

Preface

This volume is an in depth study of the recent developments in various branches of theoretical physics. Both review style articles and cutting edge research works appear in this peer reviewed collection under the Platinum Jubilee Volume series of Indian Statistical Institute. Senior experts as well as promising young scientists have contributed in this issue. Most of the articles are expanded versions of lectures delivered by the respective authors in a conference, Recent Developments in Theoretical Physics, held at I.S.I., Kolkata, during January 4–8, 2008.

The volume starts off with introductory remarks by Avinash Khare on the present status of theoretical physics, delivered at the conference. He set the tone by a critical analysis of the famous 1980 lecture by Stephen Hawking that suggested that in about twenty years most of the key issues in Theoretical Physics will be understood. Khare reviews the developments in the last two decades, (some of which in fact appear in this volume), and concludes happily that contrary to Hawking’s “prediction” Theoretical Physics is ever thriving with new discoveries and new outlooks of existing unsolved problems.

The volume covers five broad areas of Theoretical Physics: (I) **Relativity, Gravitation and Astro - Particle Physics**; (II) **High Energy Physics, Nuclear Physics & Quantum Mechanics**; (III) **Condensed Matter Phenomena**, (IV) **Nonlinear Dynamics** (V) **Quantum Information**

In (I) the articles revolve around theoretical aspects of Black Holes, both classical and quantum, with emphasis on very recent ideas. Parthasarathi Majumdar discusses the holographic principles gravitational physics, in the context of black hole thermodynamics. The connection with two dimensional conformal field theories leads to a corrected form of Bekenstein-Hawking entropy of black holes. Rabin Banerjee’s article deals with the recent excitement in Hawking Radiation from black holes as derived from gravitational anomalies. It includes some of the recent original contribu-

tions of Banerjee and collaborators in this area. On the other hand, A. S. Majumdar studies the effects of extra dimensions on classical black holes and their evolution in an intriguing braneworld scenario. The work also probes the role of Dark Matter and suggests observational signatures for braneworld black holes. The last article in this section by C. S. Unnikrishnan encompasses the basic principles of dynamics and relativity. It advocates a non-conventional view that the matter frame of the universe provides a preferred absolute frame and that its gravity determines the laws of motion. In the quantum regime, the vastly different collective behaviors of fermions and bosons are also linked to the novel idea of cosmic gravity. The author also suggests experiments to establish some of these new ideas.

In (II) the first article by Giovanni Amelino-Camelia on Doubly-Special Relativity (DSR) is in fact in the borderline of (I) and (II). Giovanni Amelino-Camelia, being the originator of the idea of this extension of Einstein's Special Theory of Relativity discusses key open issues of the theoretical and phenomenological consequences of the observer-independent small-length/large-momentum scale (Planck scale?), that is associated with DSR. In the exciting area of Astro-Particle physics, Neutrinos have captured the attention of the scientific community in the past decade. Amitava Raychaudhuri concentrates on this topic and introduces the readers, with his firsthand experience, to the ongoing India-based Neutrino Observatory (INO) project. The few years old proton spin problem is still not satisfactorily solved and A. N. Mitra analyzes a novel way of tackling this serious issue by using a three quark wavefunction, obtained recently in the high momentum regime of QCD. Afsar Abbas reviews the present status of Nuclear Physics and delves in to the recently amassed experimental data on Exotic Nuclei and the rich new physics that these nuclei are hinting at. Non-Hermitian Hamiltonians with real energy eigenvalues for a specific range of parameters have created a lot of interest in recent years. A Sinha and P Roy exploits the principles of supersymmetric quantum mechanics in their study of the Generalized Swanson Model along with its Pseudo supersymmetric Partners.

Section (III) is devoted to some specialized areas in Condensed Matter Physics where Berry's geometrical phase is playing an ever increasing role. Pratul Bandyopadhyay introduces the readers to Berry's Phase in Quantum Physics where the non-trivial topology of the parameter space spanned by the cyclic parameter, in which the quantum system evolves, plays an essential role. Pierre Gosselin, Alain Berard & Herve Mohrbach describe their very recent work on the direct effects of Berry' phase on

particle dynamics in vastly different settings such as in the Bloch electrons in solids, spin Hall effect in semiconductors, relativistic Dirac particles in strong external fields and the gravitational birefringence of photons propagating in a static gravitational field. Anyons, planar excitations having arbitrary spin and statistics, constitute a distinct phase of matter and these exotic states have been observed experimentally in Ga-As semiconductors. B. Basu explains the intrinsic spin Hall effect in Ga-As alloys by considering spinning model of anyons in external electromagnetic field. In this scheme a non-commutative configuration space is induced and once again Berry's phase plays a major role. The last article in this section by Arnab Das & Bikas K. Chakrabarti is multi-disciplinary in nature. It surveys the recent success in annealing or optimizing the cost functions of complex systems utilizing quantum fluctuations through mapping of such computationally hard problems to classical spin glass problems, quantum spin glasses and consequent annealing or analog quantum computation.

Section (IV) begins with the article by D. Grumiller and R. Jackiw on the emergence of Liouville gravity from pure Einstein gravity in a scheme that incorporates spherical reduction and dualization. Features of Einstein gravity, such as interactions with matter and the Bekenstein-Hawking entropy appear in a natural way. Avinash Khare, in his contribution, compares and contrasts various features of the discrete and the corresponding continuum field theory models in $1 + 1$ dimensions. The discussion is based on the generalized versions of discrete Φ^4 field theory and discrete nonlinear Schrodinger equation and translationally invariant, static as well as time-dependent, exact solutions of these models including kink, pulse, periodic and short-period solutions are constructed. In the fluid dynamics area Supriyo Paul, Krishna Kumar, Pinaki Pal & Mahendra K Verma describe the construction of a model for flow reversal in two-dimensional Rayleigh-Benard convection where a change in flow patterns occurs with increasing values of Rayleigh numbers. In Euclidean networks there are nodes that have well defined position coordinates and the linking probabilities are dependent on these coordinates. Parongama Sen reviews the studies concerning the effective dimensionality of a Euclidean network from a modern perspective.

Section (V), the last section, constitutes of studies in Quantum computation. In the first article, Preeti Parashar obtains the largest ensemble of qubits which satisfy the general transformation of equal superposition. This is achieved in different frameworks, namely, linearity, no-superluminal signaling and non-increase of entanglement under LOCC. The author also

considers the associated quantum random walk problem. In local Cloning of Entanglement Sujit K. Choudhary and Ramij Rahaman shows the (im) possibility of exact cloning of orthogonal but equally entangled quantum states where local operations and classical communication are concerned. They also compute the amount of entanglement necessary in blank copy for various examples.

Throughout the conference and afterwards during the process of compiling this edition, we have been very fortunate in having the active support of our Director, S. K. Pal, and all possible cooperation from our departmental colleagues, research scholars and technical staff. In particular we are very grateful to Ramij Rahaman, Senior Research Scholar, Physics and Applied Mathematics Unit, ISI, for his participation at all stages of our work and to Indranil Dutta, Machine Intelligence Unit, ISI for preparing the camera ready copy.

It is our hope that both the seasoned practitioners and young researchers of physics will get a panoramic view of the recent exciting happenings in diverse branches of physics and will enjoy and benefit from this volume.

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