity phenomenology.

The book begins with a brief introduction to the standard model and supersymmetry and leads up to the construction of the minimally supersymmetric standard model. The next few chapters discuss the basics of string theory. Of course, many more details on string theory are presented in the classic textbooks on the subject, such as volumes 1 and 2 of Joseph Polchinski's *String Theory* (Cambridge University Press, 1998; both were reviewed in PHYSICS TODAY, June 1999, page 59).