SYKO 1: Complexity

Zeit: Montag 13:00–16:45 Raum: A140

Plenarvortrag SYKO 1.1 Mo 13:00 A140

Chaoticity and Complexity — •Andreas Knauf — Fachbereich Mathematik, Universität Erlangen, Bismarckstr. 1, 91054 Erlangen

Chaoticity is a property shared by many dynamical systems, namely that one cannot predict the long term time evolution by a measurement of the initial state. This is measured by dynamical entropies. Classical dynamical systems are often chaotic whereas their quantum counterparts are not, that is, have zero dynamical entropy.

Complexity is a measure of how much the state of a composed system deviates from the product of state of its parts. The information geometry of quantum systems shows features not shared by classical systems.

We point out some of the above-mentioned phenomena and speculate about possible relations between them.

Plenarvortrag SYKO 1.2 Mo 13:35 A140

The LHC-Project: Complexity in High Energy Physics — •Thomas Lohse — Humboldt University, Dept. of Physics, Newtonstr. 15, 12489 Berlin

What is the nature of mass? What happened just after the big bang? Why is the Universe not made of anti-matter? What is the structure of space-time?

These are some of the problems, which will be attacked at the Large Hadron Collider at CERN, the largest particle accelerator ever built. Four particles detectors (ATLAS, CMS, LHCb, ALICE), constructed and operated by collaborations of thousands of physicists and engineers are ready for data taking and waiting for first colliding beams.

Complexity is an unavoidable phenomenon occurring in many aspects of such a large-scale project, some of which will be exemplified in the talk. The protons (or ions) accelerated in the LHC are complex objects by themselves and exhibit complex behavior in their interactions. The particle beams in an accelerator are subject to highly non-linear dynamics which can lead to structure formation, chaos and instability. When protons collide, the proton constituents (quarks and gluons) undergo hard scattering processes which involve an infinite hierarchy of self-similar quantum-fluctuations. These can be theoretically quantified by Feynman diagrams which become factorially more numerous from level to level and rapidly more difficult to evaluate. The particle detectors are divided into a number of different sub-detectors, each with a special task. The large particle density produced in the collisions requires all detectors to have high granularity, in total feeding millions of electronic channels which have to be processed and read out at the bunch crossing rate of 40 MHz. A worldwide network of computing centers serves for data processing and dissemination and is used as a platform for the coordinated data analysis of thousands of physicists.

Plenarvortrag SYKO 1.3 Mo 14:10 A140

Structure Formation in Astrophysics - From Cosmology to Planets — •Wolfgang Hillebrandt — MPI für Astrophysik, Karl-Schwarzschild-Str. 1, 85748 Garching

Understanding the formation (and evolution) of objects in the Universe, on vastly different length and mass scales, from galaxies to stars and planets, is a major issue in modern astrophysics, and one of the most exciting challenges of twenty-first century astronomy. Even though they are characterized by different scales, the formation of planets, stars and galaxies share many common physical processes and are rooted in the same underlying domains of physics. Similarly, non-linear growth of small-scale perturbations can lead to violent processes such as stellar explosions. Today, many of these questions are addressed by numerical simulations on supercomputers. A status report will be given in this talk.

14:45-15:05 Coffee break

Plenarvortrag SYKO 1.4 Mo 15:05 A140

The Scaling Laws of Human Travel: Tracking Dollars for New Approaches to Epidemic Modeling — •Theo Geisel — MPI für Dynamik und Selbstorganisation, Bunsenstr. 10, 37073 Göttingen

Many infectious diseases are transmitted from person to person and human travel is responsible for their geographical spread. In order to model, forecast, and control the spread of epidemics, one needs to know the statistical mechanics of human travel. How can one obtain reliable information on traveling statistics, if people can travel using very different means of transportation from bikes to planes? We have studied this problem empirically using the dispersal of bank notes as a proxy [1]. Dollar bills were tracked based on the dataset of the internet game wheresgeorge.com. Their dispersal can be described very accurately in terms of an ambivalent super- and subdiffusive process in a Lévy random walk model. The model needs 3 parameters only and predicts a spatiotemporal scaling law for the time dependent probability density in very good agreement with the empirical data.

[1] D. Brockmann, L. Hufnagel, and T. Geisel, Nature 439, 462 (2006).

Plenarvortrag SYKO 1.5 Mo 15:40 A140

Challenges of Complexity in Natural, Technical and Economic Sciences — •Klaus Mainzer — Carl-von-Linde-Akademie, TU München, Arcisstr. 21, 80333 München

The theory of complex dynamical systems is an interdisciplinary methodology to model nonlinear processes in nature, economy and society. In the age of globalization, it is the answer to increasing complexity and sensitivity of human life and civilization (e.g., life science, environment and climate, globalization, information flood). Complex systems consist of many microscopic elements (molecules, cells, organisms) interacting in nonlinear manner and generating macroscopic order. Self-organization means the emergence of macroscopic states by the nonlinear interactions of microscopic elements. Chaos and randomness, growth and innovations are examples of macroscopic states modeled by phase transitions in critical states. The models aim at explaining and forecasting their dynamics. In the case of randomness and chaos, there are restrictions to compute the macrodynamics of complex systems, even if we know all laws and conditions of their local activities. Future cannot be forecast in the long run, but dynamical trends (e.g., order parameters) can be recognized and influenced ("bounded rationality").

Literature: K. Mainzer, Thinking in Complexity. The Computational Dynamics of Matter, Mind, and Mankind, 5th enlarged ed. Springer: Berlin/Heidelberg/ New York 2007; K. Mainzer, Symmetry and Complexity. The Spirit and Beauty of Nonlinear Science, World Scientific: Singapore 2005; K. Mainzer, Komplexität, UTB-Profile 2008

16:15-16:45 Round table discussion