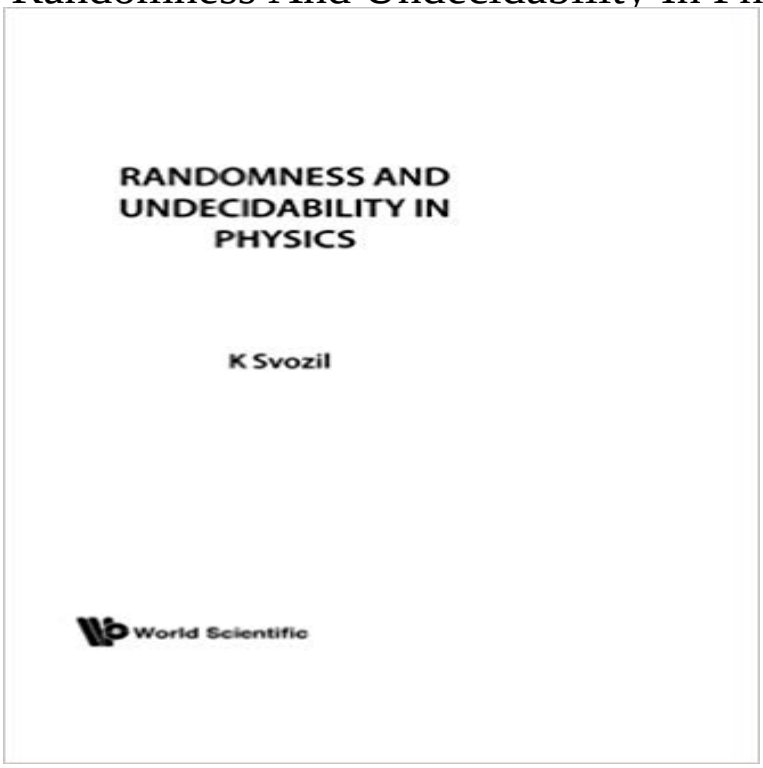
Randomness And Undecidability In Physics



Recent findings in the computer sciences, discrete mathematics, formal logics and metamathematics have opened up a royal road for the investigation of undecidability and randomness in physics. A translation of these formal concepts yields a fresh look into diverse features of physical modelling such as quantum complementarity and the measurement problem, but also stipulates questions related to the necessity of the assumption of continua.Conversely, any computer may be perceived as a physical system: not only in the immediate sense of the physical properties of its hardware. Computers are a medium to virtual realities. The foreseeable importance of such virtual realities stimulates the investigation of an inner description, a virtual physics of these universes of computation. Indeed, one may consider our own universe as just one particular realisation of an enormous number of virtual realities, most of them awaiting discovery.One motive of this book is the recognition that what is often referred to as randomness in physics might actually be a signature of undecidability for systems whose evolution is computable on a step-by-step basis. To give a flavour of the type of questions envisaged: Consider an arbitrary algorithmic system which is computable on a step-by-step basis. Then it is in general impossible to specify a second algorithmic procedure, including itself, which, by experimental input-output analysis, is capable of finding the deterministic law of the first system. But even if such a law is specified beforehand, it is in general impossible to predict the system behaviour in the distant future. In other words: no speedup or computational shortcut is available. In this approach, classical paradoxes can be formally translated into no-go theorems concerning intrinsic physical perception.It is suggested that complementarity can be modelled by experiments on finite automata, where

measurements of one observable of the automaton destroys the possibility to measure another observable of the same automaton and it vice versa.Besides undecidability, a great part of the book is dedicated to a formal definition of randomness and entropy measures based on algorithmic information theory.

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