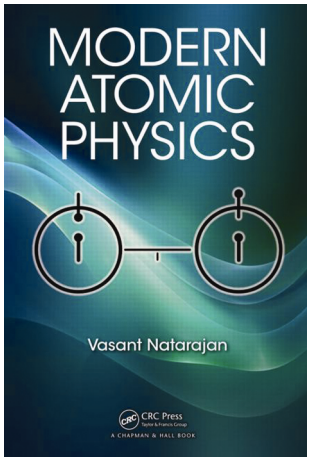

Modern Atomic Physics. Vasant Natarajan. CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, USA. 2015. xxi + 418 pages. Price: £59.99.

Atomic spectroscopy heralded early quantum concepts at the turn of the last century. Whether it was Niels Bohr's atomic model motivated by the need to explain the discrete nature of atomic spectral lines in the solar spectrum or discharge tubes, or radiative processes in atoms, through Einstein's A and B coefficients, these were all leaps in scientific thought that led to newer ways of looking at nature through the eyes of quantum mechanics. Thus, atomic physics and atomic spectroscopy played the 'lead role' in unravelling the physical world at the sub-microscopic scale. With later developments in nuclear physics, high-energy physics and subsequently the semiconductor revolution, atomic physics and pure atomic spectroscopy was all but forgotten as a branch of physics that yielded fundamental advances. Until the invention of the laser in 1960. The coming together of laser physics and its concomitant optical tools with atomic physics led to a major resurgence in research in atomic physics. The developments in our ability to slow down atoms through lasers and to confine atoms and ions in traps, even manipulate their position and structure, enabled measurements with unprecedented precision and accuracy, thus leading to new length and time standards.

This book brings forth precisely this flavour, in the treatment of atomic physics and its applications in precision measurements and the central role of atoms in probing fundamental physics and the consequences of these probes to physics beyond the standard model. The author charts this course as a pedagogist with a strong belief in anchoring the discussions to follow in what seems like a favourite formulation: 'Understanding the harmonic oscillator is the key to understanding physics. In fact, it is no exaggeration to say that you understand 90% of physics if you understand the classical harmonic oscillator and 99% of physics if you understand the quantum harmonic oscillator'. And indeed he lives up to this claim with aplomb in the chapters that follow.

The preliminaries set out the basics of the harmonic oscillator model and different models such as damped or coupled oscillators are treated. The author brings in at this stage as illustrations to coupled oscillators, the Rabi oscillations between radiatively coupled quantum states. The quantum oscillator is developed and as he goes, the concept of squeezed light, its employment as a way of getting better precision in measurements than the limits posed by uncertainty, is introduced at an appropriate stage, post a discussion of uncertainty between the position and momentum variables. The premises upon which quantum electrodynamics is built find a place here too, leading to an elegant discussion of the peculiar and fascinating consequences of the quantum vacuum, particularly the Casimir effect – the attraction between two parallel conducting plates due to confinement of the vacuum modes.

Subsequent chapters of the book are arranged in a way that brings forth a logical development to the subject – 'Atoms', a chapter that covers a summary of structure and angular momentum of atoms, followed by interactions with electric and magnetic fields. The chapters are titled 'Nucleus', 'Interaction', 'Multiphoton' and finally, 'Spectroscopy', before concluding with the Appendices. The brevity in titling ('Multiphoton phenomena', or something akin to that, instead of simply, 'Multiphoton') seems unusual at first, but one guesses that this choice is in keeping with the spirit of economy and avoiding over-descriptive titles. In 'Atoms', an interesting explanation using the solutions to the radial Schrödinger equation is made, of the Balmer–Ritz formula that encompasses the so-called Quantum defect, a phenomena wherein except for hydrogen, hydrogen-like atomic energy levels have shifted positions for the same principal quantum numbers than that of hydrogen. Relativistic effects such as the spin–orbit interactions are covered as are required for any treatment on atomic physics, before moving on to Zeeman and Stark – both DC and AC effects.

This book is clearly a treatise that is meant to highlight the very latest developments in atomic spectroscopy and the central place that investigations on atoms occupy in precision measurements. The author accomplishes this in a way that I think is an essential characteristic of a noteworthy text: through revisiting well-established results in quantum mechanics and atomic structure to develop discussions that cover the very latest advances. The search for an intrinsic electron dipole moment and putting an upper bound on the same, has profound consequences to physics beyond what is established in the standard model. Permanent dipole moments in atoms can have contributions that arise from effects, including the presence of an intrinsic electric dipole moment (EDM) of an electron. Paramagnetic atoms such as caesium or thallium can have large EDMs coming from relativistic effects. Thus, the search for EDMs in such atoms gains enormous significance in explorations of physics that pushes frontiers beyond Standard Model predictions. A short discussion on this follows, after establishing that the presence of an EDM implies a violation of time-reversal symmetry, elegantly illustrated through a simple argument of Golub and Pendlebury (*Contemp. Phys.*, 1972, **13**, 519). In continuing with interactions, the author, appropriately addresses the problem of atoms interacting with strong fields, leading to the so-called dressed atomic states picture in a two-state model, wherein the atom-plus-field state gets modified when strongly coupled. This section is a useful first-principles development, especially for researchers working in atom-intense laser field interaction studies. In the treatment of nuclear effects on electronic structure, there is a detailed development of the hyperfine structure Hamiltonian and calculation of the energy shifts. However, and despite the rigour brought in this discussion, one wishes that a simpler illustration of the hyperfine interaction in the ground state of hydrogen leading to the 21-cm line, so central to radio astronomy, could have found

mention here. In the chapter dealing with resonance, semi-classical approaches are invoked to discuss a wide set of resonance phenomena, including NMR. In dealing with interactions, in the next chapter, the dipole approximation is invoked and then used to describe dipole transitions and the origin of the selection rules governing such transitions. An extension of this treatment is found in a discussion on transition rate calculations for laser excitation, normally not found in similar treatises. Subsequent chapters on multi-photon processes and coherence engage with applications of lasers in the control of atomic state populations – useful short treatments such as coherent population trapping that has applications in atomic clocks, and electromagnetically induced transparency, that have led to applications in slowing down light, or inversionless lasing, can be found here.

The last chapters on 'Spectroscopy' and 'Cooling and Trapping', are a literal tour de force of the research preoccupations of the author in his laboratory that more or less encompass a wide range of 'hot' topics. Covering some aspects of tools invaluable in a modern atomic physics research laboratory such as diode laser, and lock-in amplifiers, he moves on to a succinct treatment of Doppler-free spectroscopy. The basics of laser cooling and trapping, extended to realization of Bose–Einstein condensates are summarized here. Dipole traps and their analogous application in trapping larger microscopic objects in optical tweezers, also find a place here.

The Appendices make for thought-provoking and interesting extras, with ideas about the concept of the photon being one of 'philosophical' contemplation for the author. In this discussion of the concept of the photon, he presents ideas mainly from Taylor and Feynman, that a photon has no independent existence but rather one can conceive this through invoking both advanced and retarded fields. This concept is shown to have profound implications to the cause–effect relationship as perceived in classical formalisms. The other chapter is on Einstein's formulation of atom–radiation interaction through the A and B coefficients, with Einstein solving the puzzle like a detective. The pieces in the 'jigsaw puzzle' have but one crucial 'piece', namely the concept of stimulated emission missing to make for a coherent (pun intended) picture. Einstein is an armchair detective, the author argues, who through the brilliance of his gedanken (thought) experiments solves the puzzle, Sherlock Holmes' style. While such a reading of the history of discovery is interesting, the allegorical nature of this reading needs a mention lest it obfuscates the more complex process in the history of ideas, with many pitfalls and mistakes made, notwithstanding the genius intellect of an Einstein. Other chapters that form the Appendix include a discussion on conceiving the photon's interaction with gravity as in the gravitational red shift, and a simple discussion of the frequency comb technique that enabled ultra high precision measurements fetching Hall and Hansch the 2005 Physics Nobel Prize.

Problem sets with meticulously worked-out solutions that extend the ideas in chapters or bring in a particular concept not treated explicitly are introduced in adequate measure. As the author states in the preface, one of the reasons for this book was to share the elaborate notes that he made as a student in MIT, USA attending the course of an eminent spectroscopist. This is done well, although surely, other texts and papers in the subject were consulted in the process. An omission here is the lack of reference lists anywhere, perhaps left out to restrain the book's girth from exceeding its already sizeable number of pages. Finally, the book is well-written and bears a distinctive style of communication that is informal without sacrificing rigour. It is invaluable as an advanced postgraduate or Ph D-level textbook, and will doubtless be used in many courses across the world as it brings under one platform the many exciting and current topics of research in atomic and laser spectroscopy, that one often has to access through information scattered in different texts and references.

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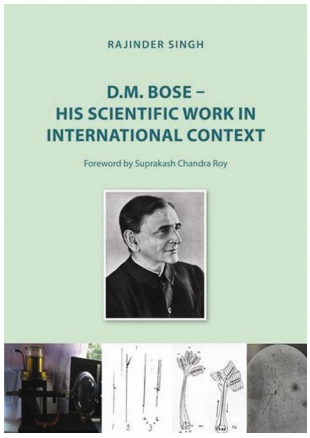

D. M. Bose – His Scientific Work in International Context. Rajinder Singh. Shaker Verlag, Aachen, Germany. 2016. 260 pp. Price: 21.90 Euro.

In the preface of this book, Rajinder Singh, the author and a well-established historian of science has given reasons for writing this book. S. C. Roy in his foreword reinforces the argument of the author by his remarks: 'In spite of his immense contributions to science, administration, education and many other areas like history of science, D. M. Bose is relatively unknown to many compared to his contemporaries. His scientific activities have been discussed sporadically, but have never been explored in totality. The idea of a book on D. M. Bose was proposed in 2010 during the 125th birth anniversary of Dr D. M. Bose when Rajinder Singh contributed a Cover Article in the journal *Science and Culture* of which I am the Editor-in-Chief'.

D. M. Bose was a reputed scientist at par with his colleagues and contemporary scientists like C. V. Raman, S. K. Mitra, M. N. Saha and S. N. Bose. His scientific contributions were of utmost significance internationally in the contemporary science of his time. His work on magnetism and discovery of artificial transmutation using cloud chamber while he was abroad, and his cosmic ray work in India with Biva Chaudhuri in discovering mu-mesons using half-tone Ilford plates are legendary. He was Director of J. C. Bose Institute founded by his uncle J. C. Bose, and tried expanding on his uncle's work to understand the physiological investigations in plants at a molecular level using biochemistry. This book presents the real worth of Bose in international context to justify its title. Another aspect revealed by the author is