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Reversible Computation

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Preface

This volume contains the proceedings of RC 2018, the 10th International Conference on Reversible Computation, held in Leicester, UK, during September 12–14, 2018. RC 2018 was the tenth event in a series of annual meetings designed to gather researchers from different scientific disciplines for the discussion and dissemination of recent developments in all aspects of reversible computation. Previous RC events took place in York, UK (2009), Bremen, Germany (2010), Ghent, Belgium (2011), Copenhagen, Denmark (2012), Victoria, Canada (2013), Kyoto, Japan (2014), Grenoble, France (2015), Bologna, Italy (2016), and Kolkata, India (2017).

Reversible computation concerns models of computation where programs or processes are logically reversible (as, for example, in undoing of program execution for reversible debugging), or physically reversible (as, for example, in quantum circuits and robotics). The main areas of research presented at the conference were reversible formal models for computation and physical systems, reversible programming languages, and reversible circuits.

The conference received 28 submissions, and we would like to thank everyone who submitted. Each submission was reviewed by at least three reviewers, who provided detailed evaluations as well as constructive comments and recommendations. After careful reviewing and extensive discussions, the Program Committee (PC) accepted 13 full papers, one tutorial paper, and seven short papers for presentation at the conference. We would like to thank the PC members and all the additional reviewers for their truly professional work and strong commitment to the success of RC 2018. We are also grateful to the authors for taking into account the comments and suggestions provided by the referees during the preparation of the final versions of their papers.

To mark the tenth edition of the conference, the conference program included four invited talks. Michael P. Frank discussed "Physical Foundations of Landauer's Principle," Ivan Lanese took the audience "From Reversible Semantics to Reversible Debugging," Norman Margolus discussed "Finite-State Classical Mechanics," and Nicolas Ollinger presented work "On Aperiodic Reversible Turing Machines." The papers that accompany the invited talks are included in these proceedings. Additionally, we were honored to welcome Edward F. Fredkin at the conference who gave a talk titled "Discrete Space-Time-State Physics"; a short abstract for the talk is included in these proceedings.

We would like to thank everyone who contributed to the organization of RC 2018, especially Ushma Chauhan, James Hoey, Claudio Antares Mezzina, and Emilio Tuosto. We also thank Lisa Jungmann and Robert Wille for helping with the conference website. We thank the Department of Informatics of the University of Leicester and the COST Action IC1405 for their financial support. Finally, we acknowledge EasyChair for facilitating PC discussions and the production of the proceedings.

September 2018

Jarkko Kari
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Discrete Space-Time-State Physics (Social Event Talk)

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Extended Abstract. Consider that, perhaps, the most microscopic elements of space, time and all of the other basic measures in physics are discrete. We certainly have no evidence to the contrary. What this could mean is that there would be natural units of length and time. If so, every actual interval of time could be exactly represented by an integer.

If we further suppose that, instead of true randomness at the level of quantum mechanics (QM), we substitute "Unknowable Determinism" or UD, where, at the level of QM, we replace the "random" by the continual influx of unknowable, microscopic information that pours into every QM event, from every direction. The unknowable information must, if this model is to correspond to reality, be essentially unaffected by any physical aspects that we can measure.

The idea is to have a model of a microscopic system where physical events are actually deterministic, but that nevertheless, appear as random to observers from within the system. A given system could have unknowable determinism which could appear just as unpredictable, to those within that system, as does true randomness. There would be no way, in general, to reliably predict the exact future of the microscopic states of any actual region. There is a simple explanation for that impossibility. Aside from consequences of laws of physics, including conservation laws, there may be many detailed microscopic states that each correspond to what can be measured macroscopically. The nature of exact reversibility and exact conservation laws are such as to impose the laws of probabilistic QM on our higher-level observations despite the possibility that underlying the apparent randomness is strict determinsism at the most microscopic levels. Thus it may be that the QM process is actually deterministic, but a more appropriate description might be "Unknowable Determinism."

It's not that microscopic physics requires a non-deterministic explanation; rather, it could be that our knowledge and understanding of exactly what is happening in the actual real microscopic world is what is necessarily uncertain.

Imagine a model of the most microscopic state with space being a 3+1 dimensional regular Cartesian array of cells, where, at each instant of discrete time, each cell is in one of a small integer number of states (such as 3). If we assign integer coordinates (x, y, z, t) to the 2nd-order space-time coordinates of each of the most microscopic cells, then $x + y + z + t$ can be thought of as always being an even number. Of course, the x, y and z coordinates must range over the size of the Universe, but the static range of the t coordinate is 2, the present time and the immediate prior time. This second-order array allows for the convenient static representation of dynamic information.

Our hypothesis is that the process that is the most microscopic discrete physics (perhaps underlying QM) could correspond exactly to the temporal evolution of state of some such discrete, deterministic system. Instead of randomness, at the bottom we might have Unknowable Determinism. Every correct picture of the actual microscopic state cannot be calculated by us until after it has arrived, naturally.

An advantage of such reversible systems to their creators is that after the detection of an extraordinary event, the process can be reversed to enable efficient study of the exact cause.

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