Preface

In recent years, the field of Atomic, Molecular and Optical physics has undergone a revolutionary change due to tremendous developments of cutting edge Scientific Technology and high performance computers. The research in this field has grown very widely and covers a broad spectrum of topics including: Structure and Dynamics of atoms and molecules, high-precision spectroscopy, cold atoms, Bose-Einstein condensates, Optical Lattices, free electron lasers etc. This field is also of great interest for applications in several neighboring areas such as astrophysics, plasma physics, condensed matter physics, biology, medicine and nano-technologies.

This present book presents the latest research from around the world and covers the topics on: Atomic Structure, Collision Physics, Photo Excitation and ionization Processes, Ultra-Cold atoms, Bose-Einstein Condensate and state-of-art technological applications in the field of Astronomy, Astrophysics, future energy source from Fusion, Biology and Nano-technology.

Under the topic of Atomic Structures, Biemont from University of Liege, Belgium in Chap. 1, presented the progress realized regarding the radiative properties (transition probabilities, lifetimes, branching fractions) of the heavy atoms and ions ($Z > 37$) of the fifth and sixth rows of the periodic table and of the lanthanides. Their knowledge is vital and strongly needed in astrophysics in relation with the problematic of stellar abundance determination, cosmochronology and nucleosynthesis. In Chap. 2, Man Mohan et al. described the present status of atomic structure calculations using several different international computer codes like CIV3, GRASP etc. and have shown the importance of correlations and relativistic effects for multi-electron systems.

In Chap. 3, Nicholas Guise et al. from NIST (USA) described highly advanced design of compact permanent-magnet Penning traps with novel unitary architectures for capture of highly charged ions extracted from an EBIT source. They demonstrated confinement within two trap geometries for various ion species. In their experiment storage times exceed 1 second in a room-temperature apparatus, enabling spectroscopic and charge-transfer studies relevant to astrophysics and metrology. Paul Mokler et al. from Max-Planck Institute, Heidelberg, Germany in Chap. 4, demonstrated that K-L inter-shell higher-order electronic recombination for highly charged ions ($18 < Z < 36$) can dominate first-order dielectronic recombination. These electron-correlation effects stress the importance of multi-electron processes and have to be included into plasma models. In Chap. 5, Aarti Dasgupta et al. from Naval Research Laboratory (USA) described the world's most powerful X-ray source, the wire-array Z-pinch, which offers a promising route for producing energy through controlled thermonuclear fusion and in which high atomic number materials are investigated as an intense X-ray radiation source on the Z facility at the US Sandia National Laboratories. In their studies, spectroscopic analysis is the key tool to understand the conditions and X-ray performance of high dense plasmas.

Further work under extreme conditions is presented by F.B. Rosmej, F. Petit-demange of Ecole Polytech., Lab., France. They studied (Chap. 6) Auger electron heating of dense matter driven by irradiation of solids with intense XUV/X-ray Free Electron Laser radiation which permits studies of dielectronic capture channels that are usually closed in standard atomic physics investigations (like, e.g., in accelerators, EBITS, Tokamaks, astrophysics). After disintegration of crystalline order dense strongly coupled plasma is formed where dielectronic capture coupled to excited states is identified as the primary population source of autoionizing hole states. Opacity is a fundamental quantity for plasmas and gives a measure of radiation transport. For explaining this, Sultana N. Nahar the Ohio State University, USA has illustrated in Chap. 7, the necessity for high precision atomic calculations for the radiative processes of photoexcitation. On the collision side with charged particles the situation is reviewed by A. Bhatia from NASA USA in Chap. 8 and R. Srivastava et al., IIT Roorkee in Chap. 9. R. Karazija et al. in Chap. 10, describe the conditions and regularities for the formation of a narrow group of intense lines in the emission and photoexcitation spectra of free ions. In Chap. 11, Henrik Hartman discusses fluorescence process behind emission lines prominent in spectra of many low-density types of plasma.

Advanced technology in the field of AMO has led to laser-cooling of alkali atoms near to zero degree Kelvin resulting in Bose Einstein condensation (BEC). Bose Einstein condensation physics has emerged as an active frontier at the cross section of AMO and condensed matter physics. In this direction, the subject of Chap. 12, by Indu Satija et al., USA, deals with the Topological Insulators, new exotic state of matter with importance at both fundamental and technological frontiers. Their particular focus is the detection of these states in the ultra-cold atom laboratories. Chapter 13 describes the investigation of coherently prepared atomic medium under external perturbation and its prospective application in developing an atomic frequency offset reference. Vermuri et al., in Chap. 14, discuss and predicted a ratchet-like motion for the light which can be achieved by utilizing phase-displaced inputs and a linear gradient for index of refraction across the waveguide array showing BEC application in communication engineering.

Chapters from 15 to 19 emphasize on the high technological applications of Atomic Physics in different fields from Astronomy, Astrophysics, Biology and Nanotechnology. In Chap. 15 from Anil Pradhan et al. from Ohio State Univ., USA, describes an astonishing connection between the physics of K-shell X-ray transitions in heavy elements (high-Z), and potential cancer therapy and diagnostics (theranostics) using high-Z nanoparticles embedded in cancerous tumors. The methodology is termed Resonant Nano-Plasma Theranostics (RNPT), and relies on the use of monochromatic X-rays and nanobiotechnolgy of targeting and delivery of high-Z (e.g. gold or platinum) nanomaterials to malignant cells. Irradiation by monochromatic X-rays is far more efficient than conventional broadband X-ray devices, such as CT scanners for imaging or Linear Accelerators for therapy. In Chap. 16, R. Schuch group from Atomic Physics Center, Stockholm, Sweden have reviewed the work on the transmission characteristics of slow and highly charged ions (HCI) through thin foils and also presented the preliminary results of pre-equilibrium energy loss and charge states of HCI after transmission through ultra-thin carbon nanosheets which are of the thickness of single and three molecular layers. Their work on interaction of energetic charged particles with matter is a subject of large interest because of its potential applications such as material modifications, radiation detectors, biological and medical treatments, and ion-implantation. In all, the book covers from basic to highly advanced topics having wide applications in several neighboring fields of science and technology.

This book will be useful for Scientists, Teachers, graduate and post graduate students, especially dealing in Atomic, Molecular and Optical Physics. The book has a wide scope with applications in Plasma Physics Astrophysics, Cold Collisions, Nano-technology and future energy sources like JET (UK) and ITER (international Thermonuclear Experimental Reactor) where several countries are co-operating for harnessing fusion power.

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