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Luís M. A. Bettencourt is a Professor at the Santa Fe Institute. He obtained his PhD from Imperial College, University of London, in 1996 for work on critical phenomena in the early Universe, and associated mathematical techniques of Statistical Physics, Field Theory and Non-linear Dynamics. He held postdoctoral positions at the University of Heidelberg, Germany, as a Director's Fellow in the Theoretical Division at LANL, and at the Center for Theoretical Physics at MIT. In 2000 he was awarded the distinguished Slansky Fellowship at Los Alamos National Laboratory for excellence in interdisciplinary research. He later became a research staff member at Los Alamos until late 2011.

Luís carries research in the structure and dynamics of complex systems, with an emphasis on dynamical problems in biology and society. Currently he works on real time epidemiological estimation, information processing in complex systems, innovation in science and technology and urban organization and dynamics. He is a member of advisory committees for international conferences and referees for journals in physics, mathematics, computer science, computational biology, urban studies and for international fellowship programs. For the last three years he was the Principal Investigator of the Synthetic Cognition project at Los Alamos National Laboratory pursuing new science and technology for image and video processing by exploring principles of biology and implementing them at unprecedented computational scales. He is also a consultant for the Office Science and Technology Information of the US Department of Energy on the subject of Scientific and Technological Innovation and Discovery.

Abstract

Does the individual matter in complex systems?

This talk will be devoted to a central conundrum in study of complex systems: Can we simplify the individual components of a complex system in terms of simple agents, particles, links, etc? Or does the detailed nature of the individual matter?

This question is intriguing because our most successful theories in science, in physics and in biology, give us seemingly opposite answers.

Fundamental theories of physics have been spectacularly successful. They have told us how the universe has evolved and what it is made of, made predictions about

new states of matter and lead to technologies that changed human societies. Physical theory has been so successful because of its emphasis on the universality of natural phenomena and of their component units and by focusing on the most statistically probable states, which are typically disordered and not particularly complex. In this sense the nature of individual components matters very little in physics and only their general properties, e.g charge and quantum numbers, need to be tallied up.

In biology, by contrast, evolution by natural selection emphasizes the individual as the fundamental basis of selection. It is the differential selection of distinct individuals (phenotypes) that lies as the source of all of life's history and diversity. In this sense the individual matters very much. A similar argument can be made for the selection and evolution of social organizations and ideas in human societies.

I conclude my talk by showing how a theory of complex systems must encapsulate these two powerful views of the world by placing them within a framework where matter, energy and information interact to create complexity in open ended ways. From this perspective I show how modern physical and biological theories are necessary but not sufficient ingredients for an eventual theory of complex systems.