Foreword

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It is a painful privilege for us to bring out the present volume of the Indian Journal of Physics dedicated to the memory of Pushan Majumdar. The emptiness inflicted by his sudden and untimely demise is still heavy on the minds of his friends and colleagues, the grief still unflinching. He who came to know Pushan could not but feel the warmth of his heart, his selfless helpfulness, his passion for football, locomotives and his infectious enthusiasm for travelling, especially to the hills and snow-capped mountains.

Pushan Majumdar was a physicist, and a fine one at that, with varied interests. Students and colleagues working in different areas often benefitted from his apt aperçus. He joined the graduate school of the Institute of Mathematical Sciences, Madras, right after finishing his bachelor studies from the Presidency College, Calcutta. After completing his PhD with H. S. Sharatchandra, he joined the Tata Institute of Fundamental Research, Bombay, as a post-doctoral fellow. Subsequently, he worked at the Max Planck Institute, Munich, the University of Graz, as a Lise Meitner Fellow and at the University of Münster, before returning to India, to join the faculty of the erstwhile Theoretical Physics department of the Indian Association for the Cultivation of Science, Calcutta.

As a graduate student, Pushan worked on certain non-perturbative aspects of the Yang–Mills theories with Sharatchandra. In particular, they found a non-local $SO(3)$ gauge theory, dual to Yang–Mills theories in $(3+1)$ dimensions. Later on, Pushan and R. Anishetty together developed a formalism to interpret the Yang–Mills theories in $(2+1)$ dimensions in terms of metrics on a three-manifold. Within the scope of this formalism, they showed that the dual gluons have the necessary interactions with the monopoles so as to furnish a mass gap, ergo, confinement. Along with other collaborators, he then went on to numerically measure these topologically non-trivial

configurations containing monopoles using the techniques of lattice gauge theory. His penchant for both theoretical and numerical methods came to be of use at this stage. Together with this, his fascination for non-perturbative aspects of gauge theories, which started during his undergraduate days at the Presidency college, according to Pushan himself, broadly shaped his research career in the years that followed. His research articles bear testimony to his endeavors, accomplishments, and versatility.

Pushan then went on to developing multilevel algorithms for gauge theories on a lattice. The remarkable idea of multilevel algorithm is due to Lüscher and Weisz to study Polyakov loop correlators in Yang–Mills theories. Since these correlators are quite noisy, one resorts to a nested averaging, first calculating the observables on smaller sub-lattices with appropriate boundary conditions followed by averaging over all such sub-lattice contributions to finally obtain the original correlator on the original lattice. Pushan made use of this idea in a novel manner for measuring observables in Yang–Mills theories which was a challenging, indeed, somewhat daunting, task. Notable among them are the measurement of the elusive glueball mass in compact QED as well as in QCD, the spectrum and excited states of QCD flux tube and studying confinement properties in compact QED, among others. One of his highly appreciated recent achievement was to adapt the multilevel algorithm to obtain one of the first results of the diffusion coefficient of (infinitely) heavy quarks in quenched QCD on the lattice.

He also had to his credit one of the early results on QCD strings by studying the Yang–Mills theories in three dimensions to obtain the confirmation of two universal features of the string potential, namely the Lüscher term and the energy difference between the successive energy states. Later on, he collaborated with N. D. Haridass to show that the QCD strings show remarkable similarity to Nambu-Goto strings.

A challenging problem in lattice gauge theory which caught his fancy was the issue of discretizing the fermion

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action preserving its chiral properties on the lattice. A no-go theorem proved by Nielsen and Ninomiya in the early 80's bars defining a Dirac operator on a lattice possessing the quartet of desired properties, namely chirality, hermiticity, ultra-locality and a valid continuum behavior, once the lattice scaffolding is removed. Versions of the fermion action which break the chiral symmetry completely, or partially, have been popular for lattice implementations owing to their computational simplicity. Problems related to the topology of gauge fields, such as chiral symmetry breaking, cannot be addressed with these actions. This led to the development of the theoretical as well as computational realization of fermion Dirac operators with exact chiral symmetry on the lattice since the beginning of 1990's. Pushan, with his collaborators at the University of Graz made significant contributions to this field. This includes the first numerical realization of chirally improved fermions for applications in QCD simulations with two degenerate flavors of dynamical fermions. Perhaps his tryst with lattice fermions had started a few years earlier, when he assumed an instrumental role in implementing the R-algorithm and measuring fermion-related observables using the so-called stochastic method during his postdoctoral stint at the Tata Institute of Fundamental Research. Furthermore, he enjoyed the art of accelerating his code and was constantly experimenting with it. This led to his interest in programming on gaming cards (GPU) and he was one of the first in the field to propose novel methods to accelerate hybrid Monte Carlo algorithms on a single as well as multi-GPUs.

Pushan contributed significantly to the growth of lattice QCD in India, playing a pivotal role in several projects and inspiring students into such programs. The supercomputing facilities at the Indian Association for the Cultivation of Science were largely a fruit of his tireless striving. The present volume commemorates the endeavors and accomplishments of Pushan Majumdar in the form of articles contributed by his teachers, collaborators and friends. The topics covered in these articles are varied and were close to his heart.

We, as editors of this memorial volume, would like to thank the authors, who agreed to contribute articles readily and enthusiastically in this testing time. We are indebted to all the reviewers who devoted their valuable time to enrich the volume through their expertise and insight. We are grateful to our colleagues in the School of Physical Sciences at the Indian Association for the Cultivation of Science and Sanatan Digal and M.V.N Murthy at the Institute of Mathematical Sciences, for their encouragement and help. We would like to thank Professor Subham Majumdar, editor-in-chief of the journal, for coming up with the idea of this memorial volume for our dear friend and esteemed colleague and for inviting us to serve as its editors, and his team for constant support throughout the process.

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