

Abstract:

"Emergence" has been a topic of discourse by philosophers for over 150 years and is one of the central themes in the currently popular science of complex systems: dynamic systems with many interdependent components. In short, it is the difference between the behaviour of a system and the sum of its parts, which was already appreciated by Aristotle. But how can one make this more precise? I suggest to use the concept of "space-time phases": probability distributions over realisations of the system compatible with its dynamics and initialisation in the distant past. If the interaction between components is non-trivial, then its space-time phases are not products over time-phases for independent units, and this difference can be quantified by a suitable metric. Even more significantly, some systems can exhibit more than one space-time phase, a phenomenon that corresponds to the philosophers' notion of "strong emergence".

Several examples where this has been proved will be illustrated with demonstrations made by Marina Diakonova, and directions for future research sketched.