Chapter 21
Wolfram and the Computing Nature

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Abstract. Stephen Wolfram’s work, and especially his New Kind of Science, presents as much a new science as a new natural philosophy—natural computationalism. In the same way as Andrew Hodges, based on Alan Turing’s pioneering work on computability and his ideas on morphological computing and artificial intelligence, argues that Turing is best viewed as a natural philosopher we can also assert that Wolfram’s work constitutes natural philosophy. It is evident through natural and formal computational phenomena studied in different media, from the book with related materials to programs and demonstrations and computational knowledge engine. Wolfram’s theoretical studies and practical computational constructs including Mathematica and Wolfram|Alpha reveal a research program reminiscent of Leibniz’ Mathesis universalis, the project of a universal science supported by a logical calculation framework. Wolfram’s new kind of science may be seen in the sense of Newton’s Philosophiae Naturalis Principia Mathematica being both natural philosophy and science, not only because of the new methodology of experimental computer science and simulation, or because of particular contributions addressing variety of phenomena, but in the first place as a new unified scientific framework for all of knowledge. It is not only about explaining special patterns seen in nature and models of complex behaviors; it is about the computational nature derived from the first computational principles. Wolfram’s as well as Turing’s natural philosophy differs from Galileo’s view of nature. Computation used in modeling is more than a language. It produces real time behaviors of physical systems: computation is the way nature is. Cellular automata as explored by Wolfram are a whole fascinating computational universe. Do they exhaust all possible computational behaviors that our physical universe exhibit? If we understand physical processes as computations in a more general sense than the computations performed by symbol manipulation done by our current computers, then universal Turing machines and universal cellular automata exhibit only a subset of all possible information-processing behaviors found in nature. Even though mathematically, there is a principle of computational equivalence, in physical nature exists a hierarchy of emergent processes on many levels of organization that exhibits different physical behavior and thus can be said compute with...
different expressive power. This article argues that, based on the notion of computing nature, where computing stands for all kinds of information processing, the development of natural computationalism have a potential to enrich computational studies in the same way as the explorations in the computational universe hold a promise to provide computational models applicable to the physical universe.

1 Evolving Ideas of Systèmes du Monde

Cosmogonies as accounts of the origin and the nature of the universe evolve with growth of human knowledge through allegories, myths, models, theories and paradigms. This development goes in parallel with the increase in the size of the known universe – from immediate surroundings in the age of great myths, to the earth, solar system, Milky Way, to astonishing 500 billion galaxies - according to current state of knowledge. After a long history of mythopoethic and allegoric accounts of the origins and functioning of the universe, Antiquity formulated first natural philosophical and scientific theories. For Pythagoras, numbers were the essence and the principle of the universe, while for Plato geometry was fundamental. Plutarch (Convivialium disputationum, liber 8,2) reports: “Plato said God geometrizes continually”. This was in modern times re-interpreted by Gauss as “o theos arithmetizei,” or “God computes”, [20]. Irrespective of the choice of arithmetic or geometry, the laws of the universe are governed by mathematical principles, even though one is discrete and the other continuous.

Leibniz (1646-1716) with his philosophy of Monadology holds a special place when it comes to the Systèmes du Monde. Monads were defined as elementary automata constituting the complex world through communicating networks [14]. In the Section 18 of Monadology, Leibniz depicts a monad as follows: “All simple substances or created Monads might be called Entelechies, for they have in them certain perfection (echousi to enteles); and a certain self-sufficiency (autarkeia) which makes them the sources of their internal activities and, so to speak, incorporeal automata.” Leibniz had visionary ideas about calculating machines, he introduced binary notation and argued for the essential role of formal languages [1]. Wiener, in The Human Use of Human Beings, describes Leibniz as a forerunner of cybernetics “Leibniz, dominated by ideas of communication, is in more than one way the intellectual ancestor of the ideas of this book for he was also interested in machine computation and automata.” ([25], p. 19). According to contemporary informational interpretation of [24], Leibniz’s monads can be interpreted as information carriers programmed by divine code to change informational contents of their internal states. The divine coding guaranteed correspondence between the activities of monads and the world of phenomena.

Système du Monde of the Clockwork (mechanistic) universe is an example of a flawlessly lawful scientifically-based universe, in the form of a perfect machine, governed by the laws of physics. Laplace (1749-1827) believed that a Supreme Intelligence, based on the laws of nature and on knowledge of the positions and