When We Say “COMPLEXITY”
What Do We Mean?

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Overview

“I think the next [21st] century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don’t know how the laws fit together, and what happens under extreme conditions. But I expect we will find a complete unified theory sometime this century. There is no limit to the complexity that we can build using those basic laws.”

Stephen W. Hawking, in answer to a question: Some say that while the twentieth century was the century of physics, we are now entering the century of biology. What do you think of this?
Overview

"Science has explored the microcosmos and the macrocosmos; we have a good sense of the lay of the land. The great unexplored frontier is complexity."

- Heinz Pagels, The Dreams of Reason
First, Simplicity:
Overview

- “Truth is ever to be found in simplicity, and not in the multiplicity and confusion of things.” Sir Isaac Newton
- “Everything should be made as simple as possible, but no simpler.” Albert Einstein
- “You can recognize truth by its beauty and simplicity.” R. Feynman
Why Is Physics Beautiful?

CAMBRIDGE – The nineteenth-century physicist Heinrich Hertz once described his feeling that James Clerk Maxwell’s equations, which depict the fundamentals of electricity and magnetism, “have an independent existence and an intelligence of their own, that they are wiser...even than their discoverers, that we get more out of them than was originally put into them.”
UNIVERSAL BEAUTY:

The E8 Lie group, pictured above, is a perfectly symmetrical 248-dimensional object. (Lie groups are used in math and physics to model symmetries.) Symmetry, Frank Wilczek says, is prominent in the fundamental laws of nature, and “connotes harmony and beauty.”

http://nautil.us/issue/32/space/beauty-is-physics-secret-weapon
Back to COMPLEXITY:
We have nothing better to show yet!

From Wikipedia
What is a Complex System?

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Complex systems research is becoming ever more important in both the natural and social sciences. It is commonly implied that there is such a thing as a complex system, different examples of which are studied across many disciplines. However, there is no concise definition of a complex system, let alone a definition on which all scientists agree. We review various attempts to characterize a complex system, and consider a core set of features that are widely associated with complex systems in the literature and by those in the field. We argue that some of these features are neither necessary nor sufficient for complexity, and that some of them are too vague or confused to be of any analytical use. In order to bring mathematical rigour to the issue we then review some standard measures of complexity from the scientific literature, and offer a taxonomy for them, before arguing that the one that best captures the qualitative notion of the order produced by complex systems is that of the Statistical Complexity. Finally, we offer our own list of necessary conditions as a characterization of complexity. These conditions are qualitative and may not be jointly sufficient for complexity. We close with some suggestions for future work.
Complex Systems and Their Features

- Non-linearity
- Feedback
- Spontaneous Order
Complex Systems and Their Features

Robustness and lack of Central Control

Emergence
Emergence

Birds flocking emerges from simple rules:

1. keep distance
2. stay aligned
3. avoid predators.
Emergence

Conus textile exhibits an emergent cellular automaton pattern on its shell.
Emergence

Persian Leopard
Think about its skin!
Emergence

Visualization of links between pages on a wiki.

See: emergence of giant component
Emergence in Physics

The concept of emergence in philosophical discussions is closely connected with the notions of antireductionism, unpredictability, and novelty. In many cases these latter concepts are explicated in mereological terms. Very crudely, something is emergent when it (the whole) is greater than the sum of its parts. Alternatively, the behavior of the emergent whole does not reduce to some function of the behavior of its components. Or, the behavior of the emergent whole is unpredictable given knowledge of the nature of its parts. Or, finally, the behavior of the emergent whole is completely different, new, and unexpected, given knowledge of the nature of its parts. In addition, there is often, again in philosophical contexts, a demand that the emergent feature is not explainable, by a theory of the nature of its parts.

Most philosophical discussions focus on the notion of emergence in the context of the mind/body problem, broadly construed: How can the mental, with all of its unique attributes, possibly obtain in a world in which the basic fundamental features are characterized by physical theory. This problem of emergence is intimately connected with the position called nonreductive physicalism.
Complex Systems and Their Features

Hierarchical Organisation

Numerosity
سوره های پیچیده: "ماهیت و ویژگی"؟

حذف: ۲۲ سال پیش، نیوووی با انتشار شاهکار خود، اصول برای فلسفه طبیعی، نگاهی جدید نسبت به بررسی طبیعت را معرفی کرد. نیوووی نیز به علم به کمک نظریه الکترونمنماتیکی که توسط مکسول جیم بیندی در نهایت توسط آلبرت اینشتین کاملاً اثبات شد، شالوده فیزیک کلاسیک را پیشتازه. انقلاب بدعزیر علم، توسط مکانیک کوانتومی، رخ داد. آنچه که مکانیک کوانتومی در قرن ۲۱ میلادی، نشانه گرفت، مسئله موضوعیت در فیزیک کلاسیک و نگاه احتمالاتی به طبیعت بود. نگاهی که سرانجام منجر به پارادایم جدید در علم، به عنوان فیزیک مدرن شد. با این وجود، برغم پیشرفت‌های خلاقانه‌شدن در فیزیک و هسته‌شناسی، مباحثات در توجهی بسیاری از پژوهشگران و فیزیک‌دانان به فیزیک کلاسیک محدود می‌ماند. با این وجود، برای برخی از فیزیک‌دانان، موضوعات خاصی در نظر گرفته نمی‌شوند. بنابراین، می‌توان به این فکر کرد که شاید در تلاش ما به طبیعت و مسائل علمی، نقش و جوید یافته باشد. به‌دیگر جهت، به دنبال نیست که مجدداً توانایی به پیشگامانه در تغییر پارادایم داشته باشیم؛ عده‌ای زیادی معتقدند.

آنچه که در قرن ۲۲ نیاز است، نگاهی جدید به مبانی علم است: نگاه پیچیدگی!

گاهی گفته می‌شود که ایده پیچیدگی، بخشی از چهارچوب اخلاق بخش درباره علم و انقلاب در فیلسوفی از سیستماتیک مانند انسان‌یا اقتصاد جهانی است که رفته‌اند ظهور آنها به‌سختی قابل پیش‌بینی نمی‌باشد. در طول زمان، بخشی از علم، بخشی خاطر با رسمیت حاضری در بررسی‌های مختلف مشاهده شده و گاهی نیز به سیستماتیک پیچیدگی، زمانی کاری خود مستند است؟ به عبارت دیگر،
To be discussed later:

- COMPLEXITY, INFORMATION, AND PROBABILITY
- MEASURES OF COMPLEXITY
- THE “PEAKED” COMPLEXITY FUNCTION
- THE FEATURES OF COMPLEX SYSTEMS REVISITED
Let’s think again;

What is Science?
What is Physics?
Who is a wise policy maker?!
Thank You