# Preface

The last few years have seen a number of experimental results that substantially confirm the interrelated paradigms within which particle physics and cosmology have advanced over the past half a century, while at the same time raising very challenging questions about the same paradigms. The announcement in March 2012 by the Daya Bay Collaboration that the leptonic mixing angle $\theta_{13}$ was as large as 9° confirmed that leptonic CP violation would be amenable to experimental investigation. Inasmuch as leptonic CP violation could play a crucial role in the generation of cosmological baryon asymmetry via the convincing scenario of leptogenesis proposed by Fukuyama and Yanagida, this discovery is destined to reverberate for long. Just a few months later, in July 2012, we witnessed the epochal confirmation of a Standard Model Higgs-like particle with a relatively large mass of ∼125 GeV by the ATLAS and CMS groups at CERN. Such a large value of the Higgs mass can be compatible with low-scale supersymmetry only if loop effects driven by large soft supersymmetry breaking parameters raise the mass of the lightest Higgs in the MSSM by over 30% above its tree-level upper limit of $M_Z$. Multi-TeV values for these parameters were rarely considered before the announcement of the Higgs mass (see however the contribution of Aulakh in this volume) inasmuch as the prevailing belief was that such large values would contradict naturalness.

The announcement in March 2014 that the BICEP-2 experiment at the South Pole had actually measured a large value for the ratio ($r = P_T/P_S$) of power in tensor to power in scalar perturbations (at the level of some parts per million) away from homogeneity of the cosmic microwave background also caused a wave of excitement to sweep across builders of unified models which supported inflation since the claimed value would put the mass scale controlling inflation at almost exactly the value of the scale of grand unification. The very first discovery of physics beyond the Standard Model, namely neutrino mass-driven neutrino oscillations, had indicated that the scale of lepton number violation also lay near the GUT scale. As the rare hints of large soft SUSY breaking parameters before Higgs discovery had also come from supersymmetric $SO(10)$ unified theories which have natural mechanisms for GUT scale-controlled lepton number violation, a stable LSP to provide the dark matter content of the standard $3$CDM matter Universe, and even GUT scale inflation, all these developments seemed to presage the most pleasing possible unification of the fundamental interactions into one overarching grand unified supersymmetric model of particle physics and cosmology.

Panjab University Chandigarh is one of the major Indian centres for experimental high energy physics, with longstanding participation in major experiments at FERMILAB, CERN, KEK etc. In addition, it has maintained a curriculum of mandatory education in quantum field theory and particle physics in the MSc programme, accompanied by theoretical research by a small but active core of faculty in these areas, for over 45 years. One of us (CSA) was fortunate to join this department and participate in and contribute to these programmes over the last twenty years. Several significant developments in supersymmetric left–right

models and $SO(10)$ grand unification were achieved at this department and contributed to its high standing in the Indian academic scene. Thus, it was a happy conjuncture that UNICOS-2014 was organized in Panjab University, Chandigarh during 13–15 May, 2014 on the occasion of the Physics Department-mandated tradition of holding a meeting to mark a faculty member (CSA) reaching the local age of superannuation. His research in supersymmetric grand unification, at the meeting point of the hyperactive fields of unification, Higgs physics, cosmology and neutrino physics, made it naturally possible for researchers in these fields in India, and some from abroad, to converge – physically or virtually – at UNICOS-2014 and share their expertise in the presence of many young graduate students from all over the country.

Already by the time of the meeting in May 2014, doubts had begun to be expressed by experts about the analysis of errors and sources of contamination of the CMB perturbation data assumed by the BICEP-2 Collaboration. This was particularly so because the BICEP-2 claims marginally conflicted with the announced results of the high-precision third-generation CMB measurements carried out by the PLANCK satellite collaboration. Ultimately, these doubts forced (see the contributions of Mohanty and Sriramkumar) a retraction of the BICEP-2 claim. However, it is fair to say that the BICEP-2 claim sensitized the particle physics and cosmology communities to the possibility of a measurable tensor–scalar ratio above $r = 10^{-3}$ and thereby confirmation of a role for quantum gravitational effects in producing observable fossils of early cosmological dynamics at the scale of unification. The large bulk of the previous models, such as those based on inflation controlled by the supersymmetry breaking scale, had assumed that the ratio $r$ would be much smaller. In this sense, the influence of BICEP-2 will last as long as the effort to measure $r$ is pursued.

We thank the Vice Chancellor of Panjab University for permission to hold the meeting and for financial support, as well as for kindly consenting to inaugurate the meeting. We thank Prof. V P Singh, the chairperson of the Physics Department, Panjab University, Chandigarh, for financial and administrative support. The workshop received funding from both National (Departments of Science and Technology of both the Government of India and the Government of the Union Territory of Chandigarh besides that from Panjab University) and International (Office of External Activities of the International Centre for Theoretical Physics (ICTP), Trieste, Italy – a UNESCO Institute) sources. It is our pleasure to thank the Director, International Centre for Theoretical Physics and the Coordinator of the Office of External Activities (OEA) of ICTP for generously supporting international participation in the meeting. This made it possible to invite scientists not only from the length and breadth of India but even from Asia and Europe to participate in the meeting. Moreover, the wonders of the internet permitted several talks to be given via Skype@ from the United States and Europe. Thus, the meeting was considered an unqualified success by all concerned. This rather arcane activity in theoretical particle physics received unstinting patronage from Panjab University, Chandigarh which has also nurtured one of the most prominent experimental high energy physics groups in the country. We were happy to enjoy the support and participation of our faculty colleagues from the EHEP group: Prof. S

Beri, Prof. J B Singh, Prof. Manjit Kaur and Dr Vipin Bhatnagar. We also thank Prof. M M Gupta and Prof. C N Kumar of the theoretical high energy group for their unstinting support and advice. This was also followed up by the sanction received from the University for publishing the proceedings from the unspent funds. In view of the uniform enthusiasm that the effort was worthwhile and to further underline the feasibility of holding full-scale international workshops at university departments, it was decided to go ahead with the publication of the proceedings in spite of the delay. We hope that these proceedings will serve as a record to inspire further efforts of this type.

We would also like to record the repeatedly expressed appreciation of the participants for the excellent logistical organization of the workshop. We thank the Director IISER Mohali for permission to accommodate the bulk of participants in the newly built and very comfortable IISER Mohali Guest House. We also thank the manager of the IISER Mohali Guest house and those of the Panjab University Guest houses for providing a comfortable stay.

The tireless work of many persons allowed the meeting to proceed smoothly. The staff of the physics department, particularly Mr Dinesh Kumar and other staff of the physics department purchase section, ably and efficiently handled all financial aspects of the meeting which included provision of travel support, as requested, to every participant. We thank Vivian Zaccaria of OEA-ICTP for very ably and efficiently ensuring timely release and transfer of the forex funds.

Among the student volunteers are first and foremost the graduate students Charanjit Kaur Khosa and Ila Garg who not only contributed to the proceedings but also handled almost all the details of the organization of the meeting including printing the posters and bulletins, registration and stationery, venue maintenance, organization of Skype talks and so on. Amit Goyal was very helpful in arranging meetings with the Department of Science and Technology of the union territory of Chandigarh. PU Graduate students Mr Amardeep Bharati, Mr Ramandeep Kumar Garg and participant Mr Jacky Singla (TIFR) also rendered invaluable services towards the transport and accommodation for participants. We also thank Dr Bimal Rai for his sage advice and able support regarding the organization of the catering services for meals and refreshments: which were much appreciated by all.

As per *Pramana* guidelines the contributions have been ably refereed by an eminent panel of referees which could mostly be drawn from the speakers at the conference itself. It is our pleasure to thank them for their able assistance and advice. The panel comprised:

1. G Rajasekaran (IMSc/CMI, Chennai)
2. A Raychaudhuri (Kolkata University)
3. SB Beri (Panjab University)
4. R Kaul (IMSc, Chennai)
5. P Majumdar (R.K.V. University, Belur Math)
6. S Goswami (PRL, Ahmedabad)
7. K Majumdar (TIFR, Mumbai)

We hope that this collection will provide a timely snapshot of the development of Indian expertise of research in these areas of fundamental physics.

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