T2022

Thermodynamics 2.0

Book of Abstracts

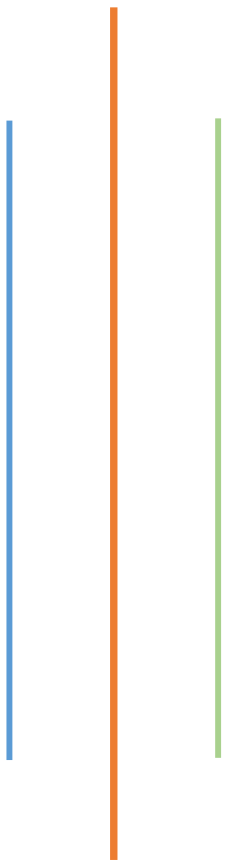
July 18 - 20, 2022
Boone, North Carolina, USA

International Association for the
Integration of Science and Engineering

www.iaisae.org

Appalachian STATE UNIVERSITY

Thermodynamics 2.0 | 2022



International Association for the Integration of Science and Engineering

Broomfield, Colorado, United States

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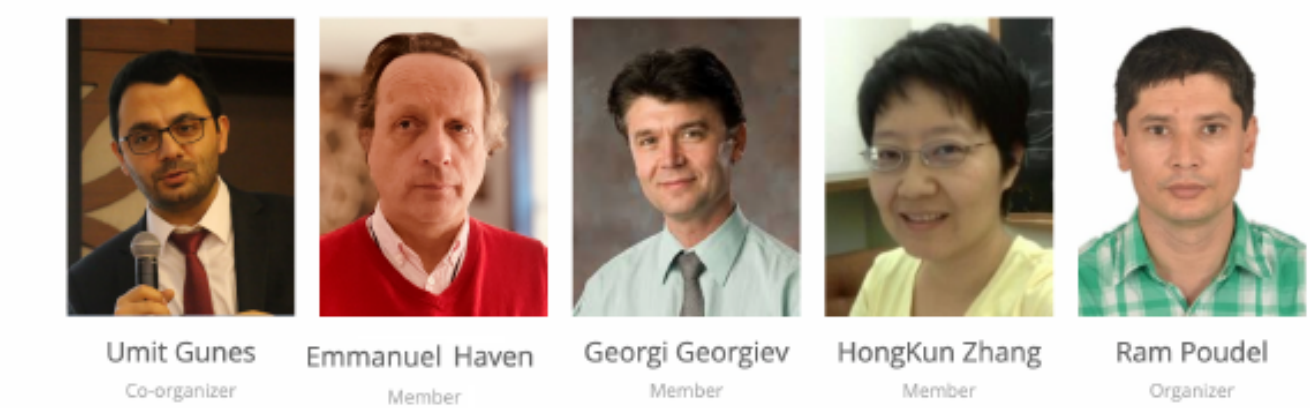
https://iaisae.org/

Organizers: Thermodynamics 2.0 | 2022

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



What is Thermodynamics2.0?

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, entropy, and information 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

EVENT SCHEDULE

https://iaisae.org/index.php/agenda-schedule-t2022/

IAISAE Schedule: Sessions and Time Table (Eastern Time (US and Canada))

International Conference on Thermodynamics 2.0 | 2022

Date→ / Time↓	17-Jul Sunday	18-Jul Monday	19-Jul Tuesday	20-Jul Wednesday	←Date / Time↓
8:30		Registration Opens	Keynote and Plenary (II) **Bejan, Bristol, Aiello**	Keynote and Plenary (III) **Tsallis, Hidalgo, Mahulikar**	8:30
8:45					8:45
9:00		Welcome and Opening Remarks			9:00
9:15					9:15
9:30		Keynote and Plenary (I) **Anilla, Funtowicz, Swenson**			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	Session T13 / Session T14	10:45
11:00					11:00
11:15					11:15
11:30		Invited Talk: Perry Marshall			11:30
11:45					11:45
12:00		Lunch Break	Lunch Break		12:00
12:15		Lunch Talk: Hubbard & Brown	Lunch Discussion: Torday & Sam Baker	Invited Talk: Addy Pross	12:15
12:30					12:30
12:45					12:45
13:00		Session T01 / Session T02	Panel 01: Energy and Economy	Panel 02 : Unity of Sciences	13:00
13:15					13:15
13:30					13:30
13:45					13:45
14:00		Session T03 / Session T04			14:00
14:15					14:15
14:30			Open Discussion	Open Discussion	14:30
14:45					14:45
15:00		Coffee Break	Coffee Break	Coffee Break	15:00
15:15		Session T05 / Session T06	Session T09 / Session T10	Session T15 / Session T16	15:15
15:30					15:30
15:45					15:45
16:00					16:00
16:15			Session T11 / Session T12	Panel 03: Evolution and Purposiveness	16:15
16:30	Registration Opens	Future of Thermodynamics 2.0			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		Open Discussion: Summary of the Day	IAISAE General Meeting Thermodynamics 2.0 | 2024		17:45
18:00				IAISAE Awards	18:00
18:15				Adjournment	18:15

Monday, July 18 | Day 1 program

Time in North Carolina, USA (Eastern Time)

09:00 - 09:30 Welcome and opening remarks
Mike McKenzie (Vice Provost); **Shannon Campbell** (Dean); **Ok-Youn Yu**

09:30 - 10:15 **Keynote: Arto Annila,** University of Helsinki, Finland

10:15 - 10:45 **Silvio Funtowicz,** University of Bergen (UiB), Norway

10:45 - 11:15 Invited: **Rod Swenson,** University of Connecticut, USA

11:30 - 12:00 Invited: **Perry Marshall**

12:15 - 12:45 Lunch Talk: **Hubbard & Brown**

13:00 - 14:00 Session T01: Physical Basis of Evolution
Session T02: Quantum formalism in Decision

14:00 - 15:00 Session T03: Energy, Entropy and Information
Session T04: Unity of Nature

15:00 - 15:15 Coffee Break

15:15 - 16:15 Session T05: Entropy and Applications
Session T06: Econophysics

16:15 - 17:30 Future of Thermodynamics 2.0
Open Discussion (Moderator: **Klaus Jaffe**)

17:30 - 17:45 Coffee Break

17:45 - 18:30 Open Discussion: Summary of the Day

Tuesday, July 19 | Day 2 program

Time in North Carolina, USA (Eastern Time)

Keynote: Adrian Bejan, Duke University, USA **08:30 - 09:15**

Terry Bristol, Portland State University **09:15 - 09:45**

Clarice Aiello, University of California Los Angeles **09:45 - 10:15**

Coffee Break **10:30 - 10:45**

Session T07: Biology Cell and Evolution **10:45 - 12:00**

Session T08: Quantum formalism in Finance

Lunch Discussion: Torday & Sam Baker **12:15 - 12:45**

Panel 01: Energy and Economy **13:00 - 14:30**

Open Discussion (Moderator: **Carey King**) **14:30 - 15:00**

Coffee Break **15:00 - 15:15**

Session T09: Physical Basis of Economy **15:15 - 16:15**

Session T10: Dissipative Structure

Session T11: Theoretical Advances **16:15 - 17:30**

Session T12: Entropy in Social Sciences

Networking Break **17:30 - 17:45**

IAISAE General Meeting Thermodynamics 2.0 | 2024 **17:45 - 18:30**

Day 3 program | Wednesday, July 20

Time in North Carolina, USA (Eastern Time)

08:30 - 09:15 **Keynote: Constantino Tsallis,** Centro Brasileiro, Brazil

09:15 - 09:45 **César A. Hidalgo,** University of Toulouse, France

09:45 - 10:15 **Shripad P. Mahulikar,** IIT Bombay, India

10:30 - 10:45 Networking Break

10:45 - 12:00 Session T13: Entropy in Social Sciences

Session T14: Constructal Law & Applications

12:15 - 12:45 Invited Lunch Talk: **Addy Pross**

13:00 - 14:30 Panel: Unity of Science

14:30 - 15:00 Open Discussion (Moderator: **Mark Ciotola**)

15:00 - 15:15 Coffee Break

15:15 - 16:15 Session T15: Quantum formalism and beyond

Session T16: Complex and Evolving System

16:15 - 17:45 Panel: Evolution and Purposiveness

17:45 - 18:00 Open Discussion (Moderator: **Alan Love**)

18:00 - 18:15 IAISAE Awards

18:15 - 18:30 Adjournment

PROGRAM

Monday, July 18 | Day 1 program

9:00 am	**Welcome and opening remarks** Mike McKenzie (Vice Provost), Academic Program Development & Strategic Initiatives Shannon Campbell (Dean), College of Fine and Applied Arts
Plenary I :	Chair: Eric Marland
9:30 am	**Keynote: Arto Annila,** *University of Helsinki, Finland* Thermodynamics of Universal Patterns
10:15 am	**Silvio Funtowicz,** *University of Bergen (UiB), Norway* Why Science doesn't Speak with One Voice
10:45 am	**Invited: Rod Swenson**, CESPA Fellow, University of Connecticut, Storrs, USA The Fourth Law and the Physical Basis for Evolution
	Chair: Parker Dubee
11:30 am	**Invited: Perry Marshall,** *Evolution 2.0, Oak Park, Illinois, USA* Negentropy: Convergence of Evolution, Cognition, the Genetic Code and Orig
12:15 pm	**Hubbard Steve and Malcolm E Brown,** *United Kingdom* A View of Falsity in the Natural Science and Social Science/Humanities Dichotomy
SESSION T01: Physical Basis of Evolution	
	Chair: Ram Poudel
1:00 pm	**Denis Noble,** *University of Oxford, UK* The Harnessing of Stochasticity by Living Organisms
1:20 pm	**Gregory S. Yablonsky,** *Washington University in St. Louis, St. Louis, USA* Joint Kinetics: A New Strategy for Bridging Thermodynamics and Kinetics
1:40 pm	**John S. Torday,** *University of California- Los Angeles, USA* A Comprehensive , Holistic Cell Theory of Thermodynamics and Life
SESSION T03: ENERGY, ENTROPY AND INFORMATION	
	Chair: Sandro Sozzo
2:00 pm	**Pier Luigi Gentili,** *Università degli Studi di Perugia, Italy* Implementing Fuzzy Sets through Molecules and Determining their Entropy
2:20 pm	**Adrian-Josue Guel-Cortez,** *Coventry University, UK* Minimum Information Variability Control
2:40 pm	**Agnieszka Giszterowicz,** *Modrzewski Krakow University, Cracow, Poland* The Entropy Counteracting Report Revealed in the Artwork

Day 1 program | Monday, July 18

SESSION T02: QUANTUM FORMALISM IN DECISION MAKING

Chair: Emmanuel Haven

1:00 pm **Jerome R. Busemeyer,** *Indiana University, United States*
Comparison of Markov versus Quantum Dynamical Models of Human Decision Making

1:20 pm **Sandro Sozzo,** *University of Leicester, Leicester, UK*
Representing Decisions in Hilbert Space: Foundations and Applications

1:40 pm **Polina Khrennikova,** *University of Leicester, UK*
Contextuality in Financial Decision Making

SESSION T04: UNITY OF NATURE

Chair: Arkady Plotnitsky

2:00 pm **Terry Bristol,** *Portland State University, Portland Oregon, USA*
Understanding Quantum Theory as Engineering Thermodynamics

2:20 pm **Alexander Laszlo,** Bertalanffy Center for the Study of Systems Science, Austria
The Humanistic Bases of Systems Science

2:40 pm **Rabindra Nath Bhattarai,** Institute of Engineering, Tribhuvan University, Nepal
Human Life and Nature

SESSION T05: ENTROPY AND APPLICATIONS

Chair: Marek Frankowicz

3:15 pm **A. Plastino,** *National University of La Plata, Argentina*
Peculiarities of the gravitational entropy

3:35 pm **Jeremy Kazimer,** *University at Buffalo, State University of New York, USA*
An Efficient Ranking of Nodes and Edges According to their Impact on Graph Von Neumann Entropy

3:55 pm **Zi-Kui Liu,** *Pennsylvania State University, University Park, USA*
Zentropy

4:15 pm **Velimir Ilić,** *Mathematical Institute of Serbian Academy of Sciences and Arts, Serbia*
Axiomatic Characterization of Statistical Complexity Measures

Monday, July 18 | Day 1 program

SESSION T06: ECONOPHYSICS

Chair: Cal Abel

3:15 pm **Victor M. Yakovenko,** *University of Maryland, College Park, USA*
Two-class Income Distribution in the USA in 1983-2018

3:35 pm **Juergen Mimkes,** *Paderborn University, Paderborn, Germany*
Differential Forms in Thermodynamics and Economics

3:55 pm **Marcin Jedrzejczyk,** *Cracow University of Economics, Krakow, Poland*
Thermodynamics as a Basis of Physical Economic

PANEL DISCUSSION: FUTURE OF THERMODYNAMICS 2.0

16:30– 17:45

Moderator: **Klaus Jaffe**

[05 min] Introduction

[45 min] Breakout sessions: Group Discussion

[15 min] Summary by Group Lead: Key questions, Ideas, and Methodology

[10 min] Draft and Documentation: T2022 Conference Proceedings

OPEN DISCUSSION

5:45 pm Open Discussion: Summary of the Day

Day 2 program | Tuesday, July 19

Plenary II : Chair: Ashuwin Vaidya

8:30 am	**Keynote: Adrian Bejan,** *Duke University, North Carolina, USA* Time and Beauty
9:15 am	**Terry Bristol,** *Portland State University, Portland Oregon, USA* Evolution is a Constructive Engineering Thermodynamic Enterprise
9:45 am	**Clarice Aiello,** *The University of California Los Angeles* From Nanotech to Living Sensors: Unraveling the Spin Physics of Biosensing…

SESSION T07: BIOLOGY CELL AND EVOLUTION

Chair: Folarin Oguntoyinbo

10:45 am	**Michael Levin,** *Allen Discovery Center at Tufts University, USA* Evolutionary Implications of the Collective Intelligence of Cells via Developmental Bioelectric Signaling
11:10 am	**Scott Turner,** *SUNY College of Environmental Science and Forestry, USA* Evolution, Cognition, and Thermodynamics
11:35 am	**Ram Poudel,** *Appalachian State University, Boone, NC, USA* A Quest for Physical Basis of Evolution: An Energetics Perspectives

SESSION T08: QUANTUM FORMALISM IN FINANCE AND ECONOMICS

Chair: Erald Kolasi

10:45 am	**David Orrell,** *Systems Forecasting, United States* A Quantum Model of Stock Markets
11:05 am	**Belal Baaquie,** *Helixtap Technologies, Singapore.* Oscillator Model for Risky Corporate Coupon Bonds
11:25 am	**Cal Abel**, Signal Power and Light, Inc., Cordova, Alabama, USA The Quantum Foundations of Utility: Resolving the Incompleteness of Economic
11:45 am	**Emmanuel Haven,** *Memorial University of Newfoundland, Canada* From social science to quantum like and beyond
12:15 pm	Lunch Discussion: **John Torday & Sam Baker** Anthropocentric Thinking in Economics

Tuesday, July 19 | Day 2 program

PANEL: ENERGY AND ECONOMY

13:00– 14:30

Moderator: Carey King

Tim Garrett, *University of Utah, USA*

Gaël Giraud, *Georgetown University, USA*

Carey W. King, *University of Texas at Austin*

Open Discussion 14:30 – 15:00

SESSION T09: PHYSICAL BASIS OF ECONOMY

Chair: Garvin H Boyle

3:15 pm **Andrew Wallace,** *Earth Organisation for Sustainability (EOS), Umeå, Sweden*
The Use of Exergy for an Alternative, Moneyless, Socioeconomic System

3:35 pm **Wojciech Koziol,** *Cracow University of Economics, Cracow, Poland*
Thermodynamic Background of Modeling the Measurement of Returns on Human Capital: : An Example of the Russian Economy

3:55 pm **Anthony Friend,** *Canada*
The Measure of Gross Domestic Product (GDP) in the System of Accounts for Global Entropy Production

SESSION T11: THERMODYNAMICS AND SUSTAINABILITY

Chair: Arezou Sadoughi

4:15 pm **Eduardo González-Mora,** *Universidad Autónoma del Estado de México*
Optimal Truncation Criterion for Compound Parabolic Collectors: A Thermodynamic Justification

4:35 pm **Ibrahim Ozsari,** *Bursa Technical University, Naval Architecture, Turkey*
The Thermodynamic Effects of Steam Injection and Exhaust Gas Recirculation Applications on Combustion in Internal Combustion Engines

4:55 pm **Johannes Lenhard,** *TU Kaiserslautern, Germany*
Created by Prediction: On the History, Ontology, and Computation of the Lennard-Jones Fluid

5:15 pm **Evgeni B. Starikov**, *Kobe University, 1-1, Rokkodai, Nada, Japan*
What Is Entropy and How to Productively Employ this Concept

Day 2 program | Tuesday, July 19

SESSION T10: DISSIPATIVE STRUCTURE

Chair: Michael Francis McCullough

3:15 pm **Mark Ciotola,** *San Francisco State University, San Francisco, USA*
Modeling Historical Dynasties as Emergent, Dissipative Mechanisms

3:35 pm **Grégoire Noël,** *Université Paris-1 Panthéon-Sorbonne, Paris, France*
Modeling the Economy as a Dissipative Structure with Scarce Resources

3:55 pm **W.F. Lawless,** *Paine College, Augusta, United States*
Exploring a Thermodynamics of Interdependence for Autonomous Human-Machine Teams with Case Studies

SESSION T12: THEORETICAL ADVANCES I

Chair: Todd Hylton

4:15 pm **Vicente Fachina,** *Petrobras, Rio de Janeiro, Brazil*
General Framework for Open Systems

4:35 pm **Bernard Guy,** *Mines Saint-Etienne, Institut Mines Télécom,France*
On the Connection between the Second Law of Thermodynamics and the Second Postulate of Relativity Theory: Some Illustrations

4:55 pm **Andrei Khrennikov,** *Linnaeus University, Växjö, Sweden*
Social Laser Theory

5:15 pm **Klaus Jaffe,** *Universidad Simon Bolivar, Caracas, Venezuela*
Experimental Law: A Thermodynamics Approach

5:45 pm **IAISAE General Meeting**
General Assembly: Organization and Planning Ahead
Thermodynamics 2.0 | 2024

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T2.0:2022-0123

THERMODYNAMICS OF UNIVERSAL PATTERNS

Arto Annila

University of Helsinki, Helsinki, Finland

ABSTRACT

Nature is not random but regular. Irrespective of scale and scope, distributions are skewed, thus cumulating sigmoidally. Although lognormal, logistic, and power-law functions follow data closely, mathematical models do not explain why the patterns are universal. A true explanation calls for substance and cause. The ubiquitous patterns imply a unity of nature. Yet, the basis of the universal laws of thermodynamics has remained only implicit. Like Newton and Galileo, also Boltzmann revered ancient atomism but did not recognize the quantum of light, the carrier of energy, as the founding postulate of statistical mechanics, the many-body theory underlying thermodynamics. Having atomism in mind, Lewis renamed the light quantum to the photon but did not revise statistical mechanics to include photon influxes and effluxes. Thus, while accounting for flows of energy, thermodynamics has remained tacit about the carrier of energy and time, the photon being the fundamental constituent of nature. Assuming everything comprises photons, I show how to mathematize a general energy level diagram to the equation of state, which, in turn, can be differentiated with respect to time into the equation of change, the 2nd law of thermodynamics. Straightforward analysis reveals the universal patterns emerging from the least-time evolution of any system toward thermodynamic balance, the free energy minimum, the entropy maximum. The holistic worldview offers humankind unprecedented understanding from elementary particles to cosmic expanses, from a gene to the biosphere, and from purchase to world trade, accompanied by unrelenting responsibility.

Keywords: axiom, entropy, evolution, free energy, photon, theory

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T2.0:2022-0172

THE FOURTH LAW AND THE PHYSICAL BASIS FOR EVOLUTION

Rod Swenson

CESPA Fellow, University of Connecticut, Storrs, CT. USA

ABSTRACT

Over its 4.6GY history the evolution of Earth, from the earliest prokaryotes to the explosive globalization of human cultural systems going on today has been characterized by the progressive (going in a direction) and opportunistic accelerating production of increasingly more highly ordered dynamic states. Given Boltzmann's probabilistic interpretation of the 2nd law of thermodynamics as a "law of disorder" each and every one of these ubiquitous and characteristic transitions, in Boltzmann's own words, would be "infinitely improbable". This view has cast physics as the "river that runs downhill" to disorder and the evolution of life, the "river that flows uphill", in apparent opposition to each other with the life somehow miraculously violating the laws of physics or, in any case, for some unexplained ("miraculous") reason in a constant battle against them. The cost of this antiquated paradigm, in addition to reenforcing an outdated and diminished physical theory, has had decimating effect on evolutionary theory. Philosophers of science have noted well the irrational persistence of paradigms even in the face of anomalies (errors of fact that falsify its claims), and we are in such a place now with regard to this old paradigm. Studies in autocatakinetics (self-organization, or spontaneous ordering more precisely defined) in simple physical systems falsify the Boltzmann's view showing that spontaneous order arises not "infinitely improbably" as he would have had it but with a probability of one, that is opportunistically, every time certain thresholds are crossed and it gets the chance. The identification, demonstration, and articulation of the 4th law of thermodynamics (the law of maximum entropy production, or LMEP), now roughly three and half decades ago provides the physical selection principle that accounts for this universal ordering, the nature of life, and natural selection. Selection is entailed by spontaneous ordering and natural selection is a special case where the components are replicating. This new paradigm easily replaces the old by all comparative methods of theory selection. The problems with orthodox evolutionary theory, the older physical view, and the new paradigm grounded in the 4th law are sketched and outlined showing the physical basis for why rather then collapsing monotonically to disorder, the world is in the order-production business.

Keywords: evolution, the law of maximum entropy production, the 4th law

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T2.0:2022-0106

WHY SCIENCE DOESN'T SPEAK WITH ONE VOICE

Silvio Funtowicz[1] and Alice Benessia [2]

[1]Centre for the Study of the Sciences & the Humanities (SVT)
University of Bergen (UiB), Norway

[2] Pianpicollo Selvatico – Center for Research in the Arts and the Sciences
Italy

ABSTRACT

Thermodynamics as a science of complexity offers powerful tools for exploring the realm of the living world, in their biological and social dynamics. Complex systems involving our species are also reflexive, and the inherent normative aspects cannot be effectively externalized from our scientific endeavors. The need to acknowledge and manage this entanglement is becoming quite clear, as we deal with critical challenges of our times. The effort to provide advice for the Covid-19 pandemics has shown that there is no privileged relevant expertise or technoscientific silver bullet. Covid-19 has taught us that Science does not speak with one and undisputed voice. It also showed that the range of disciplines that were consulted was mostly limited to a biomedical elite, along with modelers and economists. It thus revealed that the framing of policy problems is still anchored on the Modern State model of legitimation in which complexity is ignored, and facts are treated as independent of values and of what is at stake. Post-Normal Science (PNS) emerged as a problem-solving strategy that is appropriate when facts are uncertain, values are in conflict, stakes high and decisions urgent. Under those conditions the ideal of Truth gives way to Quality. In PNS quality is understood as fitness for purpose. It is operationalized through a dialogue between the experts and the extended peer communities. We have still to learn that useful knowledge does not speak only in the language of science. It requires instead a transdisciplinary effort where a plurality of styles of personal 'knowing-how' from experience complement the disciplined 'knowing-that' from textbooks. In this transition, thermodynamics can offer a fruitful choreography of metaphors, in which simple, complex, and reflexive systems become characterized by energy, entropy and quality. These serve as guiding principles for studying their dynamics and for acting consciously within them. The Covid pandemic is part of several challenges facing humanity today, such as the collapse of ecosystems, the loss of biodiversity and, in general, sustainability transitions. These all share the PNS conditions in the context of persistent extreme inequalities, weak democratic institutions, growing authoritarian temptations, and fantasies of techno-scientific silver bullets. To give effective support to decision-making and political action, Science must not continue to pursue the unattainable goals of precise prediction and total control but should rather participate in a collective effort for the creation of responsible and anticipatory knowledge.

Keywords: post-normal science, complexity, quality, extended peer communities

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T2.0:2022-0113

WE NEED A REVOLUTION IN OUR UNIVERSITIES TO SOLVE THE GLOBAL PROBLEMS WE FACE

Nicholas Maxwell

UCL London, United Kingdom

ABSTRACT

Humanity faces two absolutely fundamental problems of learning: learning about the universe and ourselves and other forms of life as a part of the universe; and learning how to create a genuinely civilized world – one in which there is peace, democracy, justice, individual liberty, and sustainable prosperity, for all. We have solved the first problem of learning. We did that in the 17th century when we created modern science. But we have not yet solved the second problem. That puts us in a situation of unprecedented danger. For, as a result of solving the first problem and creating modern science and technology, we have enormously increased our power to act. This has benefited humanity in countless ways via the development of modern medicine, hygiene, industry, agriculture, transport and communications but, in the absence of the solution to the second great problem of learning, has also led to many of our current global problems: the climate and ecological crises, pollution, the lethal character of modern war, the threat of nuclear weapons. As a matter of extreme urgency, we need to discover how to solve the second great problem of learning. If we do not, we may well end up destroying ourselves. But how is this to be done? The answer is to learn from the solution to the first great problem of learning how to solve the second one – that is, learn from scientific progress how to achieve social progress towards a civilized world. This was the basic idea of the 18th century French Enlightenment but, unfortunately, in implementing this idea, the philosophes of the Enlightenment blundered, and their mistakes are still built into natural and social science today. It is vital that we now correct these mistakes so that we may develop universities rationally and effectively devoted to helping humanity create a civilized, enlightened world. That requires that we (a) improve the progress-achieving methods of natural science, (b) generalize these methods, and then (c) transform the social sciences so that these disciplines cease to be sciences and become social methodologies, devoted to getting into society, into institutions and social endeavours, into government, industry, agriculture, the law, the media, and international relations, the progress-achieving methods generalized from those of natural science. In a little more detail, we need, first, (a) to adopt and implement a new conception of scientific method that acknowledges the profoundly problematic metaphysical, value and political assumptions inherent in the aims of science and, as a result, adopts a meta-methodology designed to facilitate improvement of aims as science proceeds. Second, (b) this aims-improving, progress-achieving conception of scientific method needs to be generalized to form a new, aims-improving, progress-achieving conception of rationality, fruitfully applicable, potentially, to all worthwhile endeavours with problematic aims. And third, (c) the social sciences need to be transformed into social methodologies so that they take up the task of helping humanity get this new, aims-improving conception of rationality into the fabric of social life, into all our other human endeavours besides science: politics, industry, agriculture, economics, the media, the law, finance, international affairs. As a result, humanity would have what it so urgently needs, a kind of academic enterprise rationally devoted to helping us make social progress towards a genuinely civilized, wise, enlightened world – a world that has the capacity to discover undesirable consequences of new actions made possible by new technology, and then modify actions before their undesirable consequences become too widespread.

Keywords: technology, power, society, scientific progress, social progress

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T2.0:2022-0104

NEGENTROPY: CONVERGENCE OF EVOLUTION, COGNITION, THE GENETIC CODE AND ORIGIN OF LIFE

Perry Marshall

Evolution 2.0, Oak Park, Illinois, USA

ABSTRACT

Erwin Schrodinger in his 1943 *What is Life* identified "negative entropy" as the force that creates order from disorder in living things. I propose that negentropy is synonymous with cognition, which all living cells possess (Shapiro 2020) and is the unifying principle behind the genetic code, origin of life, evolution, and consciousness. I propose a new framework by modeling the cell as a Volitional Turing Machine, analogous to Maxwell's Demon. We can model the agency of the cell as a computer that can choose "1" or "0" before writing its next output. This choice is a non-deterministic action of a free agent with sensory capacity and memory. It is not computable from prior states. As well as reading and reacting to its environment, it anticipates future threats, chooses goals and reasons inductively. Computers do none of these things. Negentropy is the reversal of information entropy, from uncertainty to certainty. A binary free choice of "1" or "0" creates of one unit of Shannon information, just as noise erasing one bit of information constitutes one unit of information entropy. "Biological systems are the only known source of agency in the universe" (Cronin and Walker 2016) and information is an exclusive property of biology (Walker, Davies and Ellis 2017). There is an asymmetry between entropy and negentropy because negentropy is teleological and entropy is not. I show that the following phenomena exceed the limits of computation and cannot be reduced to fixed laws but rather require negentropy: Computational choices, inductive reasoning, evolution, assigning meaning to symbols, harnessing stochasticity, axioms in mathematics, representation of scientific laws, measurement and perception, and negative information entropy. Thus the central question in both biology and computer science is: What is the nature and origin of cognition?

Keywords: negentropy, evolution, cognition, information entropy, origin of life, origin of information

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A VIEW OF FALSITY IN THE NATURAL SCIENCE AND SOCIAL SCIENCE/HUMANITIES DICHOTOMY

Steve Hubbard, Malcolm E Brown

ABSTRACT

Two systems currently dominate our species and our planet: science and art. Their influence dominates our global organisational and bureaucratic thinking and especially the education system from top to bottom. It is dominant not only in our “macro” global thinking but also in our “micro” attitude to each other in personal daily relationships. We recognise the huge challenges to achieving an alternative based on inter-disciplinary studies and briefly consider the role of education and especially academia in this. The Laws of Thermodynamics have overwhelming and inescapable application in all aspects of human life, physical and social. Nevertheless our concerns remain that even they and other “truths” that have been and will be determined cannot escape being human constructs; we have no higher agreed authority than ourselves. We emphasise the dangers of such duality in thinking and show that such a dichotomy is false. We develop our earlier model of all activity being on a “spectrum of instability.” We include recent evidence that may make the current “two perspectives” obsolete. We suggest one strategy to provide evidence about whether our human perspective is idiosyncratic.

Keywords: instability, spectrum, dichotomy, science, art, thermodynamics

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THE HARNESSING OF STOCHASTICITY BY LIVING ORGANISMS

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ABSTRACT

Standard biology represents organisms as experiencing random changes, but stops short of realising that chance variations can be used as well as experienced. The immune system does this all the time in generating new DNA sequences when it needs to find a new way to counter a novel virus or bacterium. Unicellular colonies of organisms also use this method to cope with environmental stress. We have proposed in recent articles [1] that the harnessing of stochasticity has many implications in understanding how organisms behave and are creative.

Keywords: stochasticity, hypermutation, harnessing of chance, organisms as agents

Reference:

[1] R. Noble and D. Noble, “The Harnessing of Stochasticity: Physiological and philosophical consequences,” October 2020.
https://www.denisnoble.com/wp-content/uploads/2021/01/Harnessing-Collection.pdf

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JOINT KINETICS: A NEW STRATEGY FOR BRIDGING THERMODYNAMICS AND KINETICS OF COMPLEX REACTIONS

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ABSTRACT

Joint kinetics is presented as a new strategy for chemical kinetics. Central concepts of joint kinetics based on the analysis of 'batteries' of experiments are proposed in a series of our papers, see some review in Yablonsky et al,, Current Opinion in Chemical Engineering, 29, 83-88. These concepts are "events", "trends" and "map of events and trends". "Events" are special features of kinetic dependences observed experimentally or computationally, i.e., extrema and intersections, coincidencies and momentary equilibria, "turning points" etc. In analysis of "trends", a special attention is paid to comparing the reciprocal kinetic dependences which start from the symmetrical initial conditions. Maps of kinetic events and trends are constructed and analyzed. Different events are categorized with an indication which events are unavoidable ("always"- events) and which are never happened ("never"- events). Typical models of chemical kinetics are analyzed for the batch and CSTR-reactors and systems of linear equations based on balances of elements and related to the model-free approach. In classical chemical kinetics, there is the dogma on the impossibility to predict kinetic behavior based on known equilibrium thermodynamic characteristics. Within the 'joint kinetics' this dogma is corrected. In some cases, knowing the equilibrium thermodynamic characteristics and kinetic dependencies which start from some initial conditions, it is possible to predict kinetic behavior from other initial conditions. This statement is illustrated by examples taken from heterogeneous catalysis (two-step catalytic mechanism, three-step Wei-Prater mechanism of isomerization and the water-gas shift reaction). A special attention was paid to revealing the new invariances for non-steady-state chemical reactions, both linear and non-linear. The existence of invariance for the non-linear etherification reaction was justified experimentally. The switching point between thermodynamic and kinetic control in organic reactions is analyzed as well. For the case of initial state with some equilibrium concentration(s) as initial one(s), the concept of the "conservatively perturbed equilibrium" (CPE) in chemical kinetics was distinguished using a sequence of first-order reactions (linear mechanism) and non-linear mechanisms as well. In the CPE, some, not all initial concentrations of the closed chemical system are replaced by the corresponding equilibrium concentrations at the same total amount of each chemical element and fixed temperature. Properties of CPE-phenomenon are the following ones: 1. For the substance which initial concentration is taken as the equilibrium one, the concentration extremum in a way to the equilibrium is unavoidable. 2. This extremum can be a momentary partial equilibrium for some steps of the chemical mechanism. 3. In some cases, time of occurrence of this extremum is independent of the perturbation. The CPE-effect was experimentally verified in a batch reactor for the complex esterification reaction. Experimental data obtained are analyzed based on the CPE-effect theory. It is shown that the CPE-phenomenon may lead to the possibility for processes limited by thermodynamic equilibrium achieving a yield higher than the CSTR. This is probably highly important for some industrial processes, for example, processes of the pharmaceutical industry. Also, a phenomenon of the "swapped equilibrium" (SE) is theoretically described. The SE-equilibrium occurs when the initial concentrations of two chemical species are taken as their equilibrium concentrations are swapped.

Keywords: joint kinetics, invariances, conservatively perturbed equilibrium

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A COMPREHENSIVE, HOLISTIC CELL THEORY OF THERMODYNAMICS AND LIFE

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ABSTRACT

Consciousness-based Evolution [1-3] is based on the premise that consciousness is derived from the Laws of Nature, constituting Cosmic Consciousness. The breakthrough experiment in understanding the link between physics and physiology was the loss of cellular identity in the absence of gravity [4]. The concept of consciousness as physiology was formulated by tracing the cell-cell communications that underpin embryologic development, phylogeny and injury-repair alike [5], based on The First Principles of Physiology [6]. It is through this merging of the animate and inanimate that the dissipation of heat energy based on the Second Law of Thermodynamics is circumvented over the course of the lifecycle, enabling the organism to collect epigenetic marks (Lamarck Inheritance) in order to inform the developing offspring of on-coming changes in the environment in order to adapt effectively. This strategy has been reverse-engineered all the way back to Quantum Mechanics as the fundament by focusing on emergent events underpinned by pre-adaptions (Darwin; S.J. Gould), the penultimate change being gravity impinging on the protocell, generating energy for Quantum Entanglement of particles within the cell (local), referencing gravitational forces in the Cosmos (non-local). This perspective accounts for all 6 listed outstanding questions to be addressed at Thermodynamics 2.0, constituting a unifying theory to be acquitted in my presentation.

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REPRESENTING DECISIONS IN HILBERT SPACE: FOUNDATIONS AND APPLICATIONS

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ABSTRACT

We elaborate a *general mathematical framework* to represent attitudes towards uncertainty that uses the mathematical formalism of quantum theory in Hilbert space. We show that the quantum-theoretic framework enables modelling of the *Ellsberg paradox*, which is problematical from the point of view of *expected utility theory*. We then apply the quantum-theoretic framework to concrete decision-making situations also involving financial and managerial decisions. More specifically, we work out a mathematical representation of various empirical studies which reveal that the attitudes of managers towards uncertainty shift from *ambiguity seeking* to *ambiguity aversion*, and vice versa, thus exhibiting both *hope* and *fear effects*. The present framework provides a new promising direction towards the development of a *unified quantum-based theory of human decision making*, in which individuals take the decision that maximizes expected utility with respect to a quantum probability measure. Furthermore, the results presented here support a successful research programme that investigates quantum structures, as *entanglement*, *emergence,* and *interference*, outside the microscopic world of quantum physics.

Keywords: quantum structures, human decision-making, Ellsberg paradox, quantum uncertainty

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COMPARISON OF MARKOV VERSUS QUANTUM DYNAMICAL MODELS OF HUMAN DECISION MAKING

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ABSTRACT

What kind of dynamic decision process do humans use to make decisions? In this talk, two different types of processes are reviewed and compared: Markov and quantum. Markov processes are based on the idea that at any given point in time a decision maker has a definite and specific level of support for available choice alternatives, and the dynamic decision process is represented by a single trajectory that traces out a path across time. When a response is requested, a person's decision or judgment is generated from the current location along the trajectory. By contrast, quantum processes are founded on the idea that a person's state can be represented by a superposition over different degrees of support for available choice options, and that the dynamics of this state form a wave moving across levels of support over time. When a response is requested, a decision or judgment is constructed out of the superposition by "actualizing" a specific degree or range of degrees of support to create a definite state. The purpose of this talk is to introduce these two contrasting theories, review empirical studies comparing the two theories, and identify conditions that determine when each theory is more accurate and useful than the other.

Keywords: Markov process, quantum process, superposition, human decision making

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CONTEXTUALITY IN FINANCIAL DECISION MAKING

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ABSTRACT

It has been shown that investors are prone to contextual information processing and contextual risk attitudes. Contextuality steams from framing and order effects in information presentation and evaluation. Framing and order of information trigger joint, versus separate evaluation of random variables, such as portfolio versus single stock assessment of returns. Order of processing of information signals can also produce different posterior beliefs about the financial market. In real investment settings, the complexity of financial products and the surrounding ambiguity calls for a more general formalization of agents' belief formation than offered by the standard probability theory and dynamics models based on classical stochastic processes. The main advantage of quantum probability (QP) is that it can capture contextuality of beliefs through the notion of non-commuting prospect observables. QP has the potential to model myopia in asset return evaluation, as well as inter-asset valuation. Moreover, the interference term of agents' comparison state can provide a quantitative description of their vacillating ambiguity perception characterized by non-additive beliefs. The main motivation for the application of QP mathematical framework as a mechanism of probability calculus under non-neutral ambiguity attitudes among agents coupled with a state dependence of their evolution is its ability to mathematically model belief formation under uncertainty and an interdependence of beliefs (e.g., regarding different securities in the market). Finally, we can ascertain that QP calculus provides a more complete operational model than the Bayesian update.

Keywords: contextuality, quantum probability, decision making, financial market

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IMPLEMENTING FUZZY SETS THROUGH MOLECULES AND DETERMINING THEIR ENTROPIES

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ABSTRACT

Fuzzy logic is a good model of the human ability to compute with words [1]. It has been defined as a rigorous logic of vague and approximate reasoning. It is based on the theory of Fuzzy sets proposed by the engineer Lotfi Zadeh in 1965 [2]. Fuzzy logic is a valid model of the human capacity to make decisions using natural language because there are structural and functional analogies between the human nervous system and Fuzzy logic systems [3-5]. Fuzzy logic is widely used in the field of Artificial Intelligence [6]. In Chemical Artificial Intelligence [7], molecular, supramolecular, and systems chemistries are employed to mimic some human intelligence performances and process Fuzzy logic [4]. In this contribution, we present a strategy for implementing Fuzzy sets through molecules and an algorithm for determining their entropy [8]. This study will promote the development of Chemical Artificial Intelligence, but it could also spark new ideas about the origin of life on Earth. The appearance of life on Earth was like a “phase transition” [9]. Roughly 4.0 billion years ago, there was a transition from inanimate chemical systems, unable to encode, process, communicate and store information, to the living chemical systems, able to exploit the matter and energy to encode, process, send, and store information. The development of Chemical Artificial Intelligence could unveil how that unique “phase transition” happened.

Keywords: entropy, fuzzy logic, molecules, conformations, artificial intelligence, the origin of life.

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MINIMUM INFORMATION VARIABILITY CONTROL

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ABSTRACT

Feedback control has successfully been exploited since the early 20's for industrial, medical and scientific purposes. Its success relies on both the simplicity of its conceptualization and its implementation. In general, the design of classical control techniques, such as the proportional-integral-derivative (PID) control variants, and modern techniques, like the model predictive control (MPC), depends on the solution of an optimization problem. For instance, the Linear Quadratic Regulator characterized by a cost function that minimizes the error between the dynamics and the desired stated while regularizing the control effort. Most of the current cost functions used for control design demonstrate that the tracking or regulation of the dynamics is a common requirement in the engineering scenarios. However, these cost functions can be meaningless in modern complex systems where the entropy, the information variability or the energy minimization are the set up as central goals. In this regard, this work explores the application in control design of the concept of information length, an information geometry concept used to describe the total amount of statistical changes that a probability distribution takes through time and whose minimization will thus reduce the disorder in stochastic systems. Information length is presented as a cost function that considers both information and thermodynamic aspects useful for the controllers' design. We design full-state feedback controls for linear stochastic processes, producing small statistical fluctuations and oscillations in the closed-loop time system's response. Effects on the system's entropy production are also analyzed.

Keywords: information geometry, control theory, stochastic thermodynamics

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THE ENTROPY COUNTERACTING REPORT REVEALED IN THE ARTWORK

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ABSTRACT

In the accounting theory, capital is defined as the ability to perform work. Importantly, his character is abstract and nature is elusive. This made it possible to deepen the knowledge about it, and - above all - to state that capital – the same as tangibles – comes to terms with “thermodynamic necessity” (discovery of the significant role of thermodynamic principles in the theoretical basis of accounting), and the periodical balance sheet created by accountancy is actually a report on preventing the entropy. What is more, the balance sheet phenomenon becomes obvious as soon as its thermodynamic provenience is understood. However, it comes with great difficulty. To make this process easier, since 2014 the author (according to her education and professional background) carries out a research from in between art and science (newest articles: *Between Art and Science. The Integrative Role of Accounting*, *Dynamics and Thermodynamics of Schulz’s capital*, *Paths of Familiarity with Schulz’s Accountancy*, *Accounting and Thermodynamics in* «Les *Miserables*» *of Victor Hugo*). It has been proven that very often, the artists have better skills and tools to explain complicated scientific phenomena and processes. Therefore, the ambition is to use four examples taken from art to solve the problem of the explaining ability of the capital substance. This may then contribute to spread the scientific theory of fair wages, human capital calculation, creativity valuation, and others. This time, the author uses the examples of entropy counteracting reports taken from outstanding literary works/masterpieces (V. Hugo, B. Schulz, G.W. Sebald and P. Próchniak). The aim is to answer the questions: How the “spirit” of accounting and thermodynamics manifests itself in literature? Can belles-lettres become a bridge between two cultures: natural and social sciences? What benefits derive from it (for the accounting and the economy)? All the above is consistent with the definition of Peter Atkins, according to which the science seeks the elusive spirit of the studied phenomena and formulated theories elsewhere.

Keywords: capital, accounting, entropy, art, literature

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UNDERSTANDING QUANTUM THEORY AS ENGINEERING THERMODYNAMICS

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ABSTRACT

Feynman insisted 'no one understands quantum theory'. Yet, experimentalists tell us quantum theory is the most successful theory in history. Quantum theory cannot be understood as a classical mechanical theory since it arose through the 'interpolation' of two highly successful but complementary classical mechanics: Newtonian particle mechanics and Maxwellian wave mechanics. Just as particles and waves are complementary, these two mechanics are complementary. Consequently, as illustrated by the two-slit experiment, what is experienced depends on one's choice of experimental setup. My thesis is that quantum theory can only be properly understood within the more general framework of engineering thermodynamics. In Part One I point to four essential characteristics of quantum theory that cannot possibly be understood in any classical framework defined by the presuppositions of symmetry and conservation. These four characteristics are: (1) the participatory (2) the complementary (3) the indeterminate (uncertainty) and (4) the new non-commutative mathematics (AB≠BA). In Part Two, following Atkins, I note there are two histories and two current formulations of thermodynamics: the Carnots' engineering thermodynamics and the 'rational mechanical' tradition of Clausius and Boltzmann. I will show that the four essential characteristics of quantum theory are natural characteristics of engineering thermodynamics.

Keywords: quantum theory, engineering thermodynamics, participatory, complementary, indeterminate, non-commutative, Leibniz, Statics to Dynamics, Lazare Carnot

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HUMAN LIFE AND NATURE

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ABSTRACT

The life of human beings, the most developed species on earth, is shaped by forces not yet clearly understood scientifically. Human life is sustained by space, time, and something, beyond both space and time and generally described as the core of existence or the self. The attempts to understand the self scientifically is difficult because all scientific observations require at least an observer and observed but in the process of the minute observation of the self, the gap between the observer and the observed gradually decreases. When the gap becomes zero, the observation process fails. A full understanding of the Human lives requires understanding the core of existence besides those attributes that can be physically measured and observed. Discovering the true uniqueness of human beings that separate them from other species is increasingly getting important to initiate the slow down the trend of entropy increase in nature due to the physical developmental works. In physical level, human lives are pretty much governed by the First and second law of Thermodynamics. Therefore, it becomes difficult to reduce and limit the irreversible damage to eco-system in view of the increasing human population and their capability to induce large-scale adverse effect on the finite natural system of earth, unless the style of living and the focus of physical developments are in tuned with the fundamental requirements of the self. The paper examines whether the concept of happiness, peace, satisfaction, in human life as normally understood requires re-assessment in order to move ahead sustainably.

Keywords: human lives, sustainability, development

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THE HUMANISTIC BASES OF SYSTEMS SCIENCE

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ABSTRACT

Systems science has evolved in relation to both the theoretical and the practical concerns of human welfare. We present a brief overview and assessment of the systems sciences by considering their origins and foundations in general systems thinking. The review leads to a consideration of the ways in which it complements and contrasts disciplinary methods of human-related studies. It discusses the potential for the systems sciences to enrich descriptive, instructional, and explanatory orientations of contemporary *Geisteswissenschaften* through the inclusion of normative considerations. The normative component of the systems sciences is considered within an evolutionary framework that presents holism as a methodology for understanding the dynamics of complex "real-world" (ontological) systems, and suggests action imperatives for their viable and sustainable design over time. Through the tools of metaphor, modeling and simulation, interactive design and other praxes, systems scientists investigate the goals and ends of systems and their interactions within environments shared with, and provided for, one another. In this way, social systems in general and human activity systems in particular can be described in function of their degree of purposefulness, in terms of the role of human values in concrete circumstances. In this sphere of the systems sciences there is a meeting place of pure and humanistic science, as the former becomes the ground for the latter. The systems sciences draw on the insights gained in both the social and the natural sciences, while both these sciences use the products and results of systems-scientific analysis and design. Through the tools of systems thinking and design, systems science represents the world of symbols, values, social entities, and cultures as embedded in an embracing order of hierarchies that bridges the gap between C. P. Snow's "Two Cultures" of the sciences and the humanities. The use of modeling in systems sciences provides the language of design and the means by which creativity is applied in the course of inventing, making, assessing, and implementing the designs. In this way it lends to the human sciences the capability to deal with increasing systemic complexities, rapid societal changes, and design decisions that affect the sustainable evolution of human societies within the wider context of their life support systems.

Keywords: system science, human welfare, social system, holism, humanities

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PECULIARITIES OF THE GRAVITATIONAL ENTROPY

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ABSTRACT

Entropy is lack of information, i.e., ignorance. How does this ignorance manifests itself physically. In variegated ways, of course. Just to fix ideas, we concentrate our attention now in an emblematic example: the Harmonic Oscillator (HO). The basic physical quantity one has to know in dealing with an HO is its frequency ω.
Let us begin with quantum HO at the temperature T . Let k_B stand for Boltzmann's constant, β for the inverse temperature T, and $e_{\pm} = \exp[\pm\beta\hbar\omega]$. Then we have

$$S_{qHO} = -k_B \ln(1 - e_-) + (\hbar\omega/T)[\frac{e_-}{1 - e_-}]. \quad (1)$$

It diverges if $\omega = 0$. Our ignorance is infinite. Consider now the classical HO. We have

$$S_{cHO} = -k_B \ln(\frac{\hbar\omega}{k_B T}) + constant, \quad (2)$$

that also diverges for $\omega = 0$. We see then that if the critical quantity for the theory vanishes, the ignorance augments without bounds. We will be concerned next with gravity. The critical piece of knowledge is the gravitational constant G, or more properly, the quantity $x = Gm_1m_2/k_BT$ if the m's are the interacting masses, T the temperature, and k_B Boltzmann's constant. What happens for $G = 0$? The answer is much more complicated in this scenario, as we discuss in the talk. As it is well known, appealing to conventional integration tools the gravitational thermodynamic functions turn out to be not finite . This difficulty can be circumvented by using special mathematical techniques. This involves using a combination of 1) a generalization of the dimensional regularization method and 2) an analytical extension of an associated integral made by Gradshtein and Rizik in their celebrated Table.

Keywords: entropy, information, gravity, harmonic oscillator

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AN EFFICIENT RANKING OF NODES AND EDGES ACCORDING TO THEIR IMPACT ON GRAPH VON NEUMANN ENTROPY

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ABSTRACT

Measuring the importance of edges (and subsequently nodes) is a central task in network science and complex systems, yet this pursuit has not been sufficiently explored from the perspective of information theory. To this end, we utilize the framework of von Neumann entropy (VNE) for networks and quantify the importance of edges by studying how their removals change the network's VNE. We study a formulation for VNE that is based on the eigenspectra of a Laplacian matrix, which allows us to interpret VNE (and the rankings obtained therefrom) using the perspective of diffusion dynamics. Specifically, there is intuition in our formulation which relates to heat diffusion of statistical thermodynamics. We study VNE-based rankings for synthetic and empirical networks based on the U.S. Senate, the London rail system (Fig. 1), and the human brain, exploring how the rankings change as we vary a time-scale parameter □ > 0. For example, when studying networks drawn from a stochastic block model, we find that the edges between communities can either be the top-ranked edges or have intermediate ranks, depending on □. As a practical consideration, these VNE-based rankings are too computationally expensive to directly apply to large networks, and we therefore introduce approximate rankings that utilize spectral perturba- tion theory to efficiently approximate how edge removals affect VNE.

Keywords: complex systems, network science, society, thermodynamics

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ZENTROPY

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Abstract

Entropy drives changes in all systems from quantum to black holes. In the scientific literature, three categories of entropy are usually discussed, i.e., thermodynamic, statistical, and quantum. Thermodynamic entropy represents the total entropy of a system and in physical science is obtained by integration of heat capacity over temperature from zero K to the temperature of investigation. Statistical entropy usually refers to classical statistical mechanics in terms of Gibbs distribution. While quantum entropy includes contributions from thermal electrons and phonons in terms of Fermi-Dirac and Bose Einstein distributions. The zentropy theory postulates that the combination of quantum and statistical entropies equals to the thermodynamic entropy and can be derived from the partition function when the internal energy of each configuration is substituted by its free energy as each configuration is a mixture of many pure quantum states. It is demonstrated that the zentropy theory is capable of predicting emergent phenomena including their limits at critical points where singularity appears [1].

Keywords: entropy, zentropy, internal energy, free energy, emergent phenomenon

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AXIOMATIC CHARACTERIZATION OF STATISTICAL COMPLEXITY MEASURES

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ABSTRACT

In the past, different definitions of statistical complexity were introduced based on different definitions of generalized entropies and generalized certainty measures, as an interplay between order and disorder levels of the system. However, there is no general agreement on which one is preferable since it has still not been accepted what constitutes a set of basic properties that a complexity measure should satisfy. In this work, we provide a general treatment of the statistical complexity measures starting from a set of ineluctable properties, which are stated as axioms, by which the statistical complexity measure of a discrete system is defined as a non-negative function of entropy and certainty measures, which is decomposable and attains the minimal value, in the case of fully ordered and fully disordered systems, which are considered to be the simplest one. Moreover, we require that the measure has a finite and non-vanishing limit when a discrete system tends to a continuous one, being invariant under rescaling, translation, and replication. Thus, we propose a generalized statistical complexity measure for discrete systems and differential generalized statistical complexity for continuous systems, which include some of the previously considered measures as special cases and which satisfy all the axioms. Some open questions for future research are pointed out.

Keywords: statistical complexity measures, generalized entropies, certainty measures, strongly pseudo-additive entropies, order and disorder

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DIFFERENTIAL FORMS IN THERMODYNAMICS AND ECONOMICS

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ABSTRACT

Alternating differential forms introduced by Élie Cartan (1894) have been successfully used in science. In this contribution differential forms in two dimensions are applied to thermodynamics depending on pressure and volume; and to economics depending on capital and labor.

1. In two-dimensional calculus we have complete differential forms (d E) and incomplete differential forms (đ Q). Complete differentials may be integrated by a Riemann integral, which lead to the stem function €. Incomplete differentials do not have a stem function, the Stokes integral is path dependent.

2. In thermodynamics a conservative term like energy may be represented by a complete differential form (d E). A not-conservative term like heat may be represented by an incomplete differential form (đ Q). The observation *"Heat is created by frictional work"*, , leads to the first and second laws of thermodynamics.

3. In economics, complete differential forms (d K) correspond to predictable (ex-ante) terms like interest from a savings contract. Incomplete differential forms (đ Y) represent not-predictable (ex-post) terms like income from stock markets or invested labor - (đ L). The observation *"Income is created by labor"*, , leads to the differential laws of economics.

4. It may be surprising to find the differential laws of thermodynamics the same as the differential laws of economics. But this must be true, as it is now common to apply statistical mechanics to problems of economics. Thermodynamics is closely connected to most other natural sciences. In the same way economics is closely related to most other social sciences. Accordingly, this correspondence applies more general to all natural and social sciences. This may be confirmed by applying the laws in social problems. Natural sciences and social sciences follow the same equations, only the objects and the interactions are different: Atoms follow electro-magnetic fields, people follow emotions. Both types of interactions can be attractive, indifferent or repulsive.

Keywords: differential forms, income, heat, energy, capital, work, labor, electro-magnetic fields, emotions

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THERMODYNAMICS AS A BASIS OF PHYSICAL ECONOMICS

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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. The solution of this cognitive problem in terms of the category of capital opened the way to economic theories in the sciences formula. The basis of science is the correct definition of basic concepts, identification of axioms and laws functioning within a given scientific discipline. In economic sciences for many years there has been a considerable dissonance regarding such basic issues, which often makes it impossible to conduct scientific discourse between researchers and create a coherent theory. The famous economist Ch. Bliss in 1975 wrote: “When economists reach agreement on the theory of capital they will shortly reach agreement on everything”. This extremely important statement leads to the identification of a key concept in the economic sciences. This is where thermodynamics comes to the rescue, making it possible to find the correct definition of capital as an analogy to energy in physics. Just as in the physical sciences energy does not arise from nothing, so capital does not arise from nothing and should be understood as the potential ability to perform work. From this basis one can derive further nodal definitions of concepts such as money, monetary unit, economic value, or more technical ones, such as depreciation. The set of fundamental principles, which include the principles of thermodynamics, determine the scientific framework of theories describing reality. Fundamental principles are often associated with constants that reveal what theories cannot explain. Together with the principles of thermodynamics, the discovered economic constant 0.08/year opens the way to the formulation of physical economic theory as a natural science.

Keywords: capital, duality, energy-matter, economic constant, physical economics

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TWO-CLASS INCOME DISTRIBUTION IN THE USA IN 1983-2018

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ABSTRACT

The first part of our paper [1] is a brief survey of the approaches to economic inequality based on ideas from statistical physics and kinetic theory. These include the Boltzmann kinetic equation, the time-reversal symmetry, the ergodicity hypothesis, entropy maximization, and the Fokker-Planck equation. The origins of the exponential Boltzmann-Gibbs distribution and the Pareto power law are discussed in relation to additive and multiplicative stochastic processes. The second part of the paper analyzes income distribution data in the USA for the time period 1983-2018 using a two-class decomposition. We present overwhelming evidence that the lower class (more than 90% of the population) is described by the exponential distribution, whereas the upper class (about 4% of the population in 2018) by the power law. We show that the significant growth of inequality during this time period is due to the sharp increase in the upper-class income share, whereas relative inequality within the lower class remains constant. We speculate that the expansion of the upper-class population and income shares may be due to increasing digitization and non-locality of the economy in the last 40 years.

Keywords: econophysics, entropy, inequality

References:

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EVOLUTIONARY IMPLICATIONS OF THE COLLECTIVE INTELLIGENCE OF CELLS VIA DEVELOPMENTAL BIOELECTRIC SIGNALING

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ABSTRACT

Central to the evolutionary process are the genes that are the target of random mutation and the body structure and function upon which selection acts. But the relationship between the genotype and the anatomy is not direct: body form arises as the action of the collective intelligence of cells navigating morphospace. Cells used to be independent organisms, and did not lose their basal intelligence when cooperating to form multicellular bodies. In this talk, I will describe examples of problem-solving by cellular collectives, and show the bioelectric mechanisms that serve as a kind of "cognitive glue" that enables them to act coherently toward specific physiological and anatomical goals. I will describe how these cellular competencies arise during evolution, and explore hypotheses about the many ways in which the intelligence of anatomical homeostasis impacts the rate and direction of evolutionary change. Each of us took the slow, gradual journey across the Cartesian Cut, starting out as a bag of chemicals (an unfertilized egg) and becoming a complex sentient being with self-awareness. This process, on both developmental and evolutionary timescales, offers a fascinating window into the ways in which evolution exploits physics and computation to scale ubiquitous minimal cognition into progressively larger minds.

Keywords: evolution, developmental biology, embryo, bioelectricity, regeneration, basal cognition

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EVOLUTION, COGNITION, AND THERMODYNAMICS

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ABSTRACT

Classical Darwinism can be summarized as a theory of adaptation informed by memory. As classical Darwinism morphed into a mechanical theory of gene selection, Darwinism's theoretical foundation has become increasingly alienated from the distinctive phenomenon of life itself. Among life's distinctive attributes is adaptation, which is a knowledgeable and inherently purposeful process. includes adaptation as a distinctive feature. Starting from first principles, I build a model of adaptation in the context of life as a thermodynamic phenomenon. Along with this, a broader concept of hereditary memory emerges that goes beyond modern Darwinism's narrow gene-centric focus, which recovers Darwin's own vision of evolution as adaptation informed by memory. At the same time, adaptation's inescapable purposefulness makes evolution a purposeful phenomenon, and undercuts Darwin's concept of evolution as natural selection.

Keywords: adaptation, hereditary memory, niche construction, purposefulness, natural selection

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A COMPREHENSIVE, HOLISTIC CELL THEORY OF THERMODYNAMICS AND LIFE

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ABSTRACT

Consciousness-based Evolution [1-3] is based on the premise that consciousness is derived from the Laws of Nature, constituting Cosmic Consciousness. The breakthrough experiment in understanding the link between physics and physiology was the loss of cellular identity in the absence of gravity [4]. The concept of consciousness as physiology was formulated by tracing the cell-cell communications that underpin embryologic development, phylogeny and injury-repair alike [5], based on The First Principles of Physiology [6]. It is through this merging of the animate and inanimate that the dissipation of heat energy based on the Second Law of Thermodynamics is circumvented over the course of the lifecycle, enabling the organism to collect epigenetic marks (Lamarck Inheritance) in order to inform the developing offspring of on-coming changes in the environment in order to adapt effectively. This strategy has been reverse-engineered all the way back to Quantum Mechanics as the fundament by focusing on emergent events underpinned by pre-adaptions (Darwin; S.J. Gould), the penultimate change being gravity impinging on the protocell, generating energy for Quantum Entanglement of particles within the cell (local), referencing gravitational forces in the Cosmos (non-local). This perspective accounts for all 6 listed outstanding questions to be addressed at Thermodynamics 2.0, constituting a unifying theory to be acquitted in my presentation.

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A QUANTUM MODEL OF STOCK MARKETS

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ABSTRACT

This talk presents a quantum harmonic oscillator model of price fluctuations in a stock market, which builds on a previously-published quantum model of supply and demand, and can be viewed as a quantized version of a classical econometrics model first proposed in 1933. An advantage of the approach is that it interprets market behavior in terms of entropic forces which, when expressed in quantum terms, can account for a variety of behavioral effects of the sort studied in quantum cognition and quantum decision theory. The model helps to interpret quantities such as force, mass, frequency and energy in a financial setting, and is consistent with observed phenomena such as the square-root behavior of price impact.

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Keywords: price fluctuation, harmonic oscillator, entropic forces, stock market

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OSCILLATOR MODEL FOR RISKY CORPORATE COUPON BONDS

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ABSTRACT

An exact model for Merton's formulation of risky coupon bond is derived. The coupons are stochastic, depending on the market capitalization of the issuing firms. The model has been empirically tested using 40 coupon bonds on the NYSE. Some of the results are discussed.

Keywords: oscillator model, coupon bonds, stochastic, Merton's model,

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THE QUANTUM FOUNDATIONS OF UTILITY: RESOLVING THE INCOMPLETENESS OF ECONOMIC THEORY

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ABSTRACT

Modern economic theory rests upon the von Neumann and Morgenstern axioms of Game Theory. With the rapid development of quantum computing, these familiar axioms fundamentally limit the strategy space to purely classical strategies. To resolve this deficiency, we propose a set of axioms for game theory that are based upon the axioms of quantum mechanics. We recover classical game theory at the classical limit of a quantum system. We find that utility under these more general axioms can be represented as any quantum observable and propose using the Hamiltonian as the unique quantum observable defining utility. Using empirical data, we show that classical preference is canonically distributed, justifying the use of the Hamiltonian as utility. Under this formalism, we see that the Allais paradox is a system of a mixture of two different strategies and propose that the reason for the two strategies is that what the players in the game are considering is the Helmholtz potential, which is dependent upon utility, the risk preference (temperature), and the entropy (uncertainty) of the game. With the foundations of microeconomics firmly in place we formally extend microeconomic theory to macroeconomics using the independence and indistinguishability principles. These principles in the general class of non-cooperative games results in people being characterized as bosons. This new formulation of economic theory is known as statistical economics.

Keywords: quantum mechanics, game theory, Allais paradox, entropy, statistical economics

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THE USE OF EXERGY FOR AN ALTERNATIVE, MONEYLESS, SOCIOECONOMIC SYSTEM

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ABSTRACT

The current socioeconomic system uses a debt based monetary system which enables people to exchange labour for money that they can use to purchase goods or services. This system has a number of problems with it; it results in a small percentage of the population controlling most of the resources of the planet, it results in poverty and starvation, and it has a fundamental unsustainable nature. Thus, EOS proposes an alternative system based on the energy it takes to produce goods within the system. Our proposal starts from the fact that the production of goods forms an example of a physical resource allocation system and as such requires energy to run. The energy and physical resources available places a limit of what the system can do. This paper has the following layout: first, an overview of our current system and exponential growth and why we need to explore an alternative; second, socioeconomic systems as a resources allocation system and third, an overview of energy accounting.

Keywords: exergy, sustainability, socioeconomics, resource allocation, growth

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THE THERMODYNAMIC NATURE OF TIME

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ABSTRACT

David Park, editor and co-author of 'Study of Time' (1972) wrote that 'The passage of time does not need to be explained by physics'. It is a fact that there are great discrepancies in the views of physicists, which do not disappear with the passage of time. For example, David Deutsch questions Isaac Newton's definition of time, especially the fact that time passes evenly. At the same time, he disregards human common sense and Arthur Eddington's warning: '...our intuitive sense of time's passage is so powerful that it must correspond to something in the objective world. If science cannot get purchase on it, one might say, well, so much the worse for science...' As Immanuel Kant explained time is closely related to human consciousness and mind, so it can be absolute only in the sense that it elapses equally for all modern humans with a normal emotional state. When there is no humanity, there will be no passage of time, but the laws of thermodynamics, gravity and the principle of conservation of momentum will apply. Time is thermodynamic in nature. Therefore, identification of objects undergoing the process of transformation is required. They are specified by the following definition. Time is the process of transformation of the stock of primary vital energy of modern man into the ability to perform work, i.e. personal human capital. The rate of passage of time is constant and independent of anything. This rate is determined by the constant a = 0.08 [1/year]. According to the term, time passes uniformly at an equal rate. But this uniform rate causes that the effects of transformation are not linear but exponential. With the initial value of the vital energy 1.0, the transformation is represented by the function $Z_t = e^{-at}$ for t = 0, 1, 2, ..., 120, where t - the number of astronomical years, and a - is the constant of the passage of time. At t = 120 years, $Z_{120} \approx 0$. Gerontologists point to the number 120 as the absolute end of human life, and this length of life is also recorded in ancient texts. Consideration of the thermodynamic nature of time combined with the achievements of astronomers and scholars who oversee the calendar completes the knowledge of time essential for modern man.

Keywords: thermodynamics, definition of time, constant of time passage, human capital

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THERMODYNAMIC BACKGROUND OF MODELING THE MEASUREMENT OF RETURNS ON HUMAN CAPITAL. AN EXAMPLE OF THE RUSSIAN ECONOMY

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ABSTRACT

There are times when we wonder whether investments in human resources or physical resources are more profitable. In both cases, we invest the same capital, and the creative use of human and physical resources leads to the creation of new capital carriers. The article presents an original method of calculating the rates of return on human capital. This method was used to calculate the profitability of the human capital of employees in Russia in 2013 - 2018. The article uses a model for measuring the individual human capital of employees derived from the general concept of capital. The category of capital used in the work meets the requirements of the methodology of natural sciences, and thus takes into account the fundamental laws of nature, the abstract nature of the issues under consideration, and allows for the existence of constants. In the developed concept, capital is an abstract quantity that is subject to natural influences. The analysis of these interactions also led to the discovery of the economic constant included in the formula of capital. The value of this constant represents the natural potential of capital for growth, equal to 8% per annum. Capital is an abstract category that does not come from nothing, it is possible to indicate its origin. Capital is a category with a value that changes over time and is transferred in economic processes. It can be concluded that the value of capital is influenced by thermodynamic processes. Ultimately, a proper description of capital and its sources of growth is possible through the application of the first and second laws of thermodynamics. The discovered economic constant is the consequence of the constant flow of time. It is indispensable in modeling the most important economic issues such as capital and human capital measurement, profit and remuneration analysis. The rate of return on human capital is calculated as the relation between the received annual remuneration and the value of human capital. The calculations were carried out at the macroeconomic level, which required the total amount of annual wages in Russia and the value of human capital of all employees. Information on the aggregate amount of wages was obtained directly from the Russian statistical office. Human capital is a function of the cost of living, the employee's level of education and the scope of his professional experience. Obtaining the aggregate value of the human capital of employees required the development of a model of the distribution of the human capital of the employed. The distribution of human capital is a derivative of the distribution of education and work experience among those employed in the Russian economy. The calculations show that the average rate of return on human capital in the analyzed period is 8.15% (minimum 7.44%, maximum 8.79%). An additional conclusion from the calculations is the confirmation of the 8% value of the economic constant as a deterministic value. This means that the economic constant also determines the level of human capital remuneration.

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Keywords:Economicconstant,capital,humancapital,rateofreturnonhumancapital,lawsofthermodynamics

ABSTRACT

The Measure of Gross Domestic Product (GDP) in the System of Accounts for Global Entropy Production (SAGE-P)

Gross Domestic Product (GDP) are values conserved-in-exchange (or prices) of all the final goods and services produced per annum by the Nation. The I/O matrix of market-value GDP assumes a symmetric translation (or mapping) → I/O matrix of the Material-Energy Balance Statistical System, (MEBSS).[1] The paper applies the Second Law of Thermodynamics to GDP.

SAGE-P assumes a three-dimensional accounting structure of economic, social and ecological values mapped on any well-defined I/O algorithm of (material) production → neg-entropy and consumption → entropy. The 'balance sheet' assumes the measure of the quantities and qualities (health, integrity and resilience) of economic, social, human and natural capital. The latter are redefined in terms of the Low Entropy Fund (LEF) available for human consumption, (GeorgescuRoegen,1971).

This paper describes the statistical method, with a special focus of algorithms for mining 'Big Data' and the conceptual potential for restructuring the System of National Accounts, (SNA) to be consistent with the Second Law of thermodynamics.

Government Policies of Climate Change, among other emergent issues of the Digital Age, are framed in the measure of economic growth in GDP. De-growth of GDP is seen by many experts, as a necessary condition for transition to net-zero greenhouse gas emission and towards a green economy. At the same time, higher incomes (work) are seen as a trade-off for leisure and self-actualization.

The trade-off in Policies measured against de-growth in GDP is illusionary. The proper focus of transitions Policies toward the so-called Green Economy, is found in entropy efficiencies measures of (a) consumption, (b) production and (a) capital. This may be formulated as a policy objective:
(a) Decrease to a minimum any socially acceptable rate of entropy production per unit of consumption, (i.e., values conserved in use and/or participation);

(b) increase to a maximum any economically acceptable rate of neg-entropy production per unit of production, (i.e., values conserved in exchange and/or prices);

(c) maintain the Low Entropy Fund available for human consumption at sustainable rate of entropy production. ion

GDP is expressed as a (linear) measure of the annual production of the (final) goods and services produced in the Domestic Economy measured at market prices. It is a gross value insofar as it does not subtract from GDP the annual rate of depreciation of the Nation's stock of Economic, Social, Human and Natural Capital upon which GDP is a fully dependent variable. The accounts are constructed from the following identities: (a) Production, P □ Y (Income), (i.e., payments for work and/or dividend/rent), (b) Consumption, C □ E, (Expenditure), (i.e., payments for goods and services), (c) Capital, K □ S (Saving), and (d) Trade with the rest-of-the World, T □ X (Exports) - M (Imports) □ deficit/surplus in the balance-of-trade.
The SAGE-P enables any well-defined objects and/or functions of the GDP to be translated in the language of 'thermodynamics' expressed as equivalences (i.e., symmetries) of entropy production. Thus, production (P), consumption (C) and capital accumulation (K) are reformulated into the statistics of: (a) neg-entropy production, (Pe), (b) entropy production, (Ce) and (c) net-value of entropy production, (Pe - Ce = Ke), where Ke □ Low Entropy Fund [LEF] available for human consumption at any instant in time (t). Trade with the rest-of-the-world assumes the flow across the boundary of the the nested topological domain spaces (TDS): (A) Ecosphere, [(B) Sociosphere, {(C) Econosphere]} where export Xe = outflow and import Me = inflow of entropy production.

The outflow of entropy production (e.g., waste residuals) of the (material) GDP are mapped to the TDS of A → as values conserved-in-themselves, (i.e., existential), the TDS of B → as values conserved-in-use, (i.e., participation) and TDS of C → as values conserved-in-exchange, (i.e.,prices). The value mapping is reversed for the inflow of LEF into the GDP. LEF may be assessed in both time and space in the following state-conditions: (i) Surplus-state = Pe/Ce > 1, (ii) Deficit-state = Pe/Ce < 1, and (iii) Steady-state = Pe/Ce = 1.

The assessment of sustainable GDP are the anticipatory models of the future state conditions of the LEF of the Nation available for human consumption. This may be further reduced to projections of surplus, deficit or steadystate condition of: (a) primary production (i.e., harvesting/extraction), (b) secondary production, (i.e., manufacturing) and (c) tertiary production, (i.e., services). The policy objective is to reduce to an absolute minimum the rate of entropy production per unit of consumption given: (a) the current, and future, state of technology, (b) the minimum socially acceptable rate of entropy and (c) limits of the Ecosphere to the material-energy engendered by GDP.

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1 Materials and energy balances are accounting tables that provide information on the material input into an economy delivered by the natural environment, the transformation and use of that input in economic processes (extraction, conversion, manufacturing, consumption) and its return to the natural environment as residuals (wastes). The accounting concepts involved are founded on the First Law of Thermodynamics, which states that matter (mass/ energy) is neither created nor destroyed by any physical process. (Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997).

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EXPLORING A THERMODYNAMICS OF INTERDEPENDENCE FOR AUTONOMOUS HUMAN- MACHINE TEAMS WITH CASE STUDIES

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ABSTRACT

Autonomy has begun to receive significant attention, but neither the theory nor the science has developed sufficiently to be able to design and operate an autonomous human-machine system (HMS). In this report, we review the shift from laboratory studies, which have been unable to advance the science of autonomy, to a theory of autonomy in open and uncertain environments along with supporting evidence from case studies. The need for this shift we attribute to the focus by the social sciences primarily on a science of individual, independent agents, whether for humans or machines, a focus that has been unable to generalize to new theory and new predictions. This failure of traditional social science (including economics) predicated on the individual cannot even reconstruct the social events being studied and is the problem to be overcome as prelude to solving the thermodynamics we explore. We introduce a concept from Gibbs for the energy available and entropy capacity of a team in operation by assuming it crudely approximates a fluid. As part of this review, we present a case study of how an Uber self-driving car and its operator failed to prevent a pedestrian fatality; how the US Air Force made a tragic mistake with a drone attack in Afghanistan; and how the US Department of Energy overcame the extraordinary environmental damage its practices inflicted across the USA. To advance the science, we reject independence among teammates as a viable scientific approach for teams and instead explore what we know about a theory of interdependence for human-machine systems.

Keywords: autonomy, human-machine system, interdependence, thermodynamics

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MODELING HISTORICAL DYNASTIES AS EMERGENT, DISSIPATIVE MECHANISMS

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ABSTRACT

Societies strive to maximize their economic production in accordance with the Maximum Power Principle and its implications for entropy increase. Societies and firms achieve this maximization, in part, by striving for greater efficiency via increasing their economies of scale. However, the process of establishing the structures and institutions required for economies of scale may exhibit substantial barriers to reversibility. This paper traces processes of attaining greater economies of scale using thermodynamic concepts and well as the thermodynamic implications of regimes facing intrinsic drops of overall efficiency and resource depletion. This paper applies this approach to modeling historical dynasties as emergent, dissipative mechanisms and shows how human history can, in part, be modeled as a progression of series of interacting dynastic dissipative mechanisms.

Keywords: world history, dynasties, Maximum Power Principle, entropy, dissipative mechanisms

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MODELING THE ECONOMY AS A DISSIPATIVE STRUCTURE WITH SCARCE RESOURCES

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ABSTRACT

We provide a formal framework allowing to embed macroeconomic modeling within a thermodynamic realm. An economy is viewed as a dissipative structure, that is, an out-of-equilibrium complex system obeying the laws of irreversible thermodynamics, perpetually trading energy and matter flows with its environment to grow, sustain, and complexify itself. Manufactured goods are reshaped matter whose economic value rests partly on its added internal orderliness. Industrial production is modeled as a thermodynamic conversion, operated over finite stocks of resources, whose physical consistency obtains courtesy of a minimal disaggregation of firms into two sectors of complementary thermodynamic roles: The energy sector extracts energy from the degradation of low-entropy natural resources; the manufacturing sector uses that energy to order up raw materials into manufactured non-recyclable goods and capital. The latter is reinvested into the balanced growth of both sectors. The resulting stock-flow consistent thermo-economic dynamics highlights the effects of resource scarcity on GDP and other economic indicators like under-employment, production costs and income distribution. Useful power is identified as the key through-flow of the economic process. We show that energy shortages result in immediate recessions. By contrast, the progressive dilution of mineral resources critical to industry can result in long-standing secular stagnation accompanied with rising inequalities.

Keywords: macroeconomic modeling, dissipative structure, exhaustible resources, energy peaks, secular stagnation

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WHAT IS ENTROPY AND HOW TO PRODUCTIVELY EMPLOY THIS CONCEPT

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ABSTRACT

This note discusses benefits a thoughtful thermodynamic analysis might in fact bring to generalize scientific research methodology. Not only engineers but also specialists in natural and social sciences are interested in cooperative phenomena in many-body systems. To thoughtfully analyze the pertinent mechanisms, we need first to clarify, what ought to be the relevant driving/livening forces. To manage describing the latter, Carnot's Thermodynamics or, in other words, energetics does allow for Intensity of the Energy Form in question. Above is the necessary first step. Next, it is important to realize what ought to be the realistic forces to effectively counteract the dynamics the driving/livening forces under study tend to cause. Thanks to Carnot's genius, we know now: Overcoming ubiquitous obstacles/hindrances/resistances ought to be the actual general essence both inanimate and animate branches of Nature functioning, that is, experiencing their truly eternal dynamics. Carnot's actual problem has been to grasp why natural dynamics eternal indeed does never allow us to invent any kind of *Perpetuum Mobile*? Carnot's answer has been ingenious: Even if we do imagine an ideal heat machine whose working cycle is cyclic – and whose apparent technical difficulties: frictions, heat exchange, etc., are striving for zero – we would never arrive at 100% of the energy efficiency ratio. Why? Because of counteraction's ubiquity of an action, just as Isaac Newton taught us. Thanks to geniuses of Clausius and Lord Kelvin, we know that the eternal action-counteraction struggle is describable by energy transformation, which is, in fact, energy devaluation, as the Intensity of the Energy Form at work diminishes due to the eternal action-counteraction struggle. Entropy is then synonymous to sum of counteractions, which might never be infinite, for it always reaches its maximum.

Keywords: entropy, enthalpy, compensation, implicit, explicit, energetics, thermodynamics

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OPTIMAL TRUNCATION CRITERION FOR COMPOUND PARABOLIC COLLECTORS: A THERMODYNAMIC JUSTIFICATION.

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ABSTRACT

The origin of compound parabolic concentrators (CPC) can be traced back to the mid-'60s by the developments of Baranov (USSR), Ploke (Germany), and Winston (USA), who independently described an optical system, unlike traditional systems, based on the optimal transfer of radiation, even if this implies forming aberrations, which allows reaching the thermodynamic limit for solar concentrators. Today, there is already a wide development of CPCs for solar applications, and several geometries have been generated that take advantage of non-imaging optics to concentrate solar energy on receivers of different shapes (circular, square, triangular, wedge, flat...). One problem with CPCs is that the ratio of height vs. area of the receiver (slenderness) is too large, i.e. these concentrators are too high, and this ultimately limits their application. For several years, different truncation criteria have been proposed to decrease the total height, although all have been developed from a purely geometrical perspective. However, it is possible to derive one of them from a thermodynamic perspective, which allows us to call it an optimal truncation criterion.

Keywords: CPC, truncation, optimization, thermodynamic limit, solar energy

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CREATED BY PREDICTION: ON THE HISTORY, ONTOLOGY, AND COMPUTATION OF THE LENNARD-JONES FLUID

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ABSTRACT

The Lennard-Jones (LJ) fluid, named after mathematician-physicist-chemist Sir John Lennard-Jones (1894-1954), occupies a special place among fluids. It is an ideal entity, defined as the fluid whose particles interact according to the Lennard-Jones potential. This potential describes the pairwise repelling (very small distance) and attracting (van der Waals) forces with a relatively simple and mathematically tractable expression. The contribution discusses the history of the LJ fluid in four acts. Act one starts with classical mechanics and leads to the early 20th century when theoreticians like Mie, London, and Lennard-Jones combined available data and mathematics with (theoretical) idealization. Act two reports the ease with which the computational approach incorporated quantum theory. The Lennard-Jones potential occupied a leading position. Act three welcomes the computer on the stage. Pioneering works in the 1950s and 1960s explored simulation methods to solve the "classical" equations for a large number of particles. Molecular dynamics grew into a widely used tool in both science and engineering for predicting the properties of materials. In this field, the LJ fluid acquired paradigmatic status ("the ubiquitous"). Act four offers a surprising twist. Recent work reports problems with reproducibility of LJ simulations. Although the simulations target the mathematically defined ideal object, the object that is actually simulated is different. This leads to the question of what the simulated LJ fluid actually is. Answering this "what" question requires an inquiry into the "how" question, i.e., into the methodology of simulation modeling. Viewed from the perspective of simulation, there is an under-examined layer of modeling steps that are relevant for many properties—and finally for the identity—of the simulated LJ fluid. Hence the allegedly most ideal of all fluids, created by mathematical prediction, turns out to have a bricolage character in practice.

Keywords: engineering thermodynamics, philosophy, history, simulation modeling

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THE THERMODYNAMIC EFFECTS OF STEAM INJECTION AND EXHAUST GAS RECIRCULATION APPLICATIONS ON COMBUSTION IN INTERNAL COMBUSTION ENGINES

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ABSTRACT

Applications of water/steam injection and exhaust gas recirculation (EGR) in the combustion chamber are methods proven to reduce harmful emissions and improve the performance of many internal combustion engine types. The two applications have become very popular to use both separately and together. Internal combustion engines are ensured to both increase performance and become environmentally friendly in this way. This study involves the thermodynamic simulation of the combustion of all fuels and mixtures containing CxHyOzNq in the combustion chamber of internal combustion engines. In the combustion analysis, the molarity of each exhaust type is determined with regard to chemical equilibrium according to the equilibrium-constant approach using the water/steam injection and/or EGR applications. According to previous researchers, the thermodynamic properties calculated with this approach based on the equilibrium composition are precise and used directly in predicting the performance of internal combustion engines. This study analyzes the effects from reactant mixtures using steam injection and/or EGR in combustion regarding their thermodynamic properties, as well as the adiabatic flame temperatures and combustion products by using a novel multi-feature equilibrium combustion model. The effect of steam injection and EGR has been calculated for the combustion exergy analysis while also considering changes in the equivalence ratio. Moreover, the indicated parameters for combustion performance, chemical exergy, physical exergy, total specific exergy, and exergy destruction have been painstakingly utilized in the calculations. With regard to the results obtained according to the change in the equivalence ratio, adiabatic flame temperature is observed to decrease as both steam injection and EGR increase. While the addition of steam is seen to increase the constant pressure specific heat, physical exergy, and specific combustion exergy values, the EGR application varies with respect to the lean and rich combustion regions. Meanwhile, the entropy and exergy destruction values have been concluded to increase by adding steam to the combustion chamber and to decreased when EGR is used.

Keywords: combustion, EGR, steam injection, combustion exergy, thermochemical analysis

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EXPERIMENTAL LAW: A THERMODYNAMIC APPROACH

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ABSTRACT

A universal law has been proposed stating that in open systems, increases in free energy can only be achieved by decreases of entropy of the system. Applying this principle to human society assumes that improvements in law and order in a society correspond to decreases in entropy. The same must be true for increases in knowledge, technology and economic productivity. Here we explore the relationship between free energy and entropy studying a countries sociocultural order (negentropy), as estimated by their constitutions, academic development, and national indicators of their rule of law; and free energy or amount of useful work, estimated through indicators of economic productivity, and socioeconomic health using estimates such as the rule of law, GDP, Human Development, and Infant Mortality. Empirically data was collected from the constitutions of 88 countries and related to 230 country indicators. We found strong correlations between indicators of rule of law, corruption and GDP with quantitative characteristics of constitutions such as their length (the numbers of words and articles) and qualitative descriptors (words related to specific concepts) used in their writing. Results suggest that the proliferation of populist descriptors in a constitution correlates negatively with rule of law and socioeconomic development. Our study also suggests that constitutional change confirms the relationship just described, and shows that cause-effect relations go both ways: Constitutions are affected by the social health of a country and vice-versa. Certain socioeconomic characteristics of a country are indicative of a “dysfunctional syndrome”, whereas others form part of a “progressive syndrome”. This is indicative that specific assemblages of characteristics have different entropy levels. Countries with low order and dysfunctional law have high social entropy; whereas progress is related to high economic and scientific development (higher free energy). This suggests that free energy and entropy are related, also in modern human society, and can be used to quantitatively assess the benevolence of specific laws through their effect on society. The assessment of negentropy, however, seems more problematic. Not any kind of order in a constitution has a beneficial effect on a nation’s well-being. Certainly more work is needed to clarify this issue but it seems that thermodynamic considerations do amplify our capacity to explore social and legal issues.

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SOCIAL LASER THEORY

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ABSTRACT

During the last years our society was permanently disturbed by the coherent information waves of high amplitudes. These are waves of huge social energy. Often, they are of the destructive character, a kind of information tsunami. But they can carry as well positive improvements in the human society, as waves of decision making matching rational recommendations of societal institutes. The main distinguishing features of these waves are their high amplitude, coherence (homogeneous character of social actions generated by them), and short time needed for their generation and relaxation. We show that such social phenomenon can be modelled on the basis of the recently developed social laser theory. This theory can be used to model stimulated amplification of coherent social actions. `Actions'' are treated very generally, from mass protests to votes and other collective decisions, as, e.g., acceptance (often unconscious) of some societal recommendations. We point to the main distinguishing features of the modern society simplifying social lasing: a) transformation of humans into social atoms - loss of individuality and increase of indistinguishability; b) generation by mass-media of powerful information fields leading to information overload of social atoms; c) creation of powerful social resonators based on internet Echo Chambers Functioning of internet based social resonators leads to increase of the power of the quantum information field as well as its coherence.

Keywords: social laser, social atoms, social energy, Echo Chambers

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ON THE CONNECTION BETWEEN THE SECOND LAW OF THERMODYNAMICS AND THE SECOND POSTULATE OF RELATIVITY THEORY: SOME ILLUSTRATIONS

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ABSTRACT

In our presentation, we wish to show a similarity of meaning between the Second law of Thermodynamics and the Second postulate of Relativity theory. The concept that allows us to include both principles in the same view is that of homogeneity in space. The Second law expresses that, for an isolated system, matter tends to organize itself in such a way as to occupy a homogeneous distribution in space (through the link between temporal derivatives and spatial gradients). For its part, the Second postulate expresses the "constancy of the speed of light". Without discussing again the meaning of the word *speed* (nor the relations between the two postulates of relativity theory), this convention is essential to establish regular graduations allowing to measure space; to have an operational meaning, these graduations must be based on matter. If this is the case, the homogeneity of space can then be seen, can then be said, whether it is governed by the Second law or by another cause. The two principles studied can both be understood within a probabilistic vision. Some illustrations will be given from the social sciences, at least as allegories. There are indeed many situations in social life where the spatial distances between people must conform to a homogeneous distribution: think of the sanitary distances imposed by the Covid pandemic! Any deviation from homogeneity manifests "forces" that it is interesting to study in order to better understand society (think of the inhomogeneous spatial distribution of the ordinary people and of the priests in a church or a temple; the inhomogeneous spatial distribution of social classes in cities).

Keywords: second law of thermodynamics, second postulate of relativity theory, homogeneity, probability, social sciences

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GENERAL FRAMEWORK FOR OPEN SYSTEMS

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ABSTRACT

Leontief, Nobel laureate in Economy, argued: “How long will researchers working in adjoining fields...abstain from expressing serious concern about the splendid isolation in which academic economics now finds itself?”. That may be difficult for researchers from some overly specific domains because they may build hard boundaries against other knowledge domains. Therefore, it might be worth other researchers investing time for closing such knowledge gaps. By proper language translating among knowledge domains, unsolved problems or missed opportunities might reveal themselves as not so hard to treat as they appear.

To somewhat close such gaps, this paper defines a system as a subset of environment, which is all undifferentiated fields whatsoever, the former being differentiations of the latter. To relate system and environment, one uses the concept of entropy to model the availabilities of environment towards a system, which then gets separated from other systems and environment by boundaries. From such fundamental definitions one develops a simultaneous equation set based on the conservation of quantities and entropy to calculate the maximum sizes of the elements within a system. If one manages to know the network distribution factors amongst the elements of a system, one can calculate the maximum sizes of such elements to cope with the support capacities of environment, also find the optimum system by tweaking the very network distribution factors. Some applications are given: hybrid energy farm, circular system, mathematical relation for project appraisal, EVA-Economic Value Added revisited, risk value added approach, and project as a system. In addition, the entangled quantities time, entropy, and energy are readdressed in one of the appendixes.

At last, the definitions of environment and system enable discoursing about broad and speculative issues like life, consciousness, individuality, and god, for which there is no consensus by the canonical knowledge fields.

Keywords: energy, entropy, environment, system

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MAXIMUM ENTROPY PRODUCTION PRINCIPLE AND SELF-ORGANIZATION

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ABSTRACT

Organization is the creation of flow channel structure in systems away from thermodynamic equilibrium to maximize the rate of flow of matter and energy through the system. As a result, it maximizes its entropy production. Flow channels are defined as the paths of least action for matter and energy through the system, where the obstacles for motion have been minimized by work done by the flows to remove them from the paths. Therefore, the amount of physical action for the flow of matter and energy has been minimized, which can be described by increased action efficiency of the flows. This obstructive constraint minimization is a variational principle by itself connected directly to the principle of least action. Creating this internal structure minimizes the internal entropy of the system as the degrees of freedom of its building blocks have been decreased. Therefore, the decrease in internal entropy of the system corresponds to increase of the external entropy production. We can interpret this, that the second law of thermodynamics is the principle for reducing the internal entropy in systems. In this way, it creates higher levels of organization during development and evolution of systems of any nature, being they physical, chemical, biological, engineering, economical or social. Some examples are Rayleigh-Benard convection cells, vortices, vascular networks in plants and animals, flows of energy in ecosystems and infrastructure systems.

Keywords: Maximum Entropy production principle, second law of Thermodynamics, self-organization, principle of least action, evolution, development

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MAXIMUM ENTROPY PRODUCTION PRINCIPLE AND GLOBAL SOCIETY

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ABSTRACT

Work in recent years has focused on application of the Maximum Entropy Production (MEP) principle to chemical reaction engineering in systems that operate very far from local equilibrium in the nonlinear regime of irreversible thermodynamics [1-2Elijah</author></authors></contributors><titles><title>Entropy production and chemical reactions in nonequilibrium plasma</title><secondary-title>AIChE Journal</secondary-title></titles><periodical><full-title>Aiche Journal</full-title><abbr-1>AICHE J.</abbr-1></periodical><pages>e17291</pages><volume>67</volume><number>9</number><dates><year>2021</year></dates><isbn>0001-1541</isbn><urls><related-urls><url>https://aiche.onlinelibrary.wiley.com/doi/abs/10.1002/aic.17291</url></related-urls></urls><electronic-resource-num>https://doi.org/10.1002/aic.17291</electronic-resource-num></record></Cite><Cite><Author>Uner</Author><Year>2020</Year><RecNum>3479</RecNum><record><rec-number>3479</rec-number><foreign-keys><key app="EN" db-id="0005fvda4wfsfperdz45xxwrwd2ww9vfpvax" timestamp="1592345441">3479</key></foreign-keys><ref-type name="Journal Article">17</ref-type><contributors><authors><author>Uner, Necip B.</author><author>Thimsen, Elijah</author></authors></contributors><titles><title>Superlocal chemical reaction equilibrium in low temperature plasma</title><secondary-title>AIChE Journal</secondary-title></titles><periodical><full-title>Aiche Journal</full-title><abbr-1>AICHE J.</abbr-1></periodical><pages>e16948</pages><volume>66</volume><number>6</number><dates><year>2020</year></dates><isbn>0001-1541</isbn><urls><related-urls><url>https://aiche.onlinelibrary.wiley.com/doi/abs/10.1002/aic.16948</url></related-urls></urls><electronic-resource-num>10.1002/aic.16948</electronic-resource-num></record></Cite></EndNote>]. Results to date are consistent with the MEP principle providing probabilistic expectations about the direction of evolution in nonlinear irreversible systems, and experimental efforts are being planned to more robustly test the theoretical hypothesis. For this presentation, I will posit that (1) the MEP principle can be used to describe the probability of selecting stationary states in the nonlinear regime of irreversible thermodynamics; and (2) that the earth and human societies operate in the nonlinear regime and thus their evolution is subject to the MEP principle. The earth, and life contained therein, comprises a complex dissipative system that receives heat from the sun as an input and sends thermal radiation to space as an output. Two expectations from the MEP principle can be made of the earth. With some constraints, the hypothesis is that evolutionary paths for human society, which decrease albedo and decrease the greenhouse effect, will ultimately be selected with higher probability than those that do not. Sunlight is the largest energy input to the surface of the earth [3]. The heat coming from the sun has an average temperature of approximately 5800 K, and thermal radiation from earth into space has an average temperature of approximately 287 K. Therefore, energy in sunlight absorbed by the earth and radiated into space generates entropy. The blackbody temperature of the earth, in the absence of albedo and greenhouse effect, would be approximately 250 K. The albedo of the earth, which describes the fraction of sunlight power diffusely reflected into space, without being absorbed, is approximately 30%. Sunlight diffusely reflected into space without absorption generates less entropy than absorbing the sunlight and radiating at the global average temperature. Therefore, the earth could generate more entropy if it either absorbed more sunlight (lower albedo), and/or had a lower temperature (less greenhouse effect). The conclusion presents an optimistic vision for increased solar energy harvesting in deserts comprised of high albedo minerals, and combating the rising CO_2 concentration in the atmosphere to lower the average global temperature and therefore increase the flow of entropy from earth into space. Some concrete examples and limitations of the analysis will be discussed.

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THE WAR IN UKRAINE: A STATISTICAL ANALYSIS

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ABSTRACT

The war in Ukraine can be described not only by observations but also by statistical methods. Statistics is equally recognized in the natural and social sciences. Statistics cannot calculate the future, but can show probable developments. Statistics does not depend on the kind of objects, but only on their number. Therefore, the same statistical laws apply to all natural and social science systems, but each time they are called differently:
In mathematics of many numbers, they are called stochastics.
In a message of bits and signs, they are called computer science.
In matter of atoms and molecules, they are called thermodynamics.
In markets of goods and prices, they are called economics.
In societies with different people, they are called sociology.
In a world with different states, they are called politics.
Since statistical laws are known from mathematics, these laws can be applied to any field of natural or social science and can be followed on the screen. The central quantity of statistics, entropy, depends on two parameters, in thermodynamics on the mean energy (temperature) and on pressure. At low temperature or high pressure, matter is a solid; at high temperature and low pressure, matter is a liquid. In political systems, entropy depends on mean income (standard of living) and police or military pressure. At low living standards or high pressure, a state is hierarchical or autocratic; at high living standards and low pressure, a state is democratic. Both systems cannot coexist: Ice melts in warm water, hierarchies dissolve in the neighborhood of strong democracies. To survive as an autocracy, Russia fights Ukraine and all neighboring democracies. Conclusion: the EU, as Russia's neighbor, must not only support Ukraine with all its power, it must win the battle in Ukraine in order not to become the next victim.

Keywords: society, entropy function, order - disorder

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UTILITY AND ENTROPY

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ABSTRACT

There have been many attempts to link economic concepts to thermodynamic theory, with varying degrees of success. I began my own research into this area more than four decades ago, culminating in a number of published papers and two books, along with a number of presentations to conferences and universities in Hungary, Netherlands, USA and China. I gave two presentations at the joint ISEE – ISBPE conference in Washington in 2016 and another at the JETC Thermodynamics 2.0 conference in Prague in 2021.

This paper explores some of the economic concepts that will be highlighted in a third book that I am in the middle of writing – in particular utility and its relationship to entropy to be generated on consumption of a good. I show that the economic concept of the marginal utility of a product with respect to a change in volume demanded/consumed, divided by the product's price is exactly equivalent to the marginal entropy generated with respect to change in volume demanded/consumed all divided by its price, both being equivalent to a function of the product's productive content, its relative lifetime and its demand elasticity with respect to its price.

Keywords: utility, entropy, marginal utility, marginal entropy, price

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ON A PRINCIPLE OF MINIMUM ENTROPIC GRADIENT-BASED INTERACTION

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ABSTRACT

In the context in which the second law of Thermodynamics is considered challengeable (see, for example, the constructal law that aspires to a most fundamental place than the mentioned law), the paper, after a critical examination of the two principles, proposes a third solution, namely the principle (or law) of the minimum entropic gradient-based interaction, which implies neither the second law of Thermodynamics nor the constructal law, although it seems to integrate both (such integration could feed, in turn, the proposal's aspiration to be... the most fundamental principle/law which guides our world functioning – from micro-particles to macro-galaxies. To this end, the principle is formulated and described in its logical body, then its functioning is examined for some relevant existence fields – of nature, of biological life, and of social/cultural sphere. The next part of the study is dedicated to putting face to face the three (claimed) explanations – the second law of Thermodynamics, the constructal law, and the minimum entropic gradient-based interaction, in order to get a possible order of generality among them. Finally, the paper provides some possible logical as well as empirical tests aimed at falsifying both the coherence and the correspondence-truth that, as I believe, are the necessary predicates, in fact, of the proposal. Some doubts regarding the alleged fundamental place claimed by the proposal are enunciated as well.

Keywords: entropy law, constructal law, minimum entropic gradient, interaction

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THEORY OF CONSTRUCTAL INFONIMICS: THE ESSENTIAL CONNECTION BETWEEN THERMODYNAMICS AND INFORMATION AS THE WORLD MOVES TO A CONNECTED FUTURE

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ABSTRACT

This proposed paper builds on the Theory of Constructal Infonomics [1], first presented in Bucharest, Romania in 2017 and published in the Proceedings of the Romanian Academy of Sciences. Through a better understanding of the essential thermodynamic/information architecture that motivates and defines success for all life forms, we may better understand, predict and control the evolution of our future as a species. The Theory of Constructal Infonomics describes how the thermodynamic/information architecture of life shapes and drives all life forms, from simple bacteria to sexual reproducers to extended "virtual" life forms, including families, and tribes, religions, nation-states, and social media. It explains how stored energy, including material wealth and its information equivalent, knowledge, are the essential elements that all organisms must invest, and from those investments, achieve an amplified energetic return in order to survive the Second Law. In addition, it demonstrates that hierarchical complex organisms share the precise motivation as each of their constituent dependent organisms. E.g., the motivation of a human being is identical to the motivation of every cell in its body, including all the gut bacteria, viruses, etc. Individual humans carry the same survival motivation into their roles as dependent organisms within larger, sometimes nested, virtual life forms, e.g., families, companies, nations. It defines the fundamental requirements for the origin of life and applies empirically to all life forms here on Earth and hypothetically, at least for now, throughout the universe. With that background, the paper will then focus on applying the Theory to the current world situation as a case study. Power in the societal sense is the product of both thermodynamics (material wealth and energy flows) and information (knowledge and information flows). We are now experiencing the shift from industrial revolution high-thermodynamic, low-information wealth and power accumulation to distributed-thermodynamic, high-information, global societies and organizations. Notably, some nation-states that depend on brute physical dominance and suppression of information to build their wealth find it difficult to realize a positive return for their efforts in the modern co-dependent world. The discussion will focus on:
- The impact of global, real-time communication (e.g. Web 3.0, Metaverse, Crypto, social media)
- The diminishing role of nation-states
- The rise of transnational corporate power
- The power of individuals cooperating globally
- The rise of non-state actors, e.g., Anonymous

Despite shifting forms and forces, human progress is driven by the thermodynamic calculus of using information to amplify energy and evade the Second Law. By understanding this fundamental architecture of life, we can better predict and control the evolution of our future as a species or the planet.

Keywords: Information theory, origin of life, social media, power, wealth, knowledge

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PATHWAYS TO UNITY: ENTROPY PRODUCTION AND THE CONSTRUCTAL LAW

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ABSTRACT

Questions remain regarding the extremum principles which determine the evolution of such systems. Several theorems and principles have been proposed, including that of the maximum entropy production principle and the Constructal law. At times, advocates of these systems have indicated that one principle of the other is either irrelevant, contradictory, or merely a corollary of the other. Here, it is attempted to show in the form of two separate articles that these principles are equivalent to one other. A comparative literature study that underlying both of these ideas are two principles: Firstly, flow networks operate with the ability for the flow channel to vary its conductance (either by transport coefficient or channel geometry modifications). Secondly, the flow network analyzed are branched channels. This latter point is an outgrowth of the former: adding branches increases the conductivity. Indeed, the Constructal law can be viewed mathematically as stating that the flow conductance increases in time for “thriving” systems. This formulation allows for a direct comparison to MEP, which states that the rate at which entropy is produced increases when possible. It is then shown that these expressions are indeed equivalent. In order to do so, it is shown that for isolated systems, an increase of conductivity in any part of the system is equivalent to increasing the entropy production rate for the system as a whole. Finally, the implications of these arguments for other proposed extremum principles (e.g., minimum entropy production) are considered and analyzed.
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Keywords: entropy production, Constructal law, transport conductivity

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FROM SOCIAL SCIENCE TO QUANTUM LIKE AND BEYOND

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ABSTRACT

In this talk I attempt to show how some ideas in social science have benefited from applying formalisms from different areas of physics, especially quantum mechanics. I consider also where we may go next and will include in this discussion recent advances.
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Keywords: social science, quantum mechanics, formalism.

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RECENT APPLICATIONS OF QUANTUM IDEAS OUTSIDE MICROSCOPIC WORLD

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ABSTRACT

It is nowadays believed by many authors that quantum tools, and quantum ideas, can be relevant in the understanding of several macroscopic systems. Many aspects of this connection have been discussed in recent years, with different techniques and strategies. This growing interest is mainly due to its many technical and philosophical consequences, but it is also related to the pretty good results which can be found using ideas outside its standard realm.

In my talk I will briefly review some recent applications of quantum ideas to few systems of different nature. In particular, I will describe some applications to biological systems and to decision making. More in details, I will describe how ladder operators satisfying the canonical commutation or anti-commutation relations can be used in the analysis of some cancer proliferation. As a second application, I will show how a spin Hamiltonian can be used in a simple problem of decision making, where a large group of people are asked to reach a common decision.

Keywords: quantum idea, microscopic world, cancer proliferation, decision making

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THE TASK OF DEVELOPING A 'COMPLEMENTARITY' THEORY: COMPLEMENTARITY AND BOHR'S COMPLEMENTARITY, IN PHYSICS AND BEYOND

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ABSTRACT

Several investigations in the quantum-like modeling beyond quantum physics, especially in decision making, have addressed a possible role of Bohr's concept of complementarity in these fields--understandably, given its role in quantum theory. This paper will reexamine this possibility, in part by considering, first, the difference (more common than is usually realized) between Bohr's concept of complementarity and most, virtually all, of those used beyond physics, and secondly, in part correlatively, the role of probability in Bohr's concept, essential to it but rarely considered properly, if at all. The paper, then, will use this role to address the question of information and entropy (specifically von-Neumann's entropy in quantum vs. Shannon's entropy in classical information) in quantum physics and quantum-like theories. Albert Einstein once said that thermodynamics is the only physical theory that will probably never be proved to be wrong. Perhaps, this is equally true, about quantum theory, in part for the same reason--both are irreducibly probabilistic and (informationally) entropic. On the other hand, there is no complementarity in Bohr's sense in thermodynamics, while it redefined the nature of information and entropy in quantum physics. The question is, then, whether any theory, classical-like or quantum-like, in human and social sciences is ever likely to be seen in this way, and if it is quantum-like, whether complementarity is likely to be necessary in it..

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Keywords: complementarity, quantum theory, social sciences, information, entropy

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MAXIMUM WORK RATE EXTRACTABLE FROM THE SUN

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ABSTRACT

The socio-economic model based on the fossil fuels is unstainable, resulting into various crisis related to the supply and demand, therefore, it is in the process of a conscious transition. It is urgent to shift from the current centralized system based on fossil fuels toward a system that is distributed and based on local renewable energy. Solar energy is an important part of the world's energy mix. Solar energy is clean, environmentally friendly, and freely available over the planet. Over the last 60 years, several researchers such as Jeter, Spanner, Petela, Press, Badescu, had proposed different models to define the physical limit of solar radiation conversion. These models overestimate the real maximum work rate extractable from solar radiation. The exergy of solar radiation is a useful index in the preliminary assessment of the performance of solar technologies, since the model provides upper limit of the efficiency of the system. A practical engineering model, however, should consider physical constraints associated with this useful index. In the present work, a generalized expression of a work extraction from solar radiation is presented as a function of the high-temperature radiation reservoir and a low-temperature heat sink that take into account a physical limit of the energy conversion.

Keywords: solar radiation, exergy, work extractor, exergy analysis, finite-time thermodynamics

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The Evolution of Engineering

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ABSTRACT

The fields subjected to scientific studies are shown to change over time. Prominent subjects in the field of engineering in particular have undergone more significant changes based on the problems and opportunities of the period of time. The field and types of engineering have also developed and changed, with new fields being formed accordingly. When examining the emergence of engineering fields, the respective formations of civil engineering, mechanical engineering, and electrical and electronic engineering are closely related to the problems and opportunities of the time. This study examines the changes that occurred in the subjects and fields of engineering from 1866 to the present in terms of the articles that have been produced in this field. The research analyzes a total of 15.98 million publications published on the field of engineering from the SCOPUS database according to year of publication. Keywords are important metadata for a publication, and the variation in keywords has been analyzed in order to see how the field of engineering has changed. In this way, I've found an opportunity to look at the transformations in the field of engineering in terms of the change in keywords. This study presents the timeline and intensity of the works from 1926 to the present, such as the journey from tractors, engines, ... mathematical models to computer simulations. In addition to keywords, the study also analyzes the change in publications produced in the field of engineering according to year, the most published authors in this field, most published subjects, types of publications, types of journals, institutions, supporting organizations, countries, publication languages, and most cited publications. In this way, I holistically demonstrate the change that has been experienced in the field of engineering in all its aspects. In addition to this study presenting a holistic perspective of the field from 1866 to present, it also has the feature of providing ideas about engineering evolution.

Keywords: Evolution of Science, Civil Engineering, Mechanical Engineering, Electrical Engineering, Electronic Engineering, Bibliometric Analysis.

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