2020

Thermodynamics 2.0

Book of Abstracts

June 22 – 24, Massachusetts, USA.

International Association for the Integration of Science and Engineering

www.iaisae.org

Thermodynamics 2.0 | 2020

International Association for the Integration of Science and Engineering

Superior, CO, United States

Book of Abstracts

Thermodynamics 2.0 | 2020

INAUGURAL CONFERENCE

June 22 – 24, 2020

International Association for the Integration of Science and Engineering

Superior, CO, United States

https://iaisae.org/

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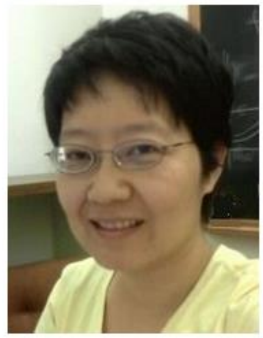
Organizers: Thermodynamics 2.0 | 2020

The following IAISAE members have volunteered to help organize the inaugural conference on Thermodynamics 2.0.

Georgi Georgiev
Organizer

Michael Radzicki
Co-organizer



HongKun Zhang
Member

Ram Poudel
Member

Organizing Team

Christine K Tang
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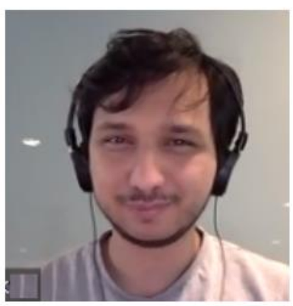

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Thermodynamics 2.0

IAISAE

2020

Thermodynamics 2.0 Meeting
ICT2.0 - 2020
June 22- 24, 2020
Massachusetts, USA

What is Thermodynamics 2.0?

Thermodynamics 2.0 is a platform where the natural sciences meet the social sciences.

Thermodynamics is a universal science. Thermodynamics 2.0 is about bisociation of thermodynamics with other academic disciplines such as physics, chemistry, biology, sociology, economics and many more. Thermodynamics 2.0 builds on ideas of Ostwald and Helm, known also as energetics. The fable about energetics is brought through times in many forms by many progenitors. This fable can be traced back to Heraclitus: πάντα ῥεῖ (panta rhei) – Everything Flows. The language of Thermodynamics 2.0 is energy or its derivatives such as power and entropy which could be more fundamental than energy in time.

Thermodynamics 2.0 is about reshaping and raising the platform of human knowledge rather than building consensus on how do we connect the dots of human knowledge. It is about merging two cultures, not just bridging the gap. We plan to share coming generation new avenues thermodynamics has opened up in the 21st century. We count on the next generation to take thermodynamics to the next level. The forthcoming generation will always be better than the passing generation and also be equipped with the advantage of time-tested ideas.

Some sample open questions in this field are:

- How did cooperative behavior evolve[1]?
- What is life?
- What is the physical principle underlying Evolution?
- What is Money?
- Why is there Poverty?
- What are the organizational forces and principles that lead to emergence, by which the whole can be greater or less than the sum of the parts, etc.?

A monolithic culture, be it either natural science or social science, finds such questions elusive. Thermodynamics 2.0 plans to integrate the engines of human ingenuity across two cultures to address such issues challenging humanity in 21st century and beyond.

[1] https://science.sciencemag.org/content/309/5731/93

THERMODYNAMICS 2.0 | INTERNATIONAL CONFERENCE

Conference Program: June 22 – 24, 2020

Website: https://iaisae.org/index.php/agenda-schedule/

Program at Glance: Sessions and Time Table*

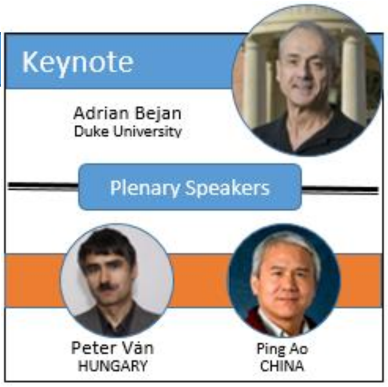
International Conference on Thermodynamics 2.0

Date→	21-Jun	22-Jun		23-Jun		24-Jun		←Date
Time↓	Sunday	Monday		Tuesday		Wednesday		Time↓
8:30		Registration Opens		Keynote and Plenary (III) **Keen, Yakovenko, Stanley**		Keynote and Plenary (V) **Gallavotti, Gladyshev, Iannacchione**		8:30
8:45								8:45
9:00		Welcome and Opening Remarks						9:00
9:15								9:15
9:30		Keynote and Plenary (I) **Bejan, Ván, Ao**						9:30
9:45								9:45
10:00								10:00
10:15								10:15
10:30				Coffee Break		Networking Break		10:30
10:45				Session T07	Session T08/T09	Session T14	Session T15	10:45
11:00								11:00
11:15								11:15
11:30		Invited Talk: Bernard GUY						11:30
11:45								11:45
12:00		Lunch Break		Lunch Break		Session T16	Session T17	12:00
12:15		Lunch talk: Why is there life?		Organizers' Brown Bag: What is Thermodynamics 2.0?				12:15
12:30								12:30
12:45								12:45
13:00		Session T01	Session T02	Keynote and Plenary (IV) **Martinas, Haddad, Swenson**		IAISAE Awards		13:00
13:15						Adjournment		13:15
13:30								13:30
13:45								13:45
14:00		Session T03	Session T04					14:00
14:15								14:15
14:30								14:30
14:45								14:45
15:00		Coffee Break		Coffee Break				15:00
15:15		Session T05	Session T06	Session T10	Session T11			15:15
15:30								15:30
15:45								15:45
16:00								16:00
16:15		Networking Break		Session T12	Session T13			16:15
16:30	**Registration Opens**	Keynote and Plenary (II) **Deacon, Kondepudi, Annila**						16:30
16:45								16:45
17:00	Opening Introduction Network Meeting							17:00
17:15								17:15
17:30				Networking Break				17:30
17:45				IAISAE General Meeting Thermodynamics 2.0 | 2022				17:45
18:00								18:00
18:15								18:15

* Time in Boston, Massachusetts, United States: Eastern Daylight Time (EDT), UTC – 4 hrs. https://time.is/Boston

Program Website: https://iaisae.org/index.php/program/

Program



Day 1 program: Monday, June 22

Monday morning, June 22 – 9:00 – 11:30 (Time in Boston, USA) REGISTER HERE

9:00 am	Welcome and opening remarks
	Chair: Cemal Basaran
9:30 am	**Keynote: Adrian Bejan**, *Duke University* Freedom and Evolution
10:15 am	**Peter Ván**, *Department of Theoretical Physics, Wigner Research Centre for Physics* Emergent or Fundamental? About the Origin of Thermodynamic Universality
10:45 am	**Ping Ao**, *Shanghai Center for Systems Biomedicine, China* Quantifying Evolutionary Processes: Roles of Fundamental Theorem of Natural…

Monday morning/afternoon, June 22 – 11:30 – 12:30 (Time in Boston, USA) REGISTER HERE

	Chair: Nabin Malakar
11:30 am	**Invited: Bernard Guy**, *Mines Saint-Etienne, Institut Mines Télécom, France* In what sense can we say that movement precedes space and time?
12:15 am	**James Thornton**, *Jensen Beach, Florida* Why is there life?

Monday afternoon, June 22 – 13:00 – 15:00 (Time in Boston, USA) REGISTER HERE

SESSION T01: EVOLUTION I

	Chair: Pier Luigi Gentili
1:00 pm	**Themis Matsoukas**, *Pennsylvania State University, University Par, USA* Thermodynamics and the Evolution of Stochastic Populations
1:20 pm	**John S Torday**, *University of California, Los Angeles, USA* A Thermodynamic Unification of Physics and Biology
1:40 pm	**Peter A. Corning**, *Institute for the Study of Complex Systems, Seattle WA, USA* Thermoeconomics: Beyond the Second Law

SESSION T03: THEORETICAL ADVANCES I

Chair: Garvin H Boyle

2:00 pm **Todd Hylton,** *University of California San Diego, USA*
Thermodynamic Neural Network

2:30 pm **Georgi Georgiev,** *Assumption University and Worcester Polytechnic Institute*
A General Model of Self-Organization and Development of Complex Systems …

Monday afternoon, June 22 – 13:00 – 15:00 (Time in Boston, USA) REGISTER HERE

SESSION T02: THERMODYNAMICS, CONSTRUCTAL LAW AND APPLICATIONS

Chair: Nathaniel Umukoro

1:00 pm **Michael T. Takac**
The Science of Rights

1:20 pm **Sam Baker**, *Global Frontiers Inc., Manchester, Vermont, USA*
A New Natural Science of Economics

1:40 pm **Veronika Poór**, *Theory in Practice, Netherlands*
Non-Equilibrium Thermodynamics for Non-Equilibrium Economics

SESSION T04: ECONOMY AND DISTRIBUTION FUNCTION

Chair: Victor Yakovenko

2:00 pm **Venkat Venkatasubramanian,** *Columbia University, USA*
How Much Income Inequality is Fair? A Statistical Teleodynamics Perspective

2:20 pm **Yunus Kinkhabwala,** *Cornell University, Ithaca, NY, USA*
Density-Functional Fluctuation Theory of Residential Demography

2:40 pm **Leila Hedayatifar,** *New England Complex Systems Institute, Cambridge, MA, USA*
Social Fragmentation: Data Analysis and Modeling Frameworks

Monday afternoon, June 22 – 15:15 – 16:15 (Time in Boston, USA) REGISTER HERE

SESSION T05: COMPLEX SYSTEM

Chair: Shabnam Mousavi

3:15 pm **Klaus Jaffe,** *Universidad Simón Bolívar, Venezuala*
Synergy overcomes the Second law by increasing Free Energy while decreasing Entropy

3:35 pm **Benjamin De Bari,** *University of Connecticut, Storrs, USA*
Functional Interdependence in Coupled Dissipative Structures: Physical Foundations of …

3:55 pm **Pier Luigi Gentili,** *University of Perugia, Italy*
The XXI Century Challenges and Complexity

Monday afternoon, June 22 – 15:15 – 16:15 (Time in Boston, USA) REGISTER HERE
SESSION T06: SOCIAL DYNAMICS: POPULATION, POWER AND NETWORK

	Chair: Michael Francis McCullough	
3:15 pm	**Blair Fix,** *York University, Toronto, Canada*	
	Energy and Institution Size	
3:35 pm	**Shimshon Bichler,** *Capital As Power, Israel*	
	Growing Through Sabotage	
3:55 pm	**Erald Kolasi**	
	The Physics of Capitalism	

Monday afternoon, June 22 – 16:30 – 18:30 (Time in Boston, USA) REGISTER HERE

	Chair: Klaus Jaffe
4:30 pm	**Keynote: Terrence Deacon,** *University of California Berkeley*
	Teleodynamics: Specifying the Dynamical Principles of Intrinsical
5:15 pm	**Dilip Kondepudi,** *Wake Forest University, USA*
	Why are Organisms so Different from Machines?
5:45 pm	**Arto Annila,** *University of Helsinki, Finland*
	The Origin of Ubiquitous Patterns

DAY 1: MONDAY, JUNE 22

Day 2 program: Tuesday, June 23

Tuesday morning, June 23 – 8:30 – 10:30 (Time in Boston, USA) REGISTER HERE

Chair: Cal Abel

8:30 am	**Keynote: Steve Keen,** *ISRS, University College London*
	Why System Dynamics Must Supplant Equilibrium Modelling
9:15 am	**Victor Yakovenko,** *University of Maryland, College Park, USA*
	Economic inequality from a statistical physics point of view
9:45 am	**H. Eugene Stanley,** *Boston University, USA*
	Econophysics: Using Statistical Physics Concepts to Offer Insights ir

Tuesday morning, June 23 – 10:30 – 11:30 (Time in Boston, USA) REGISTER HERE

SESSION T07: DYNAMICS OF LIVING SYSTEMS

Chair: Alec Groysman

10:45 am	**Soumya Banerjee,** *University of Cambridge, Cambridge, UK*
	A Roadmap for a Computational and Informational Theory of Life
11:05 am	**Seán Ó Nualláin,** *Foundations of Mind, Israel*
	Friston, Free Energy and the Late Walter Freeman III
11:25 am	**Carsten Herrmann-Pillath,** *Erfurt University, Germany*
	Thermodynamics, Economic Evolution and Growth of Information: The Perspective…

Tuesday morning, June 23 – 10:30 – 11:30 (Time in Boston, USA) REGISTER HERE

SESSION T08: THEORETICAL ADVANCES II

Chair: John S Torday

10:45 am	**Bernard Guy,** *Mines Saint-Etienne, Institut Mines Télécom, France*
	Exploring the Links between Thermodynamics and Social Sciences: The Contribution..
11:05 am	**Burin Gumjudpai,** *Naresuan University, Thailand*
	Thermodynamics Formulation of Economics
11:25 am	**Libb Thims,** *Institute of Human Thermodynamics, USA*
	A Theoretical Torricelli Social Barometer to Measure Social Pressure

Tuesday afternoon, June 23 – 12:15 – 15:00 (Time in Boston, USA) REGISTER HERE

12:15 am **Ram Poudel**, *IAISAE*
Organizers' Brown Bag: The Evolution of Cooperative Behavior in

Chair: Todd Hylton

1:00 pm **Keynote: Katalin Martinás,** *ELTE, Budapest, Hungary*
Thermodynamics for Evolution

1:45 pm **Wassim M. Haddad,** *Georgia Institute of Technology, USA*
The Role of Thermodynamics in the Control of Large-Scale Dynamical Systems and…

2:15 pm **Rod Swenson,** *CESPA Fellow, University of Connecticut, Storrs, USA*
Autocatakinetics, the 4th Law of Thermodynamics (LMEP), and the Rise, Development…

Tuesday afternoon, June 23 – 15:15 – 17:30 (Time in Boston, USA) REGISTER HERE

SESSION T10: CLASSICAL THERMODYNAMICS: THERMODYNAMICS 1.0

Chair: Erald Kolasi

3:15 pm **Elijah Thimsen,** *Washington University in Saint Louis, Missouri, USA*
Experimental Evaluation of Entropy Generation Extrema in Low Temperature Plasma…

3:35 pm **MD Shafiqul Islam,** *Bangladesh University of Engineering and Technology*
Mathematics of the 2nd Law of Thermodynamics

3:55 pm **Eduardo González-Mora,** *Universidad Autónoma del Estado de México, México*
Maximum Thermodynamic Efficiency Evaluation of a Conceptual Direct Steam Generation..

SESSION T12: EVOLUTION II

Chair: Themis Matsoukas

4:15 pm **W.F. Lawless**, *Paine College, Augusta, GA, USA*
The Thermodynamics of Autonomous Human-Machine Teams (A-HMT): Control…

4:35 pm **Ashwin Vaidya,** *Montclair State University, Montclair, NJ, USA*
Network Thermodynamic Analysis of Protein Aggregation

4:55 pm **Gábor Balázsi,** *Stony Brook University, USA*
Evolutionary Loss and Regain of Gene Network Function

Tuesday afternoon, June 23 – 15:15 – 17:30 (Time in Boston, USA) REGISTER HERE

SESSION T11: SOCIAL AND POLITICAL THERMODYNAMICS

	Chair: Blair Fix
3:15 pm	**Nathaniel Umukoro,** *Edo University, Nigeria*
	Managing Violent Conflicts in Africa: Insights from the Principles of Thermodynamics
3:35 pm	**Mirza Arshad Ali Beg,** *Karachi, Pakistan*
	Socio-Physicochemical Theory on Terror & Terrorism
3:55 pm	**Michael Francis McCullough,** *Brooklyn College (retired), Brooklyn, New York, USA*
	The American Civil Rights Movement and Speculations on Political Thermodynamics

SESSION T13: MONEY, CAPITAL, AND THERMODYNAMICS LAWS

	Chair: Carey W. King
4:15 pm	**Marcin Jedrzejczyk,** *Cracow University of Economics, Cracow, Poland*
	Capital, Work and Economic Value in the Context of the First and the Second Law…
4:45 pm	**Jurij Renkas,** *Cracow University of Economics, Poland*
	Thermodynamic Laws for Measuring Human Capital and Determining Fair Remuneration
5:05 pm	**Mieczyslaw Dobija,** *Cracow University of Economics, Cracow, Poland*
	A Physical Basis of Economics

Tuesday afternoon, June 23 – 17:45 – 18:30 (Time in Boston, USA) REGISTER HERE

5:45 pm	**IAISAE General Meeting**
	General Assembly: Organization and Planning Ahead
	Thermodynamics 2.0 | 2022

Day 3 program: Wednesday, June 24

Wednesday morning, June 24 – 8:30 – 10:30 (Time in Boston, USA) REGISTER HERE

Chair: Bruce Boghosian

8:30 am **Keynote: Giovanni Gallavotti,** *Universita' di Roma La Sapienza*
A Path from Equilibrium to Nonequilibrium Thermodynamics

9:15 am **G.P. Gladyshev,** *Institute of Chemical Physics of Academy of Scien*
Living Universe and Hierarchical Thermodynamics

9:45 am **Germano S. Iannacchione,** *Worcester Polytechnic Institute, USA*
Emergence of Order and Disorder Far-from-Equilibrium: A Fundamental Frontier….

Wednesday morning, June 24 – 10:30 – 11:30 (Time in Boston, USA) REGISTER HERE
SESSION T14: THEORETICAL ADVANCES III

Chair: Gábor Balázsi

10:45 am **Alec Groysman,** *Israel Institute of Technology, Haifa, Israel*
Thermodynamics, Humanities, and Art

11:05 am **Ashok Sengupta,** *Institute for Holistic Sustainability, Kolkata, India*
Is Nature Ill-posed Complex Holistic or Well-posed Quantum Reductionist?

11:25 am **Shamit Shrivastava,** *University of Oxford, UK*
Spike Based Computing on Self Assembled Lipid Monolayers

11:45 am **D. Bernal-Casas,** *University of Barcelona, Catalonia, Spain*
Exponential tails of Covid-19 cases are modulated by daylight hours

SESSION T16: EQUATION OF MOTION: CHANGE | TRANSFORMATION

Chair: Ashwin Vaidya

12:00 pm **Cemal Basaran,** *University at Buffalo, SUNY, USA*
Unified Mechanics Theory: Unification of Thermodynamics and Newtonian Mechanics

12:20 pm **Gian Paolo Beretta,** *Brescia State University, Brescia, Italy*
The Fourth Law of Thermodynamics: The Irreversible Component of Nonequilibrium Time…

12:40 pm **Miroslav Grmela,** *Ècole Polytechnique de Montréal, Canada*
Multiscale Thermodynamics: A Theory of Relations Among Mesoscopic Dynamical Models..

Wednesday morning, June 24 – 10:30 – 13:00 (Time in Boston, USA) REGISTER HERE
SESSION T15: ECONOPHYSICS | SOCIOPHYSICS

Chair: Emmanuel Haven

10:45 am **Cal Abel,** *Signal Power and Light, Inc., Atlanta, GA, USA*

	Generalizing Statistical Mechanics
11:05 am	**Bruce Boghosian,** *Tufts University, USA*
	New developments in agent-based models of wealth distribution
11:25 am	**Bikas K Chakrabarti,** *Saha Institute of Nuclear Physics, Kolkata, India*
	Development of Econophysics & Its Timeline
11:45 am	**Mirza Arshad Ali Beg,** *Karachi, Pakistan*
	Social Entropy of Wealth Accumulation and Resource Impoverishment

SESSION T17: BIOPHYSICAL ECONOMICS

	Chair: Jurij Renkas
12:00 pm	**Carey W. King,** *University of Texas at Austin, USA*
	HARMONEY: A Biophysical And Economic Growth Model
12:20 pm	**Garvin H Boyle,** *Orrery Software, Richmond, Ontario, Canada*
	Proposed principles of economics: Bio-symmetry and hierarchic symmetry
12:40 pm	**Shabnam Mousavi,** *Max Planck Institute for Human Development, Berlin, Germany*
	Framing Human Behavior in Physics Before Biology and Social Science

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Wednesday morning, June 24 – 13:00 – 13:30 (Time in Boston, USA) REGISTER HERE
CLOSING AND IAISAE HONORS

	Chair:
1:00 pm	**IAISAE Awards and Acknowledgments**
1:15 pm	Thermodynamics 2.0 | 2022 and Conference and Election Committee
1:20 pm	**Closing Remarks**
1:30 pm	End of Thermodynamics 2.0 | 2020 International Conference.

***

Book of Abstracts

THERMODYNAMICS 2.0 | INTERNATIONAL CONFERENCE

June 22 – 24, 2020

Conference Presentation

FREEDOM AND EVOLUTION

Adrian Bejan

J.A. Jones Distinguished Professor
Duke University, Durham, NC, USA

ABSTRACT

Evolution is the defining phenomenon of nature. Everywhere we look what we see is evolving because it is free to move and morph. Without change there is nothing--no image, no beauty, no time, no future. This abstract outlines the role played by freedom and evolution in physics (thermodynamics): given freedom, all movement exhibits the tendency to evolve into configurations that provide greater access. Let me begin with familiar designs (inanimate, animate) and conclude with why the physics of evolution is not only useful but also necessary to human progress. Man can use what he sees in evolution to improve all the things that make our lives better. The abstract is based on the new book: FREEDOM AND EVOLUTION: Hierarchy in Nature, Society and Science (Springer, New York, January 2020).

Keywords: freedom, evolution, hierarchy, society.

ICT2.0:2020-W113

EMERGENT OR FUNDAMENTAL? ABOUT THE ORIGIN OF THERMODYNAMIC UNIVERSALITY

Peter Ván[1,2,3]

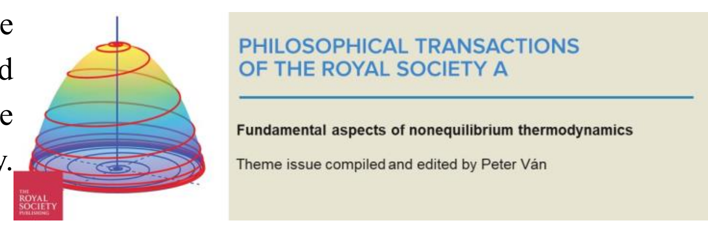
[1] Wigner Research Centre for Physics, Institute of Particle and Nuclear Physics, Department of Theoretical Physics, Budapest, Hungary
[2] Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Energy Engineering, Budapest, Hungary
[3] Montavid Thermodynamic Research Group, Budapest, Hungary

ABSTRACT

Temperature is a universal thermodynamic concept because it is independent of the structure and constituents of the material. Apparently, the whole conceptual framework of classical equilibrium thermodynamics shares this kind universality. Thermodynamics is working far beyond ideal gases with well abstracted microscopic properties. Non-equilibrium thermodynamics is a framework dealing with dissipative systems, and in several aspects, it is also universal. For example, the Fourier law of heat conduction is our number one technological model dealing with heat conduction for fluids and solids equivalently.

The various modern branches of non-equilibrium thermodynamics developed ideas that are capable of generalizing the constitutive functions like the Fourier law of heat conduction. Moreover, one can derive the evolution equations of dissipative systems. The abstraction of the metaphysical principles makes transparent the core ideas, the origin of the apparent universal properties and also the tools and means of validation. The ultimate challenge is whether the can we interpret physics without mechanics, in particular, whether can we understand mechanics through thermodynamic concepts.

In the presentation, I summarize the common aspects of the various branches of non-equilibrium thermodynamics and the related efforts to contribute to the clarification of some fundamental problems of physics like the origin of gravity.



Keywords: evolution equations, dynamics, asymptotic stability, Lyapounov function

ICT2.0:2020-W145

QUANTIFYING EVOLUTIONARY PROCESSES: ROLES OF FUNDAMENTAL THEOREM OF NATURAL SELECTION AND ADAPTIVE LANDSCAPE

Ping Ao, Yongcong Chen, Xiaomei Zhu

Shanghai Center for Quantitative Life Sciences and Department of Physics
Shanghai University, Shanghai, China

ABSTRACT

Although there is a strong consensus that general laws in biology may exist, opinions opposing such suggestion are abundant. Based on the progress in both mathematics and biology during last 20 years, we have shown that it is indeed possible. Specifically, the evolutionary dynamics, Evolution by Variation and Selection, has been explicitly and quantitatively expressed in the unique and new form of a stochastic differential equation. Salient features of the evolutionary process of Charles Darwin and Alfred Russel Wallace are captured: the probabilistic nature of evolution, ascendancy, and the adaptive landscape. Four dynamical elements are introduced in such quantitative formulation: the ascendant matrix related to fundamental theorem of natural selection of Ronald Aylmer Fisher, the transverse matrix, the evolutionary potential function as adaptive landscape of Sewall Wright, and the stochastic drive. Inspired by the fluctuation-dissipation theorem in nonequilibrium statistical physics, a new formulation of fundamental theorem of natural selection is provided, to be free from defects known for decades in theoretical biology.

The new formulation has been applying to various problems across in biology: Wright-Fisher model in population genetics; the limit cycle type dynamics; gene switch of phage lambda infection to E Coli; cancer genesis and progression; developmental processes; metabolic network dynamics; neural network dynamics; etc. Those successes confirm that evolutionary dynamics is indeed the fundamental dynamical framework in biology, and beyond.

Keywords: evolution, nonequilibrium processes, adaptive landscape, potential function, fundamental theorem of natural selection, fluctuation-dissipation theorem, generalized Einstein relation

ICT2.0:2020-W169

IN WHAT SENSE CAN WE SAY THAT MOVEMENT PRECEDES SPACE AND TIME?

Bernard Guy

Mines Saint-Etienne, Institut Mines Télécom, France

ABSTRACT

We believe that the question of time is still not satisfactorily addressed in the various fields of thought. Without claiming to solve all the difficulties associated with it, we propose to insist on the link between time and space, as the theory of relativity invites us to do; but going further into the idea of a conceptual unity (relativity still keeps two distinct concepts, two types of instruments, rulers and clocks, and always considers in advance two sets of variables). A reflection of this kind cannot avoid a discussion on how our rationality works in building our knowledge of the world. In composition with the more usual *substantial* rationality, it is appropriate to speak of a *relational* rationality: inside the world, we can only make comparisons / oppositions (time is not space, space is not time) without being able to assign to one or the other a list of characters of its own. In this context, we are led to give to movement a primary character (beginning with showing it, before defining it with words). Space and time are derived from it: space is associated with relatively slower movements than those on which we define time. To make our point of view understood, we will use thought experiments: according to the speed scales, mountains move like the waves of the sea, space is transformed into time; or, on the contrary, the grains of sand in the hourglass are motionless like the graduations of a ruler, time is transformed into space. We will discuss the epistemological status of such a point of view (role of images; use of fiction in science, in the sense of the philosopher Hans Vaihinger, 1852-1933).

This opens numerous consequences in physics. A first list will be proposed: a look at the "speed" of light; the twins paradox; Lorentz transformation and the construction of time; relations between quantum mechanics and general relativity from the point of view of their representations of time and space; composition of non-collinear Lorentz transformations; understanding thermodynamics ... Other avenues of research emerge in humanities and social sciences (anthropology, history, linguistics, mesology, psychology…).

Keywords: space, time, movement, relation-based thinking, substance-based thinking, relativity theory, physics, humanities and social sciences, fiction, images

ICT2.0:2020-W119

WHY IS THERE LIFE?

James Thornton

ABSTRACT

Ongoing theoretical explorations and experimental research on the origins of life focus predominately on the details of how life evolved. However, there remains an intriguing second-order question one step removed from these focused investigations. That is: Why is there life? Exploring the forces, mechanisms, and physical laws (and their interactions) that define the creation of animate out of inanimate matter is both theoretically interesting and useful to understanding the biological and philosophical nature of life. Defining the key factors ("effectors") behind the creation of life opens a fertile field of possibilities that is as yet incompletely explored.

The discussion of these effectors in this manuscript helps to advance our understanding of why there is life by elucidating the motive force behind the creation and evolution of life throughout the universe and by giving insight into life's apparent teleonomy and other unique characteristics. The results of these effectors, working in conjunction with the electromagnetic force, are summarized. Similarities in the evolution of animate and inanimate complex matter are explored to explain why life evolves in the universe. Characteristics considered unique to life (creation, metabolism, growth, reproduction, evolution, 'self' and the logic of the metabolic machinery, together "teleonomy") are explained employing an expanded definition of complexity applicable to both sides of the animate-inanimate divide.

Keywords: science; philosophy; creation of life

Reference:
Thornton, James Clay. "Why Is There Life?." Cosmos and History: The Journal of Natural and Social Philosophy 13, no. 3 (2017): 8-53.

ICT2.0:2020-W121

THERMODYNAMICS AND THE EVOLUTION OF STOCHASTIC POPULATIONS

Themis Matsoukas

Department of Chemical Engineering,
Pennsylvania State University, University Par, PA 16802, USA

ABSTRACT

The undeniable appeal of statistical mechanics has led to numerous attempts to extend its tools to processes and problems outside the realm of molecules and physical particles. However, no formal theory exists to guide us on the application of statistical mechanics outside physics and chemistry. In this talk I will show that the basic elements of statistical mechanics are universal to generic stochastic processes.

The theory views a stochastic process as a network of chemical reactions. We begin with a finite sample (population) of the the event space at time zero and construct all possible future paths based on the transformations that are possible under the rules of the stochastic process. We define the ensemble of states that can be reached in a fixed number of steps from the initial state (feasible space), define its probability and formulate its master equation. We show that when the size of the initial sample increases indefinitely (asymptotic limit), the feasible space becomes continuous but its probability distribution converges to discrete points that represent thermodynamic phases. If only one phase is present the ensemble is represented by its most probable distribution. We work out the calculus of the most probable distribution in the asymptotic limit, identify the functional whose maximization produces that distribution and express the most probable distribution in terms of a partition function and its derivatives. We analyze four problems under this theory: (a) random walk, (b) binary clustering (c) binary fragmentation and (d) equilibrium exchange, and give examples of phase splitting in these systems.

Keywords: entropy, statistical mechanics, stochastic process, most probable distribution, stochastic evolution, phase splitting

ICT2.0:2020-W116

A THERMODYNAMIC UNIFICATION OF PHYSICS AND BIOLOGY

JS Torday[1], WB Miller Jr[2]

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ABSTRACT

A recent publication hypothesized that there is a “Singularity of Nature”[1] through which basic thermodynamic principles can be used to reconcile physics and biology. In this way, the mission of the IAISAE to merge the natural and social sciences becomes tractable. The protocells that populated Earth originated from lipid-based micelles, capable of forming and deforming in response to the heat of the Sun, still maintaining their structural integrity. This hysteretic property is the origin of the molecular memory necessary for evolution. It is also argued that the vital relative negentropic status of the first protocells was the consequence of the obligate equal and opposite reaction to the Big Bang based on Newton's Third Law of Motion. It was this phenomenon that permitted the ongoing thermodynamic coupling between the outward environment and the interior of the cell to sustain the first primitive life. The complex cell developed out of this conjunction, fully establishing the unicellular form as the first Niche Construction as a continuous process, whereby an organism fashions itself and its environment concurrently. Those crucial evolutionary leaps that followed, such as endosymbiosis, are reiterations of this established pathway, which by necessity must adhere to commencing Cosmic Laws. Evolution can thereby be understood as the continuous process of the internalization of the environment within thermodynamic proscriptions. Further evolutionary development represents the multicellular augmentation of these fundamentals based on principles of cell-cell communication, which extends across embryologic development. In this manner, multicellular cooperativity, human physiology, society and culture all refer back to the Singularity/Big Bang as fractal iterations. This framework reconciles with the nilpotent universal computational system of Marcer and Rowland [2]. Biological reproductive reiterations that always refer to the zero origin of the Singularity are a 'creation operation' that 'conserves and proofreads' to attempt to ensure the fidelity of life.

Keywords: singularity of nature, micelle, endosymbiosis, Big Bang, evolution

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ICT2.0:2020-W153

THERMOECONOMICS: BEYOND THE SECOND LAW

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ABSTRACT

“Thermoeconomics” represents a paradigm shift in our understanding of the role of energy in living systems, and in evolution. It is based on the proposition that the role of energy in biological evolution can best be defined and understood not in terms of the Second Law of Thermodynamics but in terms of such economic criteria as “productivity”, “efficiency”, and especially the costs and benefits (or “profitability”) of the various mechanisms for capturing and utilizing available energy to build biomass and do work. Thus, thermoeconomics is fully consistent with Darwinian evolutionary theory. Economic criteria provide a better account of the advances (and recessions) in bioenergetic technologies in evolution than does any formulation derived from the Second Law.

Keywords: economics, evolution, second law, bioenergetics, entropy

ICT2.0:2020-W149

THE SCIENCE OF RIGHTS

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ABSTRACT

In 1776 Thomas Jefferson's philosophy of innate rights:
"unalienable Rights"
"Life Liberty, and the pursuit of Happiness."

In 1996 Adrian Bejan's discovery of a new law in thermodynamics:
"constructal law"
"For a flow system to persist in time (to live), it must evolve freely such that it provides greater access to its currents."

Today we explore the science of rights with the following correlation:
For a flow system to persist in time (to live) [*Life***], it must evolve freely [***Liberty***] such that it provides greater access [***the pursuit of***] to its currents [***Happiness*** (positive feedback)**]**.

The one-to-one mapping of unalienable rights to the constructal law maintains a potential paradigm shift. From this mapping a compelling exhibit develops within a simple context, traversing the fine line between science, philosophy, faith, and politics in contrast with morality, economics, and the rule of law. An exhibit setting the stage for the experts in various fields throughout the social and political sciences, as well as inviting the interested practitioner to explore the constructal law.

Keywords: evolution, human rights, society, constructal law

ICT2.0:2020-W107

A NEW NATURAL SCIENCE OF ECONOMICS

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ABSTRACT

The purpose of this paper is to develop a theoretical framework for a new natural science of macroeconomics. We use the classification "natural science" to describe our new theory of macroeconomics because the theory's hard core is based on Rod Swenson's formulation of the law of maximum entropy production (LMEP), a universal natural law, which has recently been described in the literature as the fourth law of thermodynamics [1]. LMEP (or the fourth law) provides the key to understanding the lawful behavior of open, far from equilibrium, spontaneously organizing and self-reinforcing physical systems of exchange, what Swenson calls autocatakinetic systems.

We utilize the profound intuition supplied by the fourth law (and the corollary, Swenson's universal ordering principle) to first classify modern human economies and financial markets as autocatakinetic systems and then to argue that human economies and financial markets are mutually nested and embedded together with the myriad other natural living and non-living autocatakinetic systems (animals, plants, ocean systems, ecosystems, etc) making up the larger earth's biosphere, which is itself an autocatakinetic system writ large. The classification of the human economy and financial markets in such a way -- i.e. as naturally emergent and nested physical sub-systems mutually embedded with the myriad other autocatakinetic systems making up the earth's biosphere -- provides a principled foundation for the development of a uniquely parsimonious, natural law based theory explaining the origin, evolution and historical behavior of human economies and financial markets; and in so doing, it suggests profound policy implications for world leaders facing urgent global challenges such as climate change and systemic instability in the global economy.

Keywords: law of maximum entropy production (LMEP), macroeconomics, autocatakinetic systems, far from equilibrium

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ICT2.0:2020-W181

NON-EQUILIBRIUM THERMODYNAMICS FOR NON-EQUILIBRIUM ECONOMICS

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ABSTRACT

That economic theory needs new paradigms is no news, however, as there is still a lack of sound mathematical tools to describe real-world, non-equilibrium economics, most new-economist thinking relies on equilibrium-mathematics and then tries to modify it, or just tries to get rid of mathematics entirely. In this presentation we show that the same mathematics that underlies non-equilibrium thermodynamics could be implemented in the description of non-equilibrium economics and thus provide a non-equilibrium mathematical basis for modelling our real, non-equilibrium social world.

Keywords: non-equilibrium thermodynamics, non-equilibrium economics, wealth, value, force law

ICT2.0:2020-W147

THERMODYNAMIC NEURAL NETWORK

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ABSTRACT

Idealized models of physical systems, such as the Ising model, have long played a central role in developing an understanding of the natural world. In this work, we describe a thermodynamically motivated neural network model that self-organizes to transport charge associated with internal and external potentials while in contact with a thermal reservoir. As compared to other models, the Thermodynamic Neural Network (TNN) model is distinguished by its electric circuit inspiration and its treatment of charge as a conserved quantity. Although learning is the primary objective of the model, the motivation is not the statistical generalization of a training set, the replication of a function, or the storage of a memory; rather, learning is viewed as adaptation to improve equilibration with external potentials and a thermal reservoir. The model integrates concepts of conservation, potentiation, fluctuation, dissipation, adaptation, equilibration and causation to illustrate the thermodynamic evolution of organization in open systems. A key conclusion of the work is that the transport and dissipation of conserved physical quantities drives the self-organization of open thermodynamic systems.

Keywords: self-organization, open thermodynamic systems, neural networks, dissipative adaptation, causal learning, multiscale complex systems, thermodynamic evolution

ICT2.0:2020-W126

THE EVOLUTION OF HUMAN ENERGETIC SYSTEMS

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ABSTRACT

Inspired by the work [1] of one of my Professors, Leslie A. White, who brought the thermodynamic concepts of Ostwald, Soddy, and Lotka into Anthropology, I developed my own distinctive approach in a series of articles [2, 3]. This work applied biological and energetic concepts to the analysis of human social and cultural systems to illuminate important anthropological questions as human origins, and the origin of the state and civilizations. These articles received some favorable attention, but I moved on to other issues relating to my field work in Japan and my work in applied anthropology in Los Angeles. More recently, responding to developments in ecological economics and Marxian ecology, I began to reformulate my earlier work, resulting in two articles which incorporated my earlier concept of energetics into a more general concept of metabolism [4, 5].

I want to turn now to an examination of how these concepts might be used to better understand the present condition of our species. After providing an overview of the thermodynamic development of our species from earliest times to the present, I will examine how the energetics of our global ecosystem is being distorted, first by irrational and wasteful use of fossil fuels, nuclear, and other forms of auxiliary energy, and second by the misapplication of human energy (in the form of physical and mental labor) into sustaining war, exploitation, and inequality rather than serving the well-being of or species.

Keywords: evolution, culture, energetics, ecosystem, social metabolism

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ICT2.0:2020-W163

A GENERAL MODEL OF SELF-ORGANIZATION AND DEVELOPMENT OF COMPLEX SYSTEMS ACROSS THE DISCIPLINES

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ABSTRACT

We are presenting a model of continuous self-organization, which treats physical, biological, technological and social systems in the same formalism. It is general, about the dynamics of self-organizing developing and evolving complex systems, and aims to explain the mechanisms of self-organization and development of any system independent of its constituent elements. We give examples of stellar self-organization and rolling Rayleigh-Benard convection in physics, biological, ecological, technological (CPUs, power plants and machines) and social systems, such as cities. We argue that the underlying dynamics can be derived from a variational principle and review some recent attempts to formulate non-equilibrium thermodynamics and the treatment of dissipative systems in general from expanded Hamilton's, Lagrangian and Generalized Hergholtz principles.

Keywords: self-organization, variational principle, Lagrangian, Generalized Hergholtz principle

ICT2.0:2020-W170

HOW MUCH INCOME INEQUALITY IS FAIR? A STATISTICAL TELEODYNAMICS PERSPECTIVE

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ABSTRACT

Extreme economic inequality is widely seen as a serious threat to the future of stable and vibrant capitalist democracies. Yet some inequality is inevitable, even desirable and necessary, for capitalist societies to work productively. As different people have different skills, and different capacities for work, they make different contributions in a society, some more others less. Therefore, it is only fair that those who contribute more earn more. *But how much more? What is the fairest inequality of income?* This critical question is at the heart of the inequality debate. The debate is not so much about inequality per se as it is about fairness. This central question about fair inequality has remained unanswered in economics and in political philosophy for over two centuries. Mainstream economics has offered little guidance on fairness and the ideal distribution of income in a free-market society. Political philosophy, meanwhile, has much to say about fairness yet relies on qualitative theories, such as the ones by Rawls and by Nozick, which cannot be verified by empirical data. As we take steps to address extreme inequality, we need to know what the desired target inequality is -- and for this we need a quantitative, testable theory of fairness for free-market capitalism.

In a recent book, I have proposed such a normative theory, an unorthodox transdisciplinary theory that integrates foundational principles from disparate disciplines into a unified conceptual and mathematical framework that includes the key perspectives on this question -- the perspectives of political philosophy, economics, game theory, statistical mechanics, information theory, and systems engineering. I call my theory *statistical teleodynamics*, a generalization of statistical thermodynamics for economics. My theory rests on two surprising conceptual insights. One is that the concept of entropy from statistical mechanics is the same as potential from game theory, and that these represent fairness in economics and in philosophy. The other is that when one maximizes fairness, all workers enjoy the same effective utility at equilibrium in an ideal free-market society, thereby providing the moral justification for free-market economy. We prove that the fairest inequality of pay is a lognormal distribution under ideal conditions.

Comparing this theory's predictions with the inequality data from different countries, we find that for the bottom 99% of the population, Scandinavia has achieved income shares that are close to the ideal values for the past 25 years. What is even more surprising is that these societies did not know, a priori, what the fairest distribution was, and yet they seem to have "discovered" a near-ideal outcome empirically on their own. It is quite intriguing that while this theory argues the libertarian case for the ideal free-market, the theory's predictions nevertheless result in a free-market society that looks more like Scandinavia, often favored by egalitarians. Thus, this theory seems to provide the elusive middle ground that can serve as the intellectual basis to advance the current debate on extreme economic inequality.

Keywords: income inequality, statistical teleodynamics, statistical mechanics, game theory, fairness

ICT2.0:2020-W108

DENSITY-FUNCTIONAL FLUCTUATION THEORY OF RESIDENTIAL DEMOGRAPHY

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ABSTRACT

Quantifying drivers of residential choice is crucial to understanding and addressing issues of inequality as well as forecasting human migration. In the United States, residential segregation by race/ethnicity is driven by manifold factors including racial biases, income inequality, and preferences to living in communities with shared cultures. Demographic studies commonly reduce segregation to a single index, but we show that indices are insufficient to understand important nuances. Instead, we apply a statistical physics-based method, Density-Functional Fluctuation Theory (DFFT), to measure the racial residential segregation in human populations in a functional form for the first time. This approach quantifies the probability of observing a neighborhood with a given composition in a manner independent of the overall composition of a larger region. Importantly, DFFT extracts these functions directly from data while making minimal assumptions about the nature of the segregation. Using block level racial/ethnic composition data from the 1990, 2000, and 2010 Censuses, I will present the county level multi-group racial segregation across the US through the lens of DFFT. We expect this method can be used to inform policies to reduce the well-documented negative effects of residential segregation in America.

Understanding population distributions is also essential to forecast how populations change as people become more mobile. Traditional demographic projections have yet to incorporate descriptions of segregation and thus cannot forecast population dynamics at scales finer than the county level. We use DFFT to forecast population changes from the county down to the block group scale, two orders of magnitude smaller than current demographic projections. To probabilistically forecast the composition of a block group, we start with the initial composition of the block group in 2000 and use our segregation functions to predict its composition in 2010. We expect that DFFT coupled with traditional demographic methods will provide detailed forecasts that better inform decisions made at levels from city planning to national policy.

Keywords: demography, segregation, density functional theory, emergent descriptions of complex systems

ICT2.0:2020-W166

SOCIAL FRAGMENTATION: DATA ANALYSIS AND MODELING FRAMEWORKS

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ABSTRACT

Despite the world becoming highly connected, societies seem to be increasingly polarized and fragmented. All over the globe, nationalist currents and regionalisms gain strength and threaten to radically transform the composition of countries and States as we know them. The basis of this phenomenon is in the complex structure and dynamics of social systems. Far from homogeneously mixing with each other, we self-organize into groups that can span across multiple scales, from families or friends up to cities and cultures. We study the modular structure of society using mobility and communication data obtained from social media. We see that societies are organized in geographical patches where people meet and interact both offline and online, revealing the geometry of the social tissue. The smaller patches can span across neighborhoods while the largest can span across states and countries. Given the challenges that we face as a global society, it is imperative that we learn the way societies are actually structured. The emergence of the structure we observe in the data can be explained with a network growth model that combines the preferential attachment mechanism, the human mobility gravity model and a spatial growth process based on nearest neighbors. In our model, we consider a regular lattice representing a map of geographical locations, simulating the way people travel. Three exponents control the effects of mechanisms. Model reveals that as highly connected places, cities act like gravity centers attracting human displacements from surrounding areas and creating spatial patches where people inhabit and interact with each other. The model is able to reproduce the heterogeneous spatial patterns of the degree distribution as well as the geographical modular structure of the resulting network.

Keywords: social fragmentation, mobility network, communication network, modular structure, modeling

ICT2.0:2020-W174

SYNERGY OVERCOMES THE SECOND LAW BY INCREASING FREE ENERGY WHILE DECREASING ENTROPY

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ABSTRACT

Synergy, emerges from synchronized reciprocal positive feedback loops between a network of diverse actors. For this process to proceed, compatible information from different sources synchronically coordinates the actions of the actors resulting in a nonlinear increase in the useful work or potential energy the system can manage. In contrast noise is produced when incompatible information is mixed. This synergy produced from the coordination of different agents achieves non-linear gains in free energy and in information (negentropy) that are greater than the sum of the parts. The final product of new synergies is an increase in individual autonomy of an organism that achieves increased emancipation from the environment with increases in productivity, efficiency, capacity for flexibility, self-regulation and self-control of behavior through a synchronized division of ever more specialized labor. Examples that provide quantitative data for this phenomenon are presented.

Keywords: Entropy, Free energy, Synergy

ICT2.0:2020-W109

FUNCTIONAL INTERDEPENDENCE IN COUPLED DISSIPATIVE STRUCTURES: PHYSICAL FOUNDATIONS OF BIOLOGICAL COORDINATION

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ABSTRACT

Biological behavior requires the dynamic and adaptive coordination of many degrees of freedom, within and between organisms. This coordination may be attributed to the self-organization of physiological degrees of freedom into assemblies called *coordinative structures*. Coordinative structures are contextually flexible and functionally-specific, allowing for stable performance in the face of perturbations. As an example, consider the body-wide adjustments made when we misstep while walking – distal physiological components alter their activity to maintain system stability. This phenomenon is known as *reciprocal compensation*. Reciprocal compensation can be demonstrated in a non-living self-organized system, a *dissipative structure*. We present evidence for this adaptive flexibility in an electrical dissipative structure, and motivate a shared physics underwriting the coordination of both living and non-living self-organizing systems.

Keywords: Coordinative structures, reciprocal compensation, dissipative structure

ICT2.0:2020-W146

THE XXI CENTURY CHALLENGES AND COMPLEXITY

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ABSTRACT

Scientific knowledge and technologies confer humans the power of perturbing the fragile stability of climate, ecosystems, and societies, and the delicate psychophysical well-being of every human. Humanity has to make smart and wise choices to get through the coming period of peril and opportunity. The challenges of the XXI century are global, and they regard Complex Systems. Examples of Complex Systems are living beings, ecosystems, macro-economy, societies, and the climate of the Earth. Current science is unable to describe the properties of Complex Systems exhaustively. In other words, it is not possible to predict the behavior of Complex Systems, especially in the long term. Why? There are different reasons:

- First, Natural Complexity is linked to Computational Complexity: many of the computational problems regarding Complex Systems are solvable but intractable.
- Second, Complex Systems exhibit variable patterns: variable patterns are hard to be recognized because their features depend on the context. In these situations, a Descriptive Complexity emerges.
- Third, the predictive power of science has intrinsic limitations.

Our limitations in predictions make many ethical issues highly disputable. In particular, we can now manipulate life, but we ask ourselves if it is always fair to do what technology makes doable. These kinds of questions create a Bio-ethical Complexity. How can we win the XXI century challenges that regard Complex Systems? In this contribution, we propose a promising path to answer this compelling question.

Keywords: complex systems, thermodynamics, self-organization, natural and social sciences

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ICT2.0:2020-W154

ENERGY AND INSTITUTION SIZE

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ABSTRACT

Why do institutions grow? Despite a century of scientific effort, there is no consensus on this topic. I propose a new approach to studying institutions that focuses on energy consumption. As energy use increases, institutions tend to become larger. I show that this growth of institution size can be thought of as the growth of hierarchy. In short, as energy use grows, societies tend to become more hierarchical.

Keywords: energy, institution size, growth, hierarchy, society

ICT2.0:2020-W128

GROWING THROUGH SABOTAGE

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ABSTRACT

According to the theory of capital as power, capitalism, like any other mode of power, is born through sabotage and lives in chains – and yet everywhere we look we see it grow and expand. What explains this apparent puzzle of 'growth in the midst of sabotage'? The answer, we argue, begins with the very meaning of 'growth'. Whereas conventional political economy equates the growth with a rising standard of living, we posit that much of this growth has nothing to do with livelihood as such: it represents not the improvement of wellbeing, but the expansion of sabotage itself. Building on this premise, the article historicizes, theorizes and models the relationship between changes in hierarchical power and sabotage on the one hand and the growth of energy capture on the other. It claims that hierarchical power is sought for its own sake; that building and sustaining this power demands strategic sabotage; and that sabotage absorbs a significant proportion of the energy captured by society. From this standpoint, capitalism grows, at least in part, not despite or because of sabotage, but through sabotage.

Keywords: growth, capital, power, hierarchy

ICT2.0:2020-W129

THE PHYSICS OF CAPITALISM

Erald Kolasi

ABSTRACT

Human economies are complex biophysical systems that interact with the wider natural world, and none can be fully examined apart from their underlying material conditions. By exploring some fundamental concepts in physics, we can develop a better understanding of how all economic systems work, including the ways that the energy-intensive activities of capitalism are changing humanity and the planet. This article explains how the fundamental features of both our natural and economic existence depend on the principles of thermodynamics, which studies the relationships between quantities such as energy, work, and heat. In particular, I focus on the relationships between efficiency, technological innovation, and economic growth. A firm grasp of how capitalism works at a physical level can help us understand why our next economic system should be more ecological, prioritizing long-run stability and compatibility with the global ecosphere that sustains humanity.

Keywords: energy, capitalism, efficiency, economic growth

ICT2.0:2020-W130

TELEODYNAMICS: SPECIFYING THE DYNAMICAL PRINCIPLES OF INTRINSICALLY END-DIRECTED PROCESSES

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ABSTRACT

Advances in analyzing the relationship between near-equilibrium thermodynamic processes and far-from-equilibrium self-organizing processes have led to important insights concerning living processes, but have not been able to account for the transition from inorganic to living systems that exhibit intrinsic self-preservation, self-synthesis, self-reproduction, and self-reconstitution in response to damage. In this presentation I will demonstrate that yoked self-organizing processes which generate each others' boundary conditions can produce a form of co-dependent unity that exhibits these properties. This demonstrates that thermodynamic analysis needs to be expanded to include three discontinuous but nested levels of dynamical organization. Each can be defined by three "laws" of transformation — a conservation/symmetry law, a law of spontaneous symmetry breaking and change, and a law of min/max boundary conditions. A simple empirically testable molecular model system is described for exploring these dynamical properties.

Keywords: teleodynamics, self-organization, transformation

ICT2.0:2020-W117

WHY ARE ORGANISMS SO DIFFERENT FROM MACHINES?

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ABSTRACT

The rise of Newtonian mechanics in the 18th and 19th century and quantum mechanics of the 20th century have given us an immense ability to build complex machines and describe their behavior with great precision. But these machines are fundamentally different from organisms. Still, the machine paradigm is often applied organisms, only to find that any modeling of an organism as a machine is essentially incomplete, at best. The machine approach to modeling natural systems has its roots in mechanics and the highly sophisticated technologies that emerged from it. Though mechanics has great success in describing machines, it is questionable if it has the essential elements to describe biological organisms. While it is true that machines can do some of the things organisms do, it would be wrong to conclude that organisms are simply highly complex machines. Indeed, it is legitimate to wonder if there will ever be a Newtonian theory of organism that describes it as a machine.

Thermodynamics, on the other hand, has a very different character. In contrast to mechanics, irreversibility is fundamental to thermodynamics. Though it has its roots in the study of steam engines, it evolved over time to become a science of the natural world, including organisms. It gives us a way of understanding organisms without using the machine paradigm.

Non-equilibrium self-organized systems, called dissipative structures, are clearly a paradigm for organisms because the underlying physical processes that maintain dissipative structures and organisms are the same. These aspects become very clear when we note the fundamental differences between organisms and machines. In fact, dissipative structures can exhibit primitive organism-like end-directed behavior in that they can move to locations that better supply the energy that sustains the structure. Like organisms, they are self-healing: if their structure is disrupted, the processes that generated the structure restores it. Such and other complex behavior of some of the organism-like dissipative structures can be characterized in terms of entropy production. We can now begin to formulate a thermodynamic theory of organism.

Keywords: Non-equilibrium systems, open thermodynamic systems, self-organization, dissipative structures, end-directed behavior, maximum entropy production, machine paradigm

ICT2.0:2020-W135

THE ORIGIN OF UBIQUITOUS PATTERNS

Arto Annila

ABSTRACT

The most comprehensive result of scientific inquiry across disciplines is that data, irrespective of origin, display skewed distributions, sigmoid curves, and power laws as well as oscillations and, at times, chaos. While mathematical models and computer simulations can be made to reproduce these universal patterns of nature, science is not only about modeling and mimicking the data but making sense of it. I argue that these patterns, regardless of scale and scope, follow from the least-time consumption of free energy. These natural processes can be understood by the many-body theory of open systems, i.e., non-equilibrium statistical physics of quantized systems. This theory, also known as the principle of least action in its original form and 2nd law of thermodynamics, explains the arrow of time in terms of flows of quanta that yield non-determinate, multiplicative, and path-dependent evolution, which are characterized the ubiquitous scale-free patterns.

Keywords: atomism, complexity, free energy, the principle of least action, scale-free patterns, the second law of thermodynamics

ICT2.0:2020-W143

WHY SYSTEM DYNAMICS MUST SUPPLANT EQUILIBRIUM MODELLING

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ABSTRACT

Mainstream economics is still dominated by equilibrium methodology. William Nordhaus, the person most responsible for trashing the intellectual standing of system dynamics was awarded that discipline's most prominent prize [1]. Yet economic policy today is dominated by real-world issues that defy its equilibrium, barter model of the economy. The need for system dynamics methods within economics has never been more pressing. I am working to bring this about via several interrelated research projects:

- The development of Minsky [2], an Open Source system dynamics platform with the unique capacity to generate coupled ordinary differential equations describing financial flows using a system of interlocking double-entry bookkeeping tables that we call Godley Tables;
- Developing a realistic foundation for an integrated approach to economics and ecology by incorporating the role of energy in economic models of production, springing from the insight that "labor without energy is a corpse; capital without energy is a sculpture"[3]; and
- Critiquing the appallingly bad work on climate change and economics that Nordhaus and his associates developed in place of the Limits to Growth study.

Though Neoclassical economics developed to defend capitalism against Marx's critique of it, today the main threat to the continued existence of capitalism is Neoclassical economics itself [4]. An alternative paradigm is desperately needed, and it will not come from within economics itself [5].

Keywords: system dynamics, neoclassical economics, Minsky, energy and economy

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ICT2.0:2020-W159

ECONOMIC INEQUALITY FROM A STATISTICAL PHYSICS POINT OF VIEW

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ABSTRACT

Inequality is an important and seemingly inevitable aspect of the human society. Various manifestations of inequality can be derived from the concept of entropy in statistical physics. In a stylized model of monetary economy, with a constrained money supply implicitly reflecting constrained resources, the probability distribution of money among the agents converges to the exponential Boltzmann-Gibbs law due to entropy maximization. Our empirical data analysis shows that income distributions in the USA, European Union, and other countries exhibit a well-defined two-class structure. The majority of the population (about 97%) belongs to the lower class characterized by the exponential ("thermal") distribution, which we recently observed in the data for 67 countries around the world. In contrast, the upper class (about 3% of the population) is characterized by the Pareto power-law ("superthermal") distribution, and its share of the total income expands and contracts dramatically during booms and busts in financial markets. Globally, energy consumption (and CO_2 emissions) per capita around the world shows decreasing inequality in the last 30 years and convergence toward the exponential probability distribution, as expected from the maximal entropy principle.

Keywords: econophysics, entropy, inequality

ICT2.0:2020-W142

ECONOPHYSICS: USING STATISTICAL PHYSICS CONCEPTS TO OFFER INSIGHTS INTO ECONOMIC QUESTIONS

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ABSTRACT

To a physicist, the most interesting thing about economics is that it is dominated by fluctuations in quantities of economic interest. Because big economic shocks affect the economy around the world, the possibility of an economic "meltdown" is one that we must take seriously. Big changes in big money affect not only people with large amounts of it, but also those who have very little of it — those on the margins of society.

Finding ideas that serve to address economic problems can potentially help in making progress on unsolved physics problems. A good example is turbulence. If we take a bucket of water and disturb the surface, energy is added to the system on a big scale. This energy then dissipates over progressively smaller scales. This is an unsolved physics problem; many empirical facts can be stated, but there is incomplete understanding. The economy is analogous to this example of turbulence. One can add information on a big scale to an economic system—e.g., the news of who wins a presidential election—and that information is dissipated on smaller and smaller scales. The way that you handle the "turbulence" associated with this dissipation of information in a financial market may help us understand how to approach turbulence in our physics research.

Keywords: econophysics, statistical physics, economy, turbulence, information dissipation

ICT2.0:2020-W173

A ROADMAP FOR A COMPUTATIONAL AND INFORMATIONAL THEORY OF LIFE

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ABSTRACT

Information plays a critical role in complex biological systems. Complex systems like immune systems and ant colonies co-ordinate heterogeneous components in a decentralized fashion. How do these distributed decentralized systems function? One key component is how these complex systems efficiently process information. These complex systems have an architecture for integrating and processing information coming in from various sources and points to the value of information in the functioning of different complex biological systems. This article proposes a role for information processing in questions around the origin of life and suggests how computational simulations may yield insights into questions related to the origin of life.

Such a computational model of the origin of life would unify thermodynamics with information processing and we would gain an appreciation of why proteins and nucleotides evolved as the substrate of computation and information processing in living systems that we see on Earth. Answers to questions like these may give us insights into non-carbon based forms of life that we could search for outside Earth.

We hypothesize that carbon-based life forms are only one amongst a continuum of life-like systems in the universe. Investigations into the role of computational substrates that allow information processing is important and could yield insights into: 1) novel non-carbon based computational substrates that may have "life-like" properties, and 2) how life may have actually originated from non-life on Earth. Life may exist as a continuum between non-life and life and we may have to revise our notion of life and how common it is in the universe. Looking at life or life-like phenomenon through the lens of information theory may yield a broader view of life.

Keywords: information theory, origin of life, artificial life, thermodynamics, evolution, energetics

ICT2.0:2020-W152

FRISTON, FREE ENERGY AND THE LATE WALTER FREEMAN III

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ABSTRACT

We can work on for the rest of this century assured that Walter Freeman's reputation will continue to grow. By his own testimony, his first run at the fence used the language of linear systems. What was required was a giant leap in abstraction; the use of the language of dynamical systems, with linear models being supplanted by attractors and neural dynamics being implemented by trajectories in state space. This approach culminated in masterful papers about scale-free neural dynamics [1, 2].

So matters remained until he met Giuseppe Vitiello. Initially skeptical – never having seen a quantum in his lab, as he dismissively explained – Freeman began to realize that quantum field theory (QFT) could provide a hospitable formalism for observed neural phenomena like vortices. That was only the beginning; as the last intense collaboration of his life proceeded, he became open to the idea that symmetry breaking begat what were in effect the basins of attraction he had worked with for 30 years. The convergence with synergetics and order parameters he found intoxicating; the next century will perhaps reveal whether he was correct in positing a solution to problems of consciousness and subjectivity in the elliptical and veridical language of QFT.

This giant may be new to many of the attendees of this conference. It is his adaptation of Friston's [3] free energy principle we wish to take issue with it. This is above all to confound informational energy with semantics, a move that Claude Shannon baulked at. This talk will examine why this category error must not be allowed to continue.

Keywords: scale-free neural dynamics, consciousness, synergetics, informational energy

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ICT2.0:2020-W155

THERMODYNAMICS, ECONOMIC EVOLUTION AND GROWTH OF INFORMATION: THE PERSPECTIVE OF PEIRCIAN SEMIOTICS

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ABSTRACT

Relating thermodynamics and human economy has been mainly achieved in the context of explaining economic growth, in two senses: analysing thermodynamic constraints on growth and investigating the role of energy in driving growth. This approach ignores the core feature of growth, which is the generation and accumulation of information (aka knowledge). The possible role of thermodynamics in linking the concepts of energy and information in economics remains neglected. One reason is that the existing physical concepts of information are mostly informed by the Shannon view, which leaves aside the semantic and pragmatic dimensions of information. I argue that a synthesis of thermodynamics and economics must build on a new approach to the physics of information, and I suggest that this can be achieved by semiotics as framed in the philosophy of Charles S. Peirce.

One field that has already contributed substantially to this project is modern biosemiotics, such as in Stanley Salthe's numerous contributions. I elaborated these contributions in my 2013 book *'Foundations of Economic Evolution: A Treatise on the Natural Philosophy of Economics'*. Rethinking causality is pivotal in this endeavour, especially with reference to final causality in evolutionary processes, as Terence Deacon has also argued forcefully. Integrating physics and economics via thermodynamics is impossible without eschewing common exclusive notions of efficient causality. If final causality is recognized as a physical concept, it is straightforward to approach the growth of information as an embodied form of inference mediated by semiosis, along Peircian lines. The modern correspondence in thermodynamics is the Maximum Entropy hypothesis which is employed both as a formalism of inference and as a physical mechanism of energy dissipation. I present a conceptual frame and apply this on a central concept that bridges engineering and economics in technological evolution, 'design'.

Keywords: semiotics, information, knowledge, design, economic evolution

ICT2.0:2020-W150

EXPLORING THE LINKS BETWEEN THERMODYNAMICS AND SOCIAL SCIENCES: THE CONTRIBUTION OF OUR UNDERSTANDING OF SPACE AND TIME RELATIONSHIPS

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ABSTRACT

Enlightened by our experience of the relations between physics on the one hand, thermodynamics and geology on the other, we will begin with some general considerations on the relations that can be envisaged between the different disciplines of knowledge. Depending on the case, one can try to reduce one discipline to a more fundamental one, and aggregate the "simple" models of one to organize the other; analogies can also help to propose models. It is often possible to observe an autonomy of the disciplines with respect to the others. They can cooperate, merge into new disciplines. The notion of law, of initial conditions, the role of contingencies, may differ from one field to another.

We will then focus more specifically on our understanding of the strong link between the concepts of time and space, and the functioning of thermodynamics. The object of thermodynamics is basically to link two levels of understanding of the world, a more microscopic level and a more macroscopic level. Space and time are the other name for the comparison between phenomena, within a relational rationality. They can thus function differently from one level to another. They are given a broader meaning by freezing what is at a lower level in its most probable state (intervention of the entropy function). The choices and agreements necessary for the functioning of relational rationality make us revisit a whole series of notions such as equilibrium, the distinction between work and heat, irreversibility, etc.

In the light of the foregoing, we will make some remarks on some of the relationships that can be seen, under certain conditions, between thermodynamics and social sciences. What energy can be associated with a given social system? Energy cannot be defined on its own but only in a relational way: a variation of energy is in correspondence with a variation of movement. Thus, the question of defining time, space, movement, entropy, etc. for a social system is set accordingly. Some simple examples will be given.

Keywords: thermodynamics, social sciences, space, time, movement, scale, entropy, agreement, work, heat, energy

ICT2.0:2020-W118

THERMODYNAMICS FORMULATION OF ECONOMICS

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ABSTRACT

A simplest case is to consider a group of information-symmetric consumers with one type of commodity in an efficient market. The commodity is fixed asset and is non-disposable. Connection of thermodynamics formulation to microeconomics is our goal of investigation. Caratheodory approach requires empirical existence of equation of state (EoS) and coordinates as initial ground before optimizing some relevant variables. In the procedure of our investigation, we consider and criticize on nature of EoS of various types of system and we unexpectedly discover new insights of thermodynamics, "the effect structure". We define what we dub "truly endogenous function". Effect structure criteria rules and effect structure diagrams are found as criteria in promoting an empirical equation of an aggregated system to a status of EoS. With the rules, EoS in thermodynamics are classified into two classes. Applying the conventional thermodynamics and the new rules to a group of information-symmetric consumers with one type of commodity, we can identify demand-side economics EoS. The price takes a role of intensive variable, demand quantity as extensive variable and consumer's average personal wealth as temperature. The economics EoS is found to be the new class, the Class III. Having explicitly known EoS of the economy and its coordinates lays reasonable assumptions of Hamiltonian and partition function which are central aspects in application of statistical mechanics to economics and finance.

Keywords: demand function, equation of state, thermodynamics approach to microeconomics

ICT2.0:2020-W175

A THEORETICAL TORRICELLI SOCIAL BAROMETER TO MEASURE SOCIAL PRESSURE

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ABSTRACT

An outline of a conceptual 'social barometer' is introduced, based in principle on the Torricelli vacuum (1643), wherein the balancing of the column of mercury against the weight of the atmosphere, is replaced with mercury-like human social species, confined to a mobile volumetrically confined camper or bus of sorts, is moved into and away from various massively large cities, akin to the way Blaise Pascal in 1648 had the idea to carry a Torricelli vacuum to the top of Puy de Dome mountain, to test his prediction that atmospheric pressure, specifically the 'height' of the mercury column in the tube, would decrease as one climbed the mountain. This should, in a predictive sense, translate to the equivalent effect that a working social barometer should show a decrease in social pressure, specifically the 'height' or length of the social mercury system in the social tube should decrease, as one climbs or moves away from large earth-like in social mass cities, like New York or Tokyo.

Keywords: social pressure, social barometer, large cities, social mass

ICT2.0:2020-W133

THE EVOLUTION OF COOPERATIVE BEHAVIOR IN HUMAN

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ABSTRACT

Our civilization has depended largely on cooperation among human beings. However, our science is yet to figure out 'How did cooperative behavior evolve?' This question from 'What don't we know' series from the *Science* journal has been awaiting physical reasoning for a long time. We generalize the classical field theories for an ensemble of human beings and propose a new theory. The social field theory formalizes the energy of an individual in the social field. We underpin this new energy as a physical basis for cooperation among human and the evolution of human society.

A fundamental understanding of why cooperation evolved may have a resounding effect on our understanding of social, political and economic rationale. Indeed, Darwin uncovered some general rationale of the cooperation. However, the science of evolution doesn't provide physical reasoning, and also not adequate for the 21st century human consciousness. Biologists are refining the Darwin's ideas a bit by bit. Here, engineers aspire to uncover cooperative behavior in the terms of energy to be acknowledged by the learned societies. The human cooperation is not much different literally from cooperation that takes place between an electron and nucleons in a model of an atom. It is our consciousness that makes cooperative behavior special among social beings.

Keywords: evolution, cooperation, society, social field theory, energetics

ICT2.0:2020-W101

THERMODYNAMICS FOR EVOLUTION

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ABSTRACT

Modern thermodynamics is based on a canonized assumption that real non-equilibrium systems are constructed from inert elements. They are atoms in statistical thermodynamics, and local or cellular equilibria in phenomenological thermodynamics. In physics and chemistry this works well, but in biology and evolution studies this approach is problematic. The acquisition and maintenance of order in biological systems has been a conundrum of curiosity for many thinkers, including Schrödinger who proposed a controversial quantity - "Negative Entropy" in an attempt to formalize and better understand the complexity and thermodynamics of living systems. As it was perceived that there was no need for such a quantity in physics, the result was a torrent of criticism.

In this talk a holistic approach to thermodynamics will be presented, where the whole non-equilibrium system is characterized by global variables, yielding a new thermodynamic state variable (potential) called extropy that is zero in equilibrium, while in non-equilibrium states it is a measure of order. In this holistic non-equilibrium approach a set of new concepts appear, that are not present in the equilibrium approach. Energy is the sum of internal energy and active energy, the former is characterizing the microscopic state, while the latter is for describing the mesoscopic state. A first law formulated for non-equilibrium systems and the Carnot-thesis gives a general proof for the existence of entropy function.

The non-equilibrium state space has a Riemannian geometry, with a "thermodynamic" distance: the extropy. Extropy is a vector and its direction is important. Talking about biology, thermodynamic condition for survival formulated by extropy gives an inequality, which can be called the second law of living systems.

Keywords: evolution, extropy, non-equilibrium system, second law of living systems

ICT2.0:2020-W134

THE ROLE OF THERMODYNAMICS IN THE CONTROL OF LARGE-SCALE DYNAMICAL SYSTEMS AND NETWORK CONTROL

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ABSTRACT

Due to advances in embedded computational resources over the last several years, a considerable research effort has been devoted to the control of networks and control over networks. Network systems involve distributed decision-making for coordination of networks of dynamic agents and address a broad area of applications including cooperative control of unmanned air vehicles, microsatellite clusters, mobile robotics, battle space management, and congestion control in communication networks. In this presentation, we will present a thermodynamic-based framework for addressing almost sure consensus problems for nonlinear stochastic multiagent dynamical systems with fixed communication topologies. Specifically, we present distributed nonlinear controller architectures for multiagent coordination over random networks with state-dependent stochastic communication uncertainty. The proposed controller architectures involve the exchange of generalized charge or energy state information between agents guaranteeing that the closed-loop dynamical network is stochastically semistable to an equipartitioned equilibrium representing a state of almost sure consensus consistent with basic thermodynamic principles. Furthermore, extensions for the design of semistable protocols over random networks for achieving coordination tasks in finite time are also presented. Finally, we discuss the notion of energy- and entropy-based hybrid decentralized controllers for the control of complex large-scale dynamical systems that guarantee that each subsystem–subcontroller pair of the hybrid closed-loop system is consistent with basic thermodynamic principles. Several illustrative aerospace examples are given to demonstrate the efficacy of the proposed framework.

Keywords: Energy- and entropy-based stabilization, semistability, consensus protocols, distributed control, nonlinear networks, thermodynamic protocols, communication uncertainty, Markov processes

ICT2.0:2020-W132

AUTOCATAKINETICS, THE 4TH LAW OF THERMODYNAMICS (LMEP), AND THE RISE, DEVELOPMENT, AND COLLAPSE OF SOCIOECONOMIC SYSTEMS

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ABSTRACT

Roughly 30 years ago my colleagues and I identified and elaborated the Law of Maximum Entropy Production ("LMEP", or "4th Law of Thermodynamics") as the physical selection principle that accounts for the opportunistic ordering that fills the world around us; a world populated by the origin, development/growth, and collapse of auto-catakinetic systems ("ACK systems") including the origin and evolution of life on Earth. Not long after, my colleague Michael Turvey and I were able to account, with these and additional principles, for the origin and nature of cognitive systems (or sometimes "perception-action systems"); "cognition from first principles"; the two, "the cognitive" and "the living", on this view, being co-extensive. Life was understood as an epistemic autocatakinetic process governed and driven by LMEP. ACK systems (from the non-living to living, to ecosystems at all scales) are characterized by genericity including, for example, the selection of macro from micro, symmetry breaks at origin events from indeterminate micro fluctuations to macrodeterminate ends ("progressive determinism") with reduction of the degrees of freedom of the microcomponents. Such systems tend to get hollowed out, more brittle with size and age ("old") and increasingly vulnerable/unstable (the specific entropy production goes down) to partial or full collapse again from seemingly small perturbations, or micro events. Forest ecosystem succession (or ecosystem succession in general) is an example. A small spark, microscopic infestation can bring the entire end-stage succession forest down. Socioeconomic systems ("cultures", "civilizations") are another example. The principles are briefly reviewed and discussed. It is impossible to avoid looking at the current rapid onset or the COVID-19 pandemic in this context and ask to what extent this is a wakeup call, or to what extent the train has or is pulling out of the station?

Keywords: autocatakinetic system, socioeconomic system, entropy, evolution

ICT2.0:2020-W162

EXPERIMENTAL EVALUATION OF ENTROPY GENERATION EXTREMA IN LOW TEMPERATURE PLASMA CHEMISTRY

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ABSTRACT

The concept of thermodynamic equilibrium has been valuable for predicting the direction of chemical reactions in systems governed by local equilibrium, as well as establishing a theoretical maximum for conversion and yield. Low temperature plasmas are open driven systems characterized by extreme nonequilibrium, wherein chemical species have different temperatures by more than an order of magnitude, at the same location in space. Such systems have been proposed to be governed by superlocal equilibrium, where the new term means temperature is local in both space and species. There are no established methods based upon thermodynamics for predicting the direction and maximum extent of chemical reactions in a low temperature plasma as a function of the state variables. There is an idea from nonequilibrium thermodynamics that a stationary end-state should be reached, for a given set of constrained variables, at which the entropy generation rate reaches an extremum. In systems that operate near equilibrium, it is believed that the unconstrained variables should arrange themselves to minimize the entropy generation rate at the stationary state. On the other hand, for systems that operate very far away from equilibrium, it has been proposed that the unconstrained variables should arrange themselves to maximize the entropy generation rate at steady state. Considering these opposing viewpoints, it is unclear what to expect for chemical reactions in low temperature plasmas. In this work, experimental data, from measurements of chemical reactions in a well-characterized low temperature plasma, will be used to test the two opposing hypotheses for the extremum of the entropy generation rate. The results of this work contribute evidence to the general debate about the entropy generation rate extremum in systems that operate far from equilibrium. The evidence can be used in assessments of the general applicability of the maximum entropy production principle, which has far ranging consequences for nonequilibrium systems such as human societies and the terrestrial environment.

Keywords: Plasma chemistry, superlocal equilibrium, maximum entropy production, nonequilibrium thermodynamics, entropy generation.

ICT2.0:2020-W124

MATHEMATICS OF THE 2ND LAW OF THERMODYNAMICS

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ABSTRACT

In this paper, I have shown the 2nd law of thermodynamics as a consequence of the 1st law of thermodynamics. It is not claimed that the 2nd law of thermodynamics is a redundant of the1st law, rather I shown here how we can extract the 2nd law from the mathematical formulation of the 1st law of thermodynamics. The Clausius statement of the 2nd law of thermodynamics is, it is impossible to construct a device whose sole effect is the transfer of heat from a cool reservoir to a hot reservoir. An alternative statement of the law is, “All spontaneous processes are irreversible” or, “the entropy of an isolated system always increases”. Having strong experimental evidences, this empirical law is obvious, which tells us the arrow of time and the direction of spontaneous changes. I proved the statement in this paper using the mathematical formulation of the 1st law of thermodynamics.

Keywords: thermodynamics, first law, second law, mathematical formulation

ICT2.0:2020-W161

MAXIMUM THERMODYNAMIC EFFICIENCY EVALUATION OF A CONCEPTUAL DIRECT STEAM GENERATION SOLAR POWER PLANT

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ABSTRACT

It has been established for years that comparing the thermal performance of operating power plants under the classical thermodynamic vision with the maximum performance proposed by Carnot; narrows the understanding of the real limit that the power plants present. One of the proposals has been developed by Curzon and Ahlborn, in which the irreversibilities in the heat transfer in the high and low-temperature reservoirs are modeled to approximate the maximum theoretical limit to a more realistic situation. This view of thermodynamics is known as finite-time thermodynamics (FTT) or endorreversible thermodynamics (ERT). This modeling is suitable not only for conventional power plants but also for solar energy conversion processes. The ERT analysis is carried out in a 10 MW conceptual solar thermal plan, located in Agua Prieta, Mexico, which uses Fresnel reflectors under the direct steam generation concept to feed a Rankine cycle with two and three steam extractions.

Keywords: finite time thermodynamics, solar plant, efficiency, direct steam generation

ICT2.0:2020-W158

MANAGING VIOLENT CONFLICTS IN AFRICA: INSIGHTS FROM THE PRINCIPLES OF THERMODYNAMICS

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ABSTRACT

One of the major problems confronting many African states is violent conflict. Several international organizations and scholars have identified different strategies for understanding and curbing the problem yet many African States remain in turmoil. This paper seeks to use a different approach to examine the situation. With the aid of the principles of thermodynamics this paper seeks to answer the following question: What can the principles of thermodynamics reveal about the reasons for violent conflicts in Africa? In what ways does the poor management of violent conflict in a particular African State affect other states in Africa? What specific principles of thermodynamics can be used to understand how violent conflicts can be controlled or prevented from escalation? Some thermodynamics concepts and principles used in this study include; energy, temperature, heat transfer, thermal equilibrium, exothermic reaction, and Zeroth Law of thermodynamics. The findings of the study indicate how insights from the principles of thermodynamics can be used in peacebuilding activities and the prevention of conflict escalation particularly in Africa.

Keywords: Africa, Conflict, thermodynamics, peacebuilding, conflict prevention

ICT2.0:2020-W104

SOCIO-PHYSICOCHEMICAL THEORY ON TERROR & TERRORISM

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ABSTRACT

Terror is interpreted in physicochemical terminology as an oxidant which has the potential to remove or decrease free energy from the reaction/interaction site, thereby inducing oxidative stress, creating explosive situation, increasing entropy or randomness, and completely shifting the equilibrium to targeted side. Terrorism in Socio-Physicochemical terminology is the mechanism by which terror operates; in general it describes transfer/exchange of energy during spontaneous reactions of an oxidant with a target that may or may not be prepared for the shock.

The aftermath of terror is behavioural response to physical and emotional danger. In accord with Newton's 3rd Law of Motion, response to terror is an equivalent but opposite physical force, which implies that terror begets terror in one or the other form. Terrorism generally results in spontaneous decrease of internal energy $-\Delta H°/RT$ (order) and increase in $\Delta S°/R$ (disorder/entropy), both varying with the level of severity and spontaneity of interaction. Hence the free energy minimum (at constant T and P) representing the most satisfactory compromise for sustainable living in a serene environment can be attained by maintaining the natural balance between enthalpy and entropy. Now that the different factions in the ΔG deficient countries are in conflict with one another, the order in their society has decreased to disorder and chaos leading to what appears as going into decadence. The status of compactness of the better ordered social system is put to stake.

Application of the Universal Law of Equilibrium to terrorism suggests that on incidence of terror the terrorized prepares for and is in readiness for defense. This action is due to the realization that terror will sooner or later beget terror and hence there will be an urgent need for readjustment. Restoration of equilibrium is generally sought by considering offence as the best defense. That however has been found to set a vicious circle in motion and instead of annihilating or even containing the impact of terrorism, the vicious circle remains in perpetuation.

Keywords: socio-physicochemical theory, society, terror, terrorism

ICT2.0:2020-W139

THE AMERICAN CIVIL RIGHTS MOVEMENT AND SPECULATIONS ON POLITICAL THERMODYNAMICS

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ABSTRACT

In 1956, state legislators in Montgomery, Alabama, stung by the ongoing boycott against racial segregation on the city's buses, passed a law stating that white and black players or spectators were prohibited from playing or sitting together at "any game of cards, dice, dominoes, checkers, baseball, softball, basketball, football, track, or in swimming pools, lakes or ponds, or on any beaches". The success of the boycotters in desegregating buses later that year marked the beginning of the American Civil Rights Movement and the beginning of the end of egregious racist practices like those sanctioned by the state's lawmakers.

This essay seeks to demonstrate how the political transition from the strictures of Jim Crow culture to one of greater racial equality can be interpreted in thermodynamic terms – and to offer in the process one example of how it is possible to bridge the two-cultures divide between the physical sciences and political science. Operating variables shared across political and thermodynamic systems include degrees of self-organization and disorganization, openness and closure, unpredictability and predictability, and distance from equilibrium. Jim Crow closure denied to blacks myriad avenues of participation in society, pressing them toward a predictable, stifling equilibrium, having ultimately a socially and politically disorganizing or entropic effect. The civil rights protest movement moved American society away from the Jim Crow equilibrium, producing a bifurcation or restructuring crisis, ultimately opening previously denied social and political options for the black community, enabling greater self-organization not only for blacks but for the broader polity as it discovered benefits in interracial collaboration.

Keywords: power-over, disorganizing, entropic, power-with, self-organizing

ICT2.0:2020-W167

THE THERMODYNAMICS OF AUTONOMOUS HUMAN-MACHINE TEAMS (A-HMT): CONTROL OR GOVERNANCE?

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ABSTRACT

In late 2018, a "formidable" Russian base in Syria was attacked by a "highly sophisticated" swarm of drones; Russian soldiers were killed and aircraft destroyed, but Russia denied deaths occurred, and the U.S. denied involvement. The drones in this attack were thought to be controlled individually over a long distance by humans guided by GPS. More autonomous drones can control themselves like a flock of birds without a leader or following one. But as full autonomy for machines is realized for a human-machine team working together to solve problems confronted by uncertainty, the team will begin to face the same issues of control human teams experience.

Control has been a part of the human-centered design (HCD) that has dominated Systems Engineering for over two decades; HCD, known as "human in the loop," is the preferred process for Systems Engineering. But human centered activities may not be independent, even for simple acts like driving a car, making HCD once thought to be harmful. Looking towards the future, autonomous systems are considered potentially harmful. For HCD, a common refrain is that "we must always put people before machines, however complex or elegant that machine might be." Autonomy raises the bar. In the U.S.,"Lethal autonomous weapon systems (LAWS) are a special class of weapon systems that use sensor suites and computer algorithms to independently identify a target and employ an onboard weapon system to engage and destroy the target without manual human control of the system." This concept of autonomy is known as "human out of the loop" or "full autonomy."

With their goal of control, by rejecting the cognitive model, physical network scientists and game theorists have dramatically improved the predictability of behavior in situations where beliefs are suppressed, in low risk environments, or for economic beliefs under certainty, but the predictability by these models fails in the presence of uncertainty or conflict, exactly where interdependence theory thrives; e.g., the interdependent effects in debating the possible tradeoffs to choose the next path. Facing uncertainty, debate exploits the bistable views of reality that exist to explore interdependently the tradeoffs that test, or search, for the best paths forward. Generalizing, reducing uncertainty for a system necessitates that human and machine teammates are both able to explain however imperfectly each other's past actions and future plans in causal terms.

In that no single agent can determine social context alone, resolving uncertain contexts requires a theory of interdependence to build and operate safely and ethically A-HMT systems. The best science teams are interdependent. A team's intelligence is its interdependent interactions among its teammates. We extend these findings to the open-ended debates that explore tradeoffs seeking to maximize a system's production of entropy (MEP) in highly competitive uncertain environments.

Finally, human teams cannot be controlled in the technical sense of controlling a swarm of drones. We generalize this insight to conclude that the control of teams must give way to governance.

Keywords: traditional rational theory, interdependence theory, control, governance

ICT2.0:2020-W184

COLLISION DYNAMICS AND WHY THE ENTROPY "DEAD STATE" IS NOT UNIFORM

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ABSTRACT

When two volumes of gas at different mean temperatures are mixed the first law allows us to predict the final temperature and the resulting entropy generation. To all intents and purposes the resulting system has reached a new equilibrium and one could be forgiven that all the particles making up the gas are now travelling at the same uniform speed. The reality is however that, no matter how long we wait, there will still remain considerable temperature (velocity) disparities between individual gas particles. This distribution has been described by Maxwell's law which is invariably derived at a macroscopic statistical level. This paper describes a 2D particle, dynamics investigation of this velocity distribution and highlights how it is the very nature of the interaction of particles traveling in straight line motion with curved spherical 'surfaces' which results in the non-homogenous velocity distribution. Indeed it can be shown that individual collisions at the microscopic level result in "entropy destruction" as well as creation in order to keep this steady state velocity distribution. The implications of this on the definition of entropy and at the equilibrium position are also discussed.

Keywords: entropy, Maxwell velocity distribution, particle collision dynamics

ICT2.0:2020-W125

NETWORK THERMODYNAMIC ANALYSIS OF PROTEIN AGGREGATION

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ABSTRACT

The formation of A-beta fibril plaques in the human brain has been widely studied and considered important in the pathogenesis of Alzheimer-disease (AD). Low-molecular weight A-beta oligomers are however; now thought to be a primary precursor in early AD affected brains. Prior conjectures and new experiments emphasize the interaction between A-beta and fatty acids which catalyzes an alternative, off-pathway aggregation mechanism. These off-pathway aggregates are being singled out as especially related to AD. In our theoretical study, we aspire to better understand the origins of the off-pathway kinetics and explore ways to control their aggregation. To such ends, we develop a reduced order chemical network model which captures the essential biophysical traits of the on- and off-pathway aggregation processes. We employ a game-theoretic approach to the mass-action based complex dynamical system representing the evolutions of the various species. Numerical computations of the system help us determine the conditions under which like species in each of the pathways dominate which are aptly represented using a phase diagram. A very useful outcome of this phase analysis is the identification of specific reaction topologies along which the dominant reactions occur. Of the eight identified four end up as on-pathway fibrils while the other half end up as off-pathway fibrils. The question we wish to address next is seek out interventions which can help change some of these outcomes, i.e. change network topologies to terminate in an on-pathway. This is mathematically performed by means of seeding by appropriate oligomers and fibrils which is seen to significantly change the observed phases. The presentation will provide details of the seeding studies and the favorable interventions. By varying the parameters and studying their interplay we can determine regimes where pathologically preferential pathways are dominant. The network complexity gives rise to intense dependence on parameters and initial conditions. One further focus of our study is in the thermodynamic properties of our network. We examine quantities integral to the underlying chemical networks like free energy. The tools of classic network thermodynamics help us better understand the stability of the network models.

Keywords: network thermodynamics, game-theory, protein aggregation

ICT2.0:2020-W131

EVOLUTIONARY LOSS AND REGAIN OF GENE NETWORK FUNCTION

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ABSTRACT

Natural or synthetic genetic modules can lose their biological function over long-term evolution if that function is costly. How populations can evolve to restore such broken biological function is poorly understood. To test the reversibility of evolutionary breakdown, we use a synthetic positive-feedback (PF) gene circuit integrated into haploid Saccharomyces cerevisiae cells. In previous evolution experiments, mutations in a gene eliminated the fitness costs of PF activation, corrupting gene circuit function. Since PF activation can provide drug resistance, we grew such corrupted mutants in both drug and inducer, imposing selection to develop drug resistance and possibly regain PF function. We observe three distinct adaptation scenarios with or without repairing lost gene circuit function. The data suggest unexpected interactions between intracellular gene network dynamics and evolutionary dynamics. These results highlight how an evolutionary parameter, such as the growth rate, can connect regulatory network dynamics with evolutionary dynamics, which has important consequences for understanding the evolution of drug resistance and developing future synthetic biology applications.

Keywords: evolution, gene circuit, positive feedback, bistability, regain of function

ICT2.0:2020-W165

CAPITAL, WORK AND ECONOMIC VALUE IN THE CONTEXT OF THE FIRST AND THE SECOND LAW OF THERMODYNAMICS

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ABSTRACT

In the economic sciences, the duality principle applies, according to which economic objects are perceived as material assets and the abstract capital embedded in them. There is, therefore, a strong analogy with the natural sciences, where the matter-energy paradigm applies. So, objects like cars are assets, and their capital represents the ability of these cars to transport. Similarly, man has his material organism (body), but his ability of doing work, or human capital, is important. Capital is a potential category, and its dynamic aspect is manifested in work - the transfer of capital to work objects. Assets experience depreciation, which is associated with random and spontaneous dispersion of the capital inherent in them. In the case of human capital H(p), research leads to the conclusion that the rate of this loss has an average value of p = 0.08 [1 / year]. The hypothesis that the W (p) wage that compensates for this loss is fair is also confirmed. The formula W (p) = p x H (p) is the universal principle of fair remuneration and is applicable in the USA as well as in Poland, Ukraine, Kenya and Malaysia. Wherever there is a measurement of living costs and labor law. The constant "p" represents the influence of natural forces in the creation of human capital and profits from economic activity. It is the emanation of the second law of thermodynamics and determines the average rate of dispersion of human capital. This way of thinking leads to a reevaluation of many economic concepts, pointing to the complementarity of capital and labor.

Keywords: thermodynamic laws, economic constant, human capital, fair wage, duality principle.

ICT2.0:2020-W122

THERMODYNAMIC LAWS FOR MEASURING HUMAN CAPITAL AND DETERMINING FAIR REMUNERATION

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ABSTRACT

Thermodynamics enables a deeper understanding of the nature of capital and understanding the complementarity of the capital and labor categories. It allows to move away from the well-known in economics but mistakenly contrasting capital and labor, while capital is perceived incorrectly as machines, devices or money. Capital and energy share a common phrase - an abstract ability to do work. The second law of thermodynamics in the basic formulation derived from Sir Kelvin is indispensable in economic considerations, because the human body has the characteristics of a heat engine, and therefore experiences spontaneous and random energy loss. Empirical studies have revealed that this loss is determined by 0.08 [1/year]. Therefore, compensation for this loss in the form of pay for work is the main idea of a fair pay system. The purpose of the study is to present the framework of the remuneration system set by the principles of thermodynamics and the principle of minimal action. In these studies, 0.08 [1/year] acquires the characteristics of a natural constant that allows the calculation of human capital and fair pay.

Keywords: thermodynamic laws, economic constant, human capital, fair pay.

ICT2.0:2020-W103

A PHYSICAL BASIS OF ECONOMICS

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ABSTRACT

At the beginning of economics, work and cooperation appear, which leads to better efficiency of human activities. Therefore, understanding the work and its measurement as well as scientific sharpening of the concept offered by physics is the first step to the integrity of the foundations of economics with the natural sciences. The basis for the transfer called work is the potential category of work ability, i.e. energy in science and capital in economics. Therefore, work and capital are not opposed as the classics said, but complementary. Further logical reasoning leads to a set of basic economic concepts such as value, money, assets and fair pay.

The second element integrating economics and science is associated with taking into account the forces of nature. Long-term considerations about capital, profits, interest rates and rates of return have not brought the final results so far. Can the explanations given be complete if the effects of sun rays and photosynthesis on economic processes are ignored? It can reasonably be assumed that a natural constant will appear in this field that will allow quantifying the impact of nature on the economic effects of human activity. It will also allow to estimate energy loss in the human body determined by the second law of thermodynamics, which must be compensated by an appropriate remuneration to maintain existence.

The integration of economics and sciences also requires understanding that the scientific categories in physics and economics are abstract and subject to the fundamental principles found by nature researchers. Energy and work are abstract categories, so in economics capital, value and money must be understood in a similar way. Therefore, constructive mathematical concepts are essential to describe these scientific abstract categories.

Keywords: labor, capital, thermodynamic, economic constant, photosynthesis

ICT2.0:2020-W127

MONEY TO CAPITAL?

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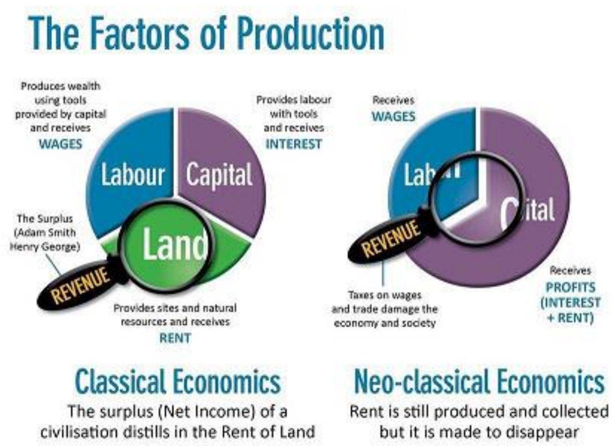
ABSTRACT

Capital involves risks and creates jobs. Accumulating money on the balance sheets does not. Capital and money are very different economic concepts, but both are decisive accounting and measurement categories for investment. Money (cash) can buy physical (capital) and non-physical assets (labor), but value and wealth creation always happens with investment into labor and capital.

Taxes on wages and trade damage the economy, society and entrepreneurship. In neo-classical economics, rent (from natural resources and locations) is still collected, but it is made to disappear on the balance sheets; interest and rent are simply counted as one single source of profit.



The investment circuit and cycle reads money into capital and capital into money, by increasing the amount of monetary profit on the statistical and dual balance sheet. Nature or land value (resources and locations) do not exist in this accounting principle. This economic duality and dialectics of accounting money to capital is the driving principle of neo-classical accounting techniques.

Keywords: money, capital, dialectics, accounting, investment, accumulation, risk.

ICT2.0:2020-W112

A PATH FROM EQUILIBRIUM TO NONEQUILIBRIUM THERMODYNAMICS

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ABSTRACT

In the last decades new ideas have arisen in thermodynamics as a consequence of the advances in the applications of dynamical systems theory and results to evolution of macroscopic systems. A key question is whether it is possible to extend the domain of thermodynamics from a general theory of relations between equilibrium states to the much more general analysis of relations and properties of stationary states arising under steady forcing of mechanical systems in contact with heat reservoirs. The familiar description of equilibrium via probability distributions (like the microcanonical ensemble) which predicts relations between observables extending the ones of classical thermodynamics has been widely extended and under general assumptions an extension of the theory of ensembles has been proposed. The new theory contains classic thermodynamics, as derived from statistical mechanics, as a special case: it relies on 'chaos' and raises important questions that are still debated: is there a suitable extension of the 'entropy', are there universal relations that can be theoretically predicted?

Keywords: equilibrium, nonequilibrium, system theory, evolution, thermodynamics

ICT2.0:2020-W172

HOMEOKINETICS AND SOCIAL PHYSICS

Thea Iberall

ABSTRACT

In the 1940s, while working on problems in exobiology, Arthur Iberall began observing an area that physics has neglected, that of complex systems with their very long internal factory day delays. He was observing systems associated with nested hierarchy and with an extensive range of time scale processes. With Harry Soodak, Iberall was able to turn keen observations and insights into a new field of the physics of complex systems. They called it homeokinetics. It was such connections, referred to as both up-down or in-out connections (as nested hierarchy) and side-side or normal physics among atomistic-like components (as heterarchy) that became the hallmark of homeokinetic problems. By 1975, Iberall and Soodak began to associate them with nature, life, humankind, mind, and society.

Social physics, in a homeokinetic sense within a nested hierarchy, is the study of the physics of groups, colonies, settlements, political units, civilizations engaged in trade and war, as well as of the history, development, and evolution of species, including the human. As large structure social time scales, Iberall and colleagues have identified various time scales of the atomisms that are part of social physics, such as the 4 hour scale of biophysical organization of the individual person (the scale for chemical thermodynamic near equilibrium), upwards to the time scale of political command-control with some added complexity for the economic scaling of the very general trading process and/or war process.

All fields, at their bottom, are atomistic-like. Thus, the key homeokinetic problem is how the bottom collective structure and functions is connected to the functionally remote character of the top collective.

In this talk, we will present an overview of key concepts of homeokinetics and then outline how a homeokinetic analysis can identify the factory day of a social system. Conservations emerge from the factory day. Each factory day or level has to be attended to by its physics, by its conservations. As one runs through the entire gamut of such factory days, one finds an entire cascade spectrum of energetic processes. Energy flows through, transforms level to level.

Keywords: homeokinetics, social physics, hierarchy, factory day, conservations, energetics

ICT2.0:2020-W183

LIVING UNIVERSE AND HIERARCHICAL THERMODYNAMICS

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ABSTRACT

The desire for simplicity - the only basis of generalization allows us to create a model of life (existence) of the universe at all hierarchical levels. This model, using a broad understanding of life, is an extended Darwinism - the physical foundation of which is hierarchical thermodynamics, governed by the principle of substance stability. The evolution of the universe is a combination of the numerous cyclic transformations of matter and energy at all hierarchical levels of transformation occurring against the background of a constant change in the physical parameters of evolving systems. Life in this broad sense of the term proceeds at almost infinite disparate speeds in different-scale structural hierarchies, consisting of clusters of galaxies, galaxies, planetary systems, geological objects, clusters of chemicals, biological organisms, environmental, social and other systems.

The broad definition of life used in the present work, significantly different from the concept of "biological life". Biological life takes place in a relatively narrow range of temperatures, pressures, and other physical parameters. It is a relatively narrow concept, distinguished by its internal multi-hierarchy and almost endless evolutionary diversity, which significantly distinguishes it from other forms of life in the universe. Undoubtedly, purines and pyrimidines, the “main building blocks” of biological life, which are thermodynamically stable at high temperatures, will be found in stellar atmospheres. Other fragments of nucleic acid chains also exist in temperature and pressure zones, where they are relatively thermodynamically stable. It should be noted that the existence of nucleobases, other fragments of nucleic acids, as well as fragments of many biomolecules found in space. Thus, it can be argued that the "molecular bricks of biological life" move in the required quantities from zones of their relatively thermodynamic stability to zones acceptable for the origin and development of biological life. Further, biological life evolves according to the well-known Darwinian scenario. Hierarchical thermodynamics, as the driving force of evolution, does its job at all levels of the hierarchical structures of universe, supporting the life of the universe.

Keywords: evolution, life, biological life, universe, hierarchical thermodynamics

ICT2.0:2020-W136

EMERGENCE OF ORDER AND DISORDER FAR-FROM-EQUILIBRIUM: A FUNDAMENTAL FRONTIER IN THERMODYNAMICS AND CONDENSED MATTER PHYSICS

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ABSTRACT

Equilibrium Thermodynamics and Statistical Mechanics that underpins it, is a triumph of 19th century physics. The framework explains equations of state, phases and phase transitions, critical phenomena, and universality classes just to name a few of its successes. However, despite this profound advance in our understanding of the universe around us, it cannot address behavior of systems far-from-equilibrium and yet, such systems display a myriad of organizations and order that emerge spontaneously. Such order (and the complimentary disorder) are seen systems from hard to soft condensed matter and extend into the biological world. This talk will review some representative systems that cover this breath of emergent behavior and will attempt to define some of the more outstanding questions to be answered for the next revolution in thermodynamics.

Keywords: equations of state, organization, order, emergence, statistical mechanics, thermodynamics

ICT2.0:2020-W176

THERMODYNAMICS, HUMANITIES, AND ART

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ABSTRACT

What is the relationship between thermodynamics and humanities, and art? There is mutual influence between these "cultures". What is the meeting point in them? We speak about interdisciplinary and humanitarian thinking, enrichment, "beautifying" and "philosophizing" of thermodynamics. The aim of this work is to show how humanitarian aspects, in particular art, music, poetry, philosophy and humor can help in learning and understanding of thermodynamics.

The way to reach this aim is a demonstration the young generation of educators, scientists, engineers and students that the application of humanitarian aspects in teaching, learning, education and our very existence may be more interesting, fascinating, creative, productive, exciting, attractive, and as a result beautiful and "rich". The examples of the use of different arts (music, painting, poetry etc.), history, philosophy and humor in the curricula and teaching of thermodynamics are shown. Special attention is given to thermodynamics of love. Students and young scientists/engineers who learn the subject of thermodynamics with the use of humanitarian aspects including philosophy and humor manifest more creativity, inspiration, passion, and satisfaction in their job and life, and as a result, are happier.

Keywords: thermodynamics, humanities, art, education

ICT2.0:2020-W157

IS NATURE ILL-POSED COMPLEX HOLISTIC OR WELL-POSED QUANTUM REDUCTIONIST?

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ABSTRACT

While the last centuries have been intellectually dominated by the well-posedness of the quantum world with its own “(EPR) paradoxes”, “(Copenhagen) interpretations” and “(measurement) problems” leading for example, to dropping of blow-up inconveniences, the actual absence of infinities in the natural world prompts the conjecture that this paradigmatic neglect might well be instrumental for the inability of a reality check in the dynamics of Nature to accommodate such niched inconveniences, with 2 and 2 admitting a possible 22 rather than the superpositional 4. The resulting ill-posed complexity has a language and bearing of its own, as distinct and characteristic as well-posed superpositions. This research is dedicated to the new ill-posed complex macro science of the 21st century of climate-change, global warming, multiplicities, contradictions and niched blow-up inconveniences of smooth well-posedness.

What impact is coronavirus likely to have on the climate emergency? With threat to planet Earth overshadowed by the pandemic, the world will nonetheless have to grapple with the standing threat of environmental degradation. Indeed, the spotlight is on man’s troubling relationship with Nature --- the degradation and exploitation of Nature being largely responsible for the corona, the World Bank having predicted a possible rerun of the Great Depression of the 1930’s, all efforts now ought to be focused on renewable energy and low-carbon infrastructure.

The renewed shock of human vulnerability in the face of Covid-19 will doubtless usher in an increased realization of global interconnected perils of macro sustainability and climate change. With postponement of the crucial UN biodiversity schedule it is imperative not to live on borrowed times and continue to hope for the best. There is no honourable soft exit strategy for our planet.

Keywords: well-posedness, climate-change, dynamics of Nature, sustainability

ICT2.0:2020-W151

SPIKE BASED COMPUTING ON SELF ASSEMBLED LIPID MONOLAYERS

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ABSTRACT

A new physical platform inspired by the physics of biological neurons is presented, which will allow testing and implementing thermodynamically optimized computing schemes at the hardware level. While the remarkable energy efficiency of neuronal processes is inspiring the next generation hardware, the physical basis of this efficiency within neuroscience is surprisingly a matter of debate. The electrical spikes in neurons, also known as action potentials, are believed to be purely electrical phenomenon. The standard model of the phenomenon assumes that the information, in the form of a spike, travels via directed mass transfer or diffusion as it irreversibly depletes an electrical gradient across the outer membrane of a neuron. However, recent research strongly suggests that information can also travel in such systems, i.e. the outer membrane of a neuron, via momentum transfer, a reversible process similar to the propagation of sound.

Such spikes have now been realized experimentally as two-dimensional nonlinear sound waves that propagate within single molecule thin films of lipids, which provide the physical basis for the new computational platform [1]. These waves can mimic all the computationally relevant properties of spikes in neuron, such as a threshold for excitation, solitary wave propagation, its dependence on environmental variables like pressure and temperature, and annihilation of spikes upon collision. The lipid monolayers that support the phenomenon are extremely robust and quickly self-assemble at the air/water interface and provide a practical platform to develop brain-like computing. The device operates at energy and timescales comparable to real neurons, and is also highly scalable as the platform employs nonlinear wave mechanics in a planar continuous medium, which allow for massively parallel computing. Furthermore, as the phenomenon occurs at a material phase transition in the lipids, the platform provides unique capabilities to implement self-organized criticality (SOC) and momentum based optimization, as well as dissipation based learning at the hardware level.

Keywords: self-organized criticality, SNN hardware, 2D materials, shock waves, avalanches

Reference

[1] Shrivastava, Shamit, and Matthias F. Schneider. "Evidence for two-dimensional solitary sound waves in a lipid controlled interface and its implications for biological signalling." Journal of the Royal Society Interface 11, no. 97 (2014): 20140098.

ICT2.0:2020-W160

EXPONENTIAL TAILS OF COVID-19 CASES ARE MODULATED BY DAYLIGHT HOURS

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ABSTRACT

The environmental factors that affect Covid-19 are not apparent yet. There is an urgent need to elucidate them, especially if we want to anticipate a more than likely second hit. While some researchers speculate than heat indexed by the average temperature and humidity indexed by the average percentage of vapor water in the air may affect viral spreading, results are not conclusive. This work aims to shed light on this topic of substantial interest in everybody's life. Over the last weeks, we have taken publicly available data from Ireland and fitted a plethora of mathematical models. Strikingly, the independent variable that shows the most substantial influence on the number of cases since Ireland reached the maximum is daylight hours.

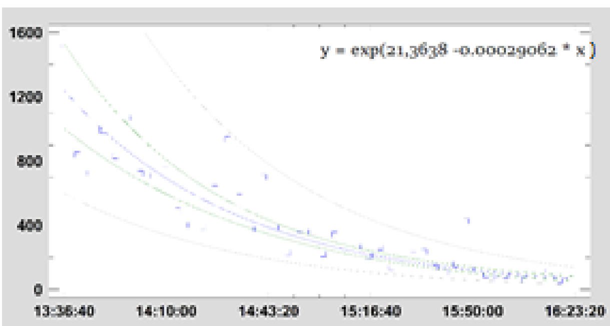

Figure 1: Case number versus daylight hours in Ireland

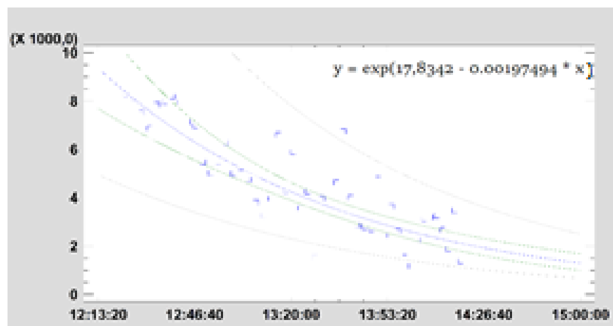

Figure 2: Case number versus daylight hours in Spain

While findings are preliminary, the variance explained by daylight hours is humongous. The model itself explains about 90% of the variability in the number of cases. Interestingly, this statistical significance seems to be consistent in other European countries such as Spain, with the exponential coefficient converging to the same value as the one estimated in Ireland.Importantly, the fitted responses are independent of the number of inhabitants of each country but show a significant relation with daylight length.We stress that we should take these analyses with caution. Especially now that national governments for different reasons are updating the reported values on a day-by-day basis; however, the statistical significance is very high and seems to point out that daylight length has a substantial impact on viral spreading.

Keywords: COVID-19, environmental factor, daylight hours, Ireland, Spain

ICT2.0:2020-W180

GENERALIZING STATISTICAL MECHANICS

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ABSTRACT

Gibbs' approach to thermodynamics used information theory to derive its laws directly from the canonical distribution. Gibbs' formalism is much more general in its application than simply describing classical or quantum mechanical systems. It is not mechanic in nature, it is information theoretic in nature. Its generality allows the description of the time evolution of our knowledge of a system.

To demonstrate the generality the paper begins with the log-normal distribution. This distribution appears throughout nature and human systems. It can be used to express our knowledge of species distribution, income distributions, crypto currency transaction distributions, particle size distribution, etc. Because of its ubiquitous nature, taking a closer look through Gibbs' lens can provide some profound insights into the world around us.

This paper will derive the second law expression for a multivariate log-normal distribution using an adaptation of Gibbs' method. From here, we will derive the equation of state that is the expression of the multivariate log-normal distribution. Next, we will contrast conventional macro-economic theory with this expression of a system of people and show that entropy is the missing factor in macro-economics. To test this, we will apply this to the Bitcoin blockchain and show how to practically estimate an equation of state in a complex economic system. We will see that entropy is not disorder as is conventionally described and communicated. It is, instead, simply a measure of a system's complexity.

Keywords: entropy, information theory, statistical mechanics, economics, log-normal, bitcoin, income inequality, Cobb-Douglas production function, Keynes' General Theory

ICT2.0:2020-W123

NEW DEVELOPMENTS IN AGENT-BASED MODELS OF WEALTH DISTRIBUTION

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ABSTRACT

Agent-based models of wealth distribution, employing simple, idealized binary transactions between pairs of agents were first proposed in the 1980s, and methods of statistical physics have been applied to their analysis since the turn of the century. This presentation will describe one such model, the recently developed Affine Wealth Model, that (i) demonstrates remarkable agreement with empirical wealth data, (ii) exhibits rich phenomenology, including a second-order phase transition to a wealth-condensed state, (iii) sheds new light on the precise nature of oligarchy and the role of chance in wealth accumulation, (iv) is predictive of measurable quantities such as upward mobility, agent flux, and wealth flux, and (v) suggests new empirical tests of microeconomic theory.

Keywords: wealth distribution, wealth inequality, agent-based models, asset-exchange models, upward mobility, wealth condensation, oligarchy, microeconomic theory

ICT2.0:2020-W144

DEVELOPMENT OF ECONOPHYSICS AND ITS TIMELINE

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ABSTRACT

The interdisciplinary fusion of statistical physics and economics, leading to the development of econophysics will be discussed. A brief sketch of its development timeline up to year 2000 and beyond year 2000 will be presented on several important advances based on a selected list of published papers, reviews, books, popular reports.

Keywords: econophysics, economics, statistical physics, development timeline

ICT2.0:2020-W156

SOCIAL ENTROPY OF WEALTH ACCUMULATION AND RESOURCE IMPOVERISHMENT

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ABSTRACT

Development processes aiming to improve the quality of life and inculcate superiority complex, invariably consume the internal resources and cause their irreversible depletion in the ecosystem. Since $\Delta H << T\Delta S$, all activities requiring external energy input are entropy-driven. Development activities being exploitative in character will use up available resources, irreversibly transform them (internal energy ΔH into another form and increase the entropy; they reduce the ΔG, the driving force of the system and push the (Earth's) resources to impoverishment and the unprivileged stakeholders to the poverty line. They additionally induce impoverishment of resources, and alter the order and quality of socio-physicochemical structures. Accordingly the exploiting community skims out as the main beneficiary and emerges as the top of the status pyramid.

Affluence and poverty have assumed new dimensions in that the rich with its entropy-driven manipulative skill is in a better position to transform the resources into available and unavailable forms. Technology has the potential to induce oxidative stress. As such development of the capacity to apply technology sets the driving force ΔG and uses the internal energy ΔH; there is accompanying increase in entropy in the meantime. The lust to avail higher capacity to apply technology and become rich is entropy driven. Going by Forbes data for 2015, it is noted that the race of the rich to become richer has entailed rapid increase of entropy, which in turn has resulted in uneven class structure.

Keywords: resource, wealth accumulation, social entropy, society

ICT2.0:2020-W171

UNIFIED MECHANICS THEORY: UNIFICATION OF THERMODYNAMICS AND NEWTONIAN MECHANICS

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ABSTRACT

The field of classical mechanics is based on Sir Isaac Newton's work in "The Principia," published in 1687. In this work, Newton introduced the world to three universal laws of motion, which describe the relationships of any object, the forces acting upon it and the object's resulting motion. It is these three laws that make up the foundation for classical mechanics, and all subsequent theories of mechanics are derived from them. However, Newtonian mechanics still cannot account for the past, present or future of any aspect of a physical body or its governing equations.

Around 1850, Rudolf Clausius and William Thomson (Kelvin) formulated both the First and Second Laws of Thermodynamics. Because the field of thermodynamics governs the past, present and future of all physical bodies, the aging process and life span of any physical system can be modeled in accordance with the thermodynamics laws. Still, thermodynamics alone cannot convey the response of a physical body under an external force at any given moment – something classical mechanics equations are able to achieve.

Over the last 150 years, many unsuccessful attempts were made to unify the fields of classical mechanics and thermodynamics, in order to create a generalized and consistent theory of evolution of life span of inorganic and organic systems. All past attempts to unify Newtonian Mechanics and Thermodynamics were based solely on the use of curve fitting to physical experiments, and empirical models. Unified Mechanics Theory unifies laws of Newton and Thermodynamics using entropy generation rate with following equations,

$$F = m\,\frac{d[v(1-\Phi)]}{dt} \qquad and \qquad F_{12} = \,[k_{21}(1-\Phi)]\,u_{21}$$

Where Φ is a Thermodynamics State Index (TSI) can have values between zero and one. TSI is directly calculated from the thermodynamic fundamental equation of the system, which includes all entropy generation mechanisms.in the material/system, without curve fitting and/or life prediction testing.

Unified Mechanics Theory can predict the degradation, fatigue and fracture of any physical system based purely on mathematical calculations and without the need for testing or curve fitting phenomenological models. In this presentation, recent advances in Unified Mechanics Theory will be presented.

Keywords: evolution, Thermodynamics, Newtonian Mechanics, Entropy, Life Prediction

ICT2.0:2020-W106

THE FOURTH LAW OF THERMODYNAMICS: THE IRREVERSIBLE COMPONENT OF NONEQUILIBRIUM TIME EVOLUTION IS CHARACTERIZED BY A (DISSIPATIVE) METRIC FIELD WHICH DEFINES THE DIRECTION OF STEEPEST ENTROPY ASCENT

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ABSTRACT

When thermodynamics is understood as the science (or art) of constructing effective models of natural phenomena capable of capturing the essential features of the physical reality of interest, the scientific community has identified a set of general rules that the model must incorporate if it aspires to be consistent with the body of known experimental evidence. Some of these rules are believed to be so general that we think of them as laws of Nature, whose "greatness" derives from their generality, such as the great conservation principles and the second law of thermodynamics. In Ref. [1] we show that, in the past four decades, an enormous body of scientific research devoted to modeling the essential features of nonequilibrium natural phenomena has converged from many different directions and frameworks towards the general recognition (albeit still expressed in different but equivalent forms and language) that another rule is also indispensable and reveals another great law of Nature that we propose to call the "fourth law of thermodynamics." We state it as follows: every nonequilibrium state of a system or local subsystem must be equipped with a metric in state space with respect to which the irreversible component of its (local) time evolution is in the direction of steepest entropy ascent compatible with the (local) conservation constraints. In this presentation I will propose that, to qualify as "thermodynamic," a model of social, economic, human, biological, evolutionary behavior must conform to the fourth law.

Keywords: evolution, nonequilibrium, irreversibility

Reference:

[1] G.P. Beretta, The fourth law of thermodynamics: steepest entropy ascent, arxiv.org/1908.05768

ICT2.0:2020-W114

MULTISCALE THERMODYNAMICS: A THEORY OF RELATIONS AMONG MESOSCOPIC DYNAMICAL MODELS OF COMPLEX SYSTEMS

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ABSTRACT

Thermodynamics in a general sense [1],[2] is a theory of relations among mesoscopic dynamical models of complex systems. Models involving less details are related to (are reduced from) models involving more details. The reduction process is a pattern recognition process in which the phase portrait (collection of solutions) of the reduced model is recognize as a pattern in the phase portrait of the model involving more details. Thermodynamics is thus a meta-physics since it is a theory of theories. Reduction of a mesoscopic dynamical theory to equilibrium thermodynamics brings to the latter theory the fundamental thermodynamic relation (i.e. entropy as a function of the thermodynamic state variables). The reduction is made by following the mesoscopic time evolution to its conclusion, i.e. to fixed points at which the time evolution ceases to continue. The approach to fixed points is driven by entropy that, if evaluated at the fixed points, becomes the thermodynamic entropy. Since the fixed points are parametrized by the thermodynamic state variables (by constants of motion), the thermodynamic entropy arises as a function of the thermodynamic state variables and thus the final outcome of the reduction is the fundamental thermodynamic relation.

This reduction process extends also to reductions in opens systems in which the reduced theory still involves the time evolution (e.g. reduction of kinetic theory to hydrodynamics). The essence of the extension is the replacement of the mesoscopic time evolution of the state variables with the corresponding to it mesoscopic time evolution of the vector field (i.e. of the fluxes). The fixed point in this flux time evolution is the vector field generating the reduced mesoscopic time evolution. The flux-entropy driving the flux time evolution becomes, if evaluated at the fixed point, the flux fundamental thermodynamic relation in the reduced dynamical theory. We show that the flux-entropy is a potential related to the entropy production.

Keywords: mesoscopic time evolution, open complex systems, thermodynamics

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ICT2.0:2020-W120

INCOME INEQUALITY AND DEBT ARE LINKED TO NATURAL RESOURCE CONSUMPTION: AN EXPLANATION VIA "HARMONEY", A BIOPHYSICAL AND ECONOMIC GROWTH MODEL

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ABSTRACT

The Human and Resources with Money (HARMONEY) model is a new framework for modeling economic growth enabled by natural resource consumption [1]. HARMONEY is a two industrial sector system dynamic model (sector 1: resource extraction; sector 2: production of capital goods) that enables exploration of interdependencies among resource extraction rate and depletion; the accumulation of population, capital, and debt; and the distribution of money flows within the economy. The post-Keynesian economic framework enables a self-consistent linkage between biophysical and monetary flows. Thus, it overcomes critical limitations in neoclassical theory, and it also provides a way to add important macroeconomic concepts (e.g., wages, debt) to previous system dynamic models, such as World3 used in *The Limits to Growth* studies, that do not explicitly consider the role of credit and money in the modern capitalist economy.

The HARMONEY framework is verified by mimicking trends that are also exhibited in the United States data. Examples are the wage share starts declining and the debt:GDP ratio rapidly increases after the model no longer increases per capita resource extraction rate. ***This model framework is perhaps the first*** that clearly links physical metrics (e.g., natural resources allocation and extraction, net power flows, population) to important socioeconomic indicators (e.g., wages, debt, and gross domestic product). The patterns occur using constant model parameters that govern socioeconomic concepts such as how wages are determined (e.g., "labor/bargaining power"), and thus biophysical principles can improve our explanation of socioeconomic trends (debt, wages, etc.) compare to purely social explanations.

Keywords: economic growth, biophysical economics, ecological economics, income distribution

References:

[1] King, Carey W. (2020) An Integrated Biophysical and Economic Modeling Framework for Long-Term Sustainability Analysis: the HARMONEY Model, *Ecological Economics*, 169, March 2020, 106464, https://doi.org/10.1016/j.ecolecon.2019.106464.

ICT2.0:2020-W105

PROPOSED PRINCIPLES OF ECONOMICS: BIO-SYMMETRY AND HIERARCHIC SYMMETRY

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ABSTRACT

The word "symmetry" has a special meaning in the hard sciences. We start by examining the technical meaning in that context, reviewing the role it has played in the hard sciences, abstracting the implications, and considering the wider possibilities for application. We then place the disciplines of sociology and economics into the context of a ladder of sciences, in which each level of the ladder is more complex and more inclusive than the lower rungs, with sociology and economics occupying the second-from-top and top rungs on the ladder. In that context we examine two proposed symmetries for social and economic systems, as follows:

By the principle of biosymmetry, the problems of anthropocentrism and externalities are resolved. The concept of an economic system is redefined in a non-anthropocentric fashion, opening the door for a Copernican-like revolution in economic world view. We start with the recent but well-studied concept of anthroposphere, and identify three non-overlapping key components: the biologically human components, the human technosphere and the human noösphere. We name it as a specific example of a more general concept which we call phenosphere, and show how each species has an economy having all three key components dependent on its phenotype. Finally, we relate the collection of resulting inter-species economies using concepts well-studied in ecology such as parasitism, commensalism and mutualism.

By the principle of hierarchic symmetry a methodology is proposed to transport the wealth of scientific concepts from the hard sciences into a new science-based economic theory. The concept of universal dynamic is explored, and a prototype framework for organizing and categorizing universal dynamics is presented. Two examples that link thermodynamics to economic phenomena are presented, along with the agent-based models that enabled their study.

Keywords: principles of science, ladder of sciences, gauge theories, universal dynamics, econodynamic framework.

ICT2.0:2020-W138

FRAMING HUMAN BEHAVIOR IN PHYSICS BEFORE BIOLOGY AND SOCIAL SCIENCE

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ABSTRACT

Social sciences start by looking at the social-psychological attributes of humans to model and explain their observed behavior. However, we suggest starting the study of observed human behavior with the universal laws of physics, e.g., the principle of minimum action. In our proposed three-tier framework, behavior is a manifestation of action driven by physical, biological, and social-psychological principles at the core, intermediate, and top tier, respectively. More broadly, this reordering is an initial step towards building a platform for reorganizing the research methods used for theorizing and modeling behavior. This perspective outlines and illustrates how a physical law can account for observed human behavior and sketches the elements of a broader agenda.

Keywords: principle of minimum action, human behavior, physical laws

ICT2.0:2020-W168

Historical attempts to bridge the two cultures: Natural science and social science

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ABSTRACT

A short overview of recent historical attempts, in the last two centuries, to bridge the so-called natural sciences, e.g. physics and chemistry based knowledge, with the so-called social sciences, e.g. arts and humanities; the presentation being centered around Charles Snow’s 1959 two cultures division of the presumed highly-educated class of humans, between those who understand Clausius and those who understand Shakespeare..

Keywords: two cultures, bridge, natural science, social science

ICT2.0:2020-W182

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