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Preface

Preface to the Special Issue on Physics and Computation "Towards a Computational Interpretation of Physical Theories"

The present special issue includes a selection of papers presented at the Third International Workshop on Physics and Computation held on the Nile, in a cruise connecting Luxor and Aswan, August 31–September 5, 2010, organized by Cristian S. Calude (University of Auckland), José Félix Costa (Technical University of Lisbon), Walid Gomaa (University of Alexandria), Hélia Guerra (University of Azores), and Karl Svozil (Technische Universität Wien).

There is a long tradition of workshops on "Physics and Computation" inaugurated by the famous 1982 meeting whose proceedings have been published in a special issue of the *Int. J. Theor. Phys.* Volume 21, Numbers 3–4, April (1982), which starts with Toffoli's programatic article "Physics and Computation" (pp. 165–175).

This (renaissance) most recent series of workshops started in Vienna in 2008, when the steering committee was formed, constituted by Časlav Brukner (University of Vienna), Cristian S. Calude (University of Auckland), Gregory Chaitin (IBM's Thomas J. Watson Research Center), José Félix Costa (Technical University of Lisbon), and István Németi (Hungarian Academy of Sciences).

For the third edition of the workshop, original papers were submitted via EasyChair in diverse areas of Physics and Computation (and related fields), such as analogue computation, axiomatization of physics (completeness, decidability), Church-Turing thesis, computing beyond the Turing barrier, philosophy of computation, quantum computation (digital, analogue), quantum logics, relativity (spacetimes, computation, time travel, speedup), and theory of measurement (axiomatization, complexity). Papers have been first refereed by a program committee constituted by Andrew Adamatzky (University of West England), Selim Akl (Queen's University), Hajnal Andreka (Alfréd Rényi Institute of Mathematics, Budapest), Edwin Beggs (University of Swansea), Olivier Bournez (École Polytechnique), Dan Browne (University College London), Cristian Calude (University of Auckland, Arturo Carsetti (University of Rome "Tor Vergata"), Barry Cooper (University of Leeds), Bob Coecke (University of Oxford), José Félix Costa (Technical University of Lisbon), Gilles Dowek (École Polytechnique and INRIA), Walid Gomaa (University of Alexandria), Viv Kendon (University of Leeds), Carlos Lourenço (University of Lisbon), Judit Madarász (Alfréd Rényi Institute of Mathematics, Budapest), Yasser Omar (Technical University of Lisbon), Sonja Smets (University of Groningen), Mike Stannett (University of Sheffield), Karl Svozil (Technische Universität Wien), John V. Tucker (University of Swansea), Jiří Wiedermann (Academy of Sciences of the Czech Republic), Karoline Wiesner (University of Bristol), and Martin Ziegler (University of Paderborn).

Accepted papers, presented during the Workshop, were resubmitted, in a call opened to other researchers, to special issues of the three journals: Applied Mathematics and Computation (Elsevier), International Journal of Unconventional Computing (Old City Publishing), and Natural Computing (Springer).

Seven of the fourteen papers submitted to Applied Mathematics and Computation were accepted. Below, we shortly describe the contents of each one:

- *De-quantisation of the Quantum Fourier Transform*, by Alastair Abbott. The author shows that one of the key ingredients of the known quantum algorithms (such as Shor's algorithm for prime factorisation), the quantum Fourier transform, in certain identified cases, can be replaced by a classical algorithm, more efficient than its quantum counterpart. The technique introduced by Alastair Abbott is also interesting from a foundational point of view, since it highlights the linearity of quantum mechanics and its role in quantum computation.
- *The Emergence of Meaning at the Co-Evolutionary Level, An Epistemological Approach,* by Arturo Carsetti. We can think that natural selection hardwires the evolutive process at the biological level, behaving as a coder, providing a semantic meaning to every evolutionary success in a given environment/landscape. This paper addresses the nature of the mathematical structure of natural selection, focusing on the problem to know what mathematical structure is engraved on the evolutive landscape and what theories of mathematics are more suitable to provide a synthesis of the processes which moulds coder's activity.

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- *Error Scaling in Fault Tolerant Quantum Computation*, by Marco Lanzagorta and Jeffrey Uhlmann. The authors show that nontrivial quantum algorithms exhibit nonlinear sensitivity to *any* circuit error and that this sensitivity affects algorithmic complexity. The joint effects of circuit error and quantum-algorithmic iteration are examined for the case of quantum search, and more complete complexity results are derived.
- *Coalgebras and Non-Determinism: an Application to Multilattices*, by I. P. Cabrera, P. Cordero, G. Gutiérrez, J. Martínez and M. Ojeda-Aciego. The authors prove a coalgebraic characterization of the notion of finitary multi(semi)lattice, a generalization of that of semilattice which arises naturally in several areas of computer science and provides the possibility of handling non-determinism, with possible applications in quantum computation.
- *Physics and Proof Theory*, by Bruno Woltzenlogel Paleo. In this paper, the author proposes an axiomatization of physics seen from a computer science perspective, e.g., where the dynamics of a particle can be deduced in different ways in a sequent calculus. Moreover the proposed calculus clarifies the different options by highlighting the places in a proof where different paths to the solution can emerge. This approach allows, by means of proof theory, to open new conceptual bridges between Physics and Computer Science.
- *Computing the appearance of physical reality*, by Mike Stannett. The author claims that the current standard mathematical models of physics can not be used to truly explain the nature of physical reality, namely that the standard models of quantum and relativity theories are logically equivalent to models in which the nature of classically observable motions is a form of ''necessary illusion''. Mike Stannett then discusses the standard interpretation of the nature of space, time and motion, and where these interpretations can fail.
- *Numerical Evaluation of Algorithmic Complexity for Short Strings: A Glance into the Innermost Structure of Randomness*, by Hector Zenil and Jean-Paul Delahaye. The authors describe a method to numerically approximate the algorithmic complexity of all $\sum_{n=1}^{8} 2^n$ bit strings up to 8 bits long, and for some between 9 and 16 bits long. An output frequency distribution is then computed, from which the algorithmic probability is calculated and the algorithmic complexity evaluated by way of the (Levin-Chaitin) coding theorem.

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