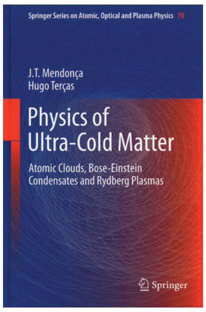
RECENSIONI



J. T. MENDONÇA AND H. TERÇAS

PHYSICS OF ULTRA-COLD MATTER
ATOMIC CLOUDS, BOSE-EINSTEIN CONDENSATES AND RYDBERG PLASMAS

Springer Series on Atomic, Optical and Plasma Physics, Vol. 70.
Springer, 2013

pp. XVIII+ 394; €135,15
ISBN: 978-1-4614-5412-0

e-book: €107.09
ISBN: 978-1-4614-5413-7

Ultra-cold matter has become a fundamental test-bench of quantum mechanics, since its manifestations occur at a meso- or macroscopic scale, accessible to various characterization methods and even to visualization. Moreover ultra-cold matter provides a tool, via scaling laws covering several orders of magnitude, to simulate phenomena and validate theories of particle physics or cosmological interest, not accessible to present accelerators nor to current astrophysical investigation.

It is enough to browse through titles and abstracts of major physics journals to discover that ultracold alkaline-earth atoms in optical lattices provide a quantum simulator for lattice gauge theories; that Majorana fermions, a chimera in particle physics, pop out of two-dimensional spin-orbit coupled Fermi superfluids. Not just that: in a two-dimensional superfluid you may even fish a Higgs mode. With more fantasy, the momentum creation by ^{3}He superfluid vortices offers a model for primordial baryogenesis. In case you were struggling for monopoles, just have a look into a chiral superconductor; neither you have to go too far for Wess-Zumino supersymmetry, you may encounter it in a cold atom-molecule mixture in two-dimensional optical lattices. Grisha Volovik anticipated these developments in an eloquent question (PNAS, 96, 2042 (1999)) "Field theory in superfluid ^{3}He: What are the lessons for particle physics, gravity, and high-temperature superconductivity?

The excellent book by J. Tito Mendonça and Hugo Terças may not be the place where you find answers to the above question. It is rather the starting point, the pedagogical textbook where condensed-matter physicists and quantum-field theorists can learn the fundaments which have permitted in the recent decades to enter the immense territory of ultra-cold matter, extending below the cosmic background temperature as many orders of magnitudes as we know to exist above in the astrophysical realm. After introducing the reader to the laser cooling methods and the wave kinetic theory of ultra-cold matter, the authors consider three basic states of ultra-cold matter, which are treated in the three parts of the book: the uncondensed atomic clouds, the Bose-Einstein condensates (BECs), and the ultra-cold plasmas. The dynamical phenomena of interest in each of the three states are discussed in the respective parts: the oscillations in clouds (including the phonon laser) and the properties of photons in ultra-cold gases; the basic physical concepts of BECs and their elementary (linear and nonlinear) excitations, superfluidity, vortices and quantum coherence; the nature and different kinds of ultra-cold plasmas, the physics and waves of Rydberg plasmas and their kinetic theory.

As it may be expected, the book, though pedagogical in its aim, offers however a few fascinating excursions into some of the apparently remote fields of fundamental physics mentioned above. Examples are the phonon Casimir effect, the acoustic black holes and Hawking radiation, refering here to Novello, Visser and Volovik's book on *Artificial Black Holes* (World Sci, 2002), and the acoustic (Unruh) analogue of Painlevé-Lemaître metric for BECs. The book also discusses the idea that ultra-cold atom interferometry may detect gravitational quantum fluctuations, thus opening a window on quantum gravity. As to ultra-cold plasmas, the close analogy between the perfect fluid nature of ultra-cold atoms and the quark-gluon plasma (see L. Cifarelli *et al.*, Europhysics News 43/2 (2012)) comes to mind: just refer to 2009 Research Triangle workshop "Nearly perfect fluids: from Quark-Gluon Plasma to Ultra-Cold Atoms" (chair Steffen A. Bass *et al.*), or to Dieter Vollhardt's 2009 seminar (on the web) on Superfluid Helium-3, offering the reverse path: Dieter will bring you "from very low temperatures to the Big Bang"! But don't hurry up, just start from Mendonça and Terças book, and of course from the rich literature cited therein.

G. Benedek
Università di Milano-Bicocca