Thermodynamics 2.0 | 2024

International Association for the Integration of Science and Engineering

Broomfield, Colorado, United States

Book of Abstracts

Thermodynamics 2.0 I 2024

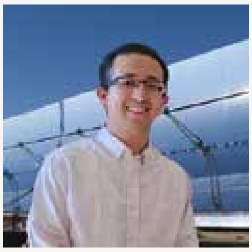
August 5 - 7, 2024

International Association for the Integration of Science and Engineering

Broomfield, Colorado, United States
https:/iaisae.org/

Organizers: Thermodynamics 2.0 I 2024

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



Eduardo González-Mora

Member

Emmanuel Haven

Member

Georgi Georgiev

Member

Ram Poudel

Organizer

What is Thermodynamics 2.0?

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

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

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

Some sample open questions in this field are:

- How did cooperative behavior evolve?
- 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

.

Foreword

Thermodynamics has undergone significant evolution since its inception in the early 19th century. The foundational work of Sadi Carnot, " Réflexions sur la puissance motrice du feu et sur les machines propres à développer cette puissance" (1824), marked the genesis of this field, introducing the concept of the Carnot cycle. Subsequent contributions from luminaries such as Rudolf Clausius, William Thomson (Lord Kelvin), and Ludwig Boltzmann expanded the scope of thermodynamics, incorporating notions of entropy, absolute temperature, and kinetic theory.

The 20th century witnessed substantial advancements in thermodynamics, including Max Planck's introduction of the quantum concept and Constantine Caratheodory's axiomatic formulation. Lars Onsager's theory of irreversible processes and Erwin S. Bauer's Universal Law of Biology further broadened the field's horizons. Ilya Prigogine's work on dissipative structures and self-organization in nonequilibrium systems constituted a pivotal development. Additionally, Zoran Rant, Ingo Müller, and Bjarne Andresen made notable contributions through their development of theories pertaining to thermodynamic exergy, extended thermodynamics, and finite-time thermodynamics.

The bicentennial of Carnot's seminal work in 2024 provides an opportune occasion to reflect on the profound impact of thermodynamics on our comprehension of the natural world. Nevertheless, the field's evolution continues unabated. In the 21st century, scholars such as Adrian Bejan and Giovanni Gallavotti have propelled thermodynamics forward, developing constructal theory and chaotic dynamics. These advancements have paved the way for the emergence of "Thermodynamics 2.0," a paradigmatic framework wherein natural sciences converge with social sciences, facilitating an integrated understanding of human knowledge.

Thermodynamics 2.0 represents a novel era of interdisciplinary collaboration, wherein thermodynamic principles are applied to complex systems, encompassing biological networks and socioeconomic structures. This synthesis enables a more nuanced comprehension of the intricate relationships between energy, entropy, and organization. By embracing this holistic approach, researchers can develop innovative solutions to pressing global challenges, such as sustainability and climate change.

The bicentennial of Carnot's work serves as a poignant reminder of the legacy of thermodynamics' pioneers, while the advent of Thermodynamics 2.0 heralds an exciting new chapter in the field's ongoing evolution. This dynamic discipline continues to inspire new generations of researchers, fostering a deeper understanding of our complex world and our place within it.

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

Thermodynamics 2.0

2024 Conference

8:30
8:45
9:00
9:15
9:30
9:45
10:00
10:15
10:30
10:45
11:00
11:15
11:30
11:45
12:00
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
14:15
14:30
14:45
15:00
15:15
15:30
15:45
16:00
16:15
16:30
16:45
17:00
17:15
17:30
17:45
18:00
18:15

Sunday 4th

- Registration Opens
- Opening Introduction Network Reception @Booneshine

Monday 5th

- Registration Opens
- Welcome and Opening Remarks
- Keynote and Plenary I: Miroslav Grmela, Perry Marshall
- Victor M. Yakovenko
- Lunch Break
- David Lacoste
- Pier Luigi Gentili, Eduardo González-Mora
- Máté Pszota Terrence W Deacon
- Coffee Break
- Mark Ciotola Sam Baker
- Soumya Banerjee Xin-Yan Zhang
- Open Discussion: Summary of the Day

Tuesday 6th

- Keynote and Plenary II: Francois Gay-Balmaz, Terry Bristol
- Coffee Break
- Klaus Jaffe, Jürgen Mimkes
- Lunch Break
- Phillip Johnson
- Robert Pepperell Alec Groysman
- Open Discussion
- Coffee Break
- Sam Baker, Ram Poudel
- Gregory S. Yablonsky Eduardo González-Mora
- Networking Break
- IAISAE General Meeting Thermodynamics 2.0 | 2024

Wednesday 7th

- Keynote and Plenary (III) Kati Martinas Themis Matsoukas
- Networking Break
- Angel Plastino
- IAISAE Awards
- Adjournment

PROGRAM

5 Monday August

Day 1 program

9:00	**Welcome and opening remarks**
Plenary I	
9:30	**Keynote: Miroslav Grmela,** *École Polytechnique de Montréal, Canada,* Thermodynamics Of Externally Driven Systems
10:30	**Perry Marshall,** *Evolution 2.0, USA* Synthetic Induction vs Natural Intelligence
10:30	**Victor M. Yakovenko,** *University of Maryland, USA* The End Of Hyperbolic Growth In Global Human Population
12:15	**David Lacoste,** ESPCI Paris, Sadi Carnot's Legacy
	SESSION T01: Entropy and Applications
13:00	**Pier Luigi Gentili,** *Università degli Studi di Perugia, Italy* Characterizing The Micro-Heterogeneity Of Chemical Systems By Determining Their Fuzzy Entropy
13:30	**Eduardo González-Mora,** *Universidad Autónoma del Estado de México, México* Holistic Relation Of Étendue And Entropy: An Application For Solar Energy Systems
	SESSION T02: Variational Principle in Thermodynamics
15:15	**Mark Ciotola,** *San Francisco State University, USA* Variational Thermodynamics: It's History, And Applications To Physical Cases And Social Sciences Exam
15:45	**Sam Baker,** *Global Frontiers LLC., United Kingdom* Economic Forces, Variational Principles And The Bending Of Spacetime
16:30	**Soumya Banerjee,** *University of Cambridge, United Kingdom* Life And Intelligence As We Do Not Know It
17:00	**Xin-Yan Zhang,** Life As I Understand It
17:45	**Open Discussion: Summary of the Day**

6 Tuesday August

Day 2 program

Plenary II

8:30 **Keynote: Francois Gay-Balmaz,** *Nanyang Technological University,Singapore*
Variational Principles In Non-Equilibrium Thermodynamics And Applications

9:30 **Terry Bristol,** *Portland State University, USA*
Understanding Motion and Work in Engineering Thermodynamics

SESSION T03: General Applications

10:45 **Klaus Jaffe,** *Universidad Simon Bolivar, Caracas*
Infodynamics, A Review

11:15 **Jürgen Mimkes,** *Paderborn University, Germany*
System Science in Politics - Europe and the War in Ukraine

12:15 **Phillip Johnson,** *New College Franklin, USA*
Constructing a Framework For a Thermodynamic Grand History

SESSION T04: Philosophical Applications

13:00 **Robert Pepperell,** *Cardiff Metropolitan University, UK*
"The Very Beautiful Principles Of Natural Philosophy": Michael Faraday And The Physics Of Organic Forms

13:30 **Alec Groysman,** *Israel Institute of Technology, Israel*
Philosophical Problems Of Thermodynamics: Beauty, Art, Humor

SESSION T05: Physical Economics

15:15 **Sam Baker,** *Global Frontiers LLC., UK*
The Principle Of Least Action: Applications To The Law Of Maximum Entropy Production And A New Natural Science Of Economics

15:45 **Ram Poudel,** *Appalachian State University, USA*
A Similitude Analysis of Flows and Potentials in Economics and Thermodynamics

SESSION T06: Kinetics

16:15 **Gregory S. Yablonsky,** *Washington University, USA*
'Joint Kinetics': A New Approach in Bridging chemical Kinetics and Thermodynamics

16:45 **Eduardo González-Mora,** *Universidad Autónoma del Estado de México, México*
Endoreversible Description Of Radiative Vuilleumier Refrigeration Machines

17:45 **IAISAE General Meeting Thermodynamics 2.0 I 2024**

7 Wednesday August

Day 3 program

Plenary III

8:30	**Keynote: Kati Martinas,** *Budapest, Hungary* Unified Macroscopic Physics
9:30	**Themis Matsoukas,** *Penn State, USA* Stochastic Processes And Statistical Mechanics
	SESSION T07: Stochastic Thermodynamics
10:45	**Angel Plastino,** *National University of La Plata, Argentina* Probabilistic Description Of Thermodynamics' Third Law
11:30	**IAISAE Awards**
11:45	**Adjournment**

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0121

Thermodynamics of externally driven systems

Miroslav Grmela

École Polytechnique de Montréal, Montréal. Québec, Canada

Abstract

Externally unforced and externally driven systems differ in the way in which they approach reduced descriptions. In the former systems the reductions gradually continue till the level of equilibrium thermodynamics on which no time evolution takes place. In the latter systems the reductions stop on a mesoscopic level on which the time evolution still takes place (e.g. reductions of the Rayleigh-Bénard system stop on the level of fluid mechanics). The difference disappears if the time evolution of externally driven systems is seen as the time evolution of vector fields. The final stage of the reduction process is again a level with no time evolution, the asymptotic state is the time independent vector field generating the time evolution on the mesoscopic level (in the example of the Rayleigh-Bénard system it is the vector field generating the Boussinesq time evolution).

Reduction in externally unforced systems are driven by entropy that at equilibrium states gives rise to the equilibrium thermodynamics. Reductions in externally driven systems are driven by a rate entropy (related to the entropy production) that at the equilibrium vector field gives rise to rate thermodynamics. The maximum entropy principle in the equilibrium thermodynamics is replaced in the rate thermodynamics by the Onsager variational principle (that is the minimum rate entropy principle). Details of this approach to rate thermodynamics are in: M.Grmela, Thermodynamics and Rate Thermodynamics, J.Stat.Phys. 191:75 (2024), M.Grmela, Roles of Energy and Entropy in Multiscale Dynamics and Thermodynamics, J. Phys. Commun. Grmela 2024 https://doi.org./10.1088/2399-6528/ad5b3a

Keywords: Externally driven systems, Mesoscopic level, Onsager variational principle

Corresponding Author E-Mail: miroslav.grmela@polymtl.ca

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0101

Synthetic Induction vs Natural Intelligence

Perry Marshal
Evolution 2.0

Abstract

AI propelled "hallucinate" into public consciousness and was the 2023 Cambridge Dictionary word of the year. Any process capable of making inferences inevitably makes statements that are not true. But in this paper, I prove using Turing mathematics that even the most advanced AIs are not doing induction, but rather "synthetic induction" which is sophisticated deduction using a large dataset. The induction is performed entirely by humans. In contrast, Biology makes inferences from small amounts of information in a way that transcends computation. Computers calculate, but Maxwell's Demon is an agent that models the cell's ability to make choices. Computers by Turing's definition are incapable of rivaling living things. This underscores a range of unsolved problems in the life sciences, as well as limits of current human technology. Maxwell's Demon remains one of the most elusive questions in science and AI will not "wake up" any time soon. The conventional utopias and dystopias are impossible, short of a new discovery as pivotal as quantum mechanics, the periodic table or the genetic code.

Keywords: induction, deduction, agency, AI, Turing machine

Corresponding Author E-Mail: evolution@evo2.org

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5-7, 2024 I Boone, NC, USA

T2.0:2024-0110

The End of Hyperbolic Growth in Global Human Population

Victor M. Yakovenko

Department of Physics and JQI, University of Maryland, College Park, USA

Abstract

Using current empirical data from 10,000 BCE to 2022 CE, we re-examine a hyperbolic pattern of human population growth with a singularity in 2026, as predicted in a Science article by von Foerster et al. in 1960. We find that human population initially grew exponentially in time: N(t)~et/T with T≈3050 years. This growth then gradually evolved to be super-exponential with a form similar to the Bose function in statistical physics. Between 1600 and 1700, population growth further accelerated, entering the hyperbolic regime as N(t)=C/(ts-t) with the singularity year ts=2026 identified by von Foerster et al. We attribute the switch from the super-exponential to the hyperbolic regime to the onset of the Industrial Revolution and the transition to massive use of fossil fuels. This claim is supported by a linear relation that we find between the increase in CO2 level and population from 1700 to 2000. By the end of the 20th century, the inverse population curve 1/N(t) begins to deviate from a straight line and to follow a pattern of "avoided crossing," thus not reaching zero and avoiding a literal singularity. From our fit of the avoided crossing, we predict that human population will attain a maximum Nmax of slightly more than 8 billion people at t=ts. The width in time of the population peak is 2τ≈55 years, indicating a decrease in population to Nmax/√2 at t=ts±τ. We compare this prediction with current demographic forecasts.

Keywords: human population growth, hyperbolic singularity, population peak, Industrial Revolution, fossil fuels

Corresponding Author E-Mail: yakovenk@umd.edu

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5-7, 2024 I Boone, NC, USA

T2.0:2024-0128

SADI CARNOT'S LEGACY

David Lacoste

Department of Physics and JQI, University of Maryland, College Park, USA

Abstract

This year, 2024, marks the 200th anniversary of Sadi Carnot's publication of "Réflexions sur la puissance motrice du feu" (Reflections on the motive power of fire), considered to be the birth certificate of thermodynamics. To celebrate this anniversary, we are organizing a colloquium entitled S. Carnot's legacy, that will provide an overview of the many uses of the second principle and the notion of entropy across a variety of different fields. The symposium will take place at the Ecole Polytechnique near Paris in France from September 16 to 18, 2024. Details of the program and how to register can be found on the event website: https://carnot-legacy.sciencesconf.org/

In this talk, in addition to presenting the colloquium, I will highlight certain aspects of Carnot's work, which were instrumental not only for the development of classical thermodynamics but also for future developments in Finite time thermodynamics and Stochastic Thermodynamics.

Keywords: Classical thermodynamics, finite time thermodynamics, Stochastic Thermodynamics.

Corresponding Author E-Mail: david.lacoste@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0103

UNTANGLING COMPLEX SYSTEMS: THE CONTRIBUTION OF CHEMICAL ARTIFICIAL INTELLIGENCE

Pier Luigi Gentili

Department of Chemistry, Biology, and Biotechnology, Università degli Studi di Perugia, Perugia, Italy.

Abstract

Th Humanity is spurred to face global challenges. These challenges involve Complex Systems, whose investigation requires an interdisciplinary endeavor. Complexity Science is contributing to bridging the natural and social sciences and facing contemporary global challenges. In this talk, I will propose an attempt to unscramble the ontology and epistemology of Complex Systems. Finally, I will present some promising strategies to tackle the Epistemological Complexity. Among them, I will highlight the research line of Chemical Artificial Intelligence, which will probably help us to colonize the molecular world and unveil the essence of some amazing emergent properties, such as intelligence and life.

References

[1] P. L. Gentili, *"Untangling Complex Systems: A Grand Challenge for Science"*, CRC Press, 2018, Boca Raton (FL, USA).
[2] P. L. Gentili, *Rend. Fis. Acc. Lincei*, 2021, 32, 117.
[3] P. L. Gentili, P. Stano, *Front. Robot. AI.* 2023, 10, 1238492.
[4] P. L. Gentili, P. Stano, *Front. Robot. AI.* 2023, 10, 1266011.

Keywords: Complex Systems, Complexity, Thermodynamics, Non-linear Dynamics, Emergent Properties, Artificial Intelligence

Corresponding Author E-Mail: pierluigi.gentili@unipg.it

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA

T2.0:2024-0116

Entropy Metric: Framework For Analyzing Changes In Systems

Framework to measure changes

Vicente Fachina

Independent researcher

Abstract

This paper devises a general framework for analyzing changes in systems by utilizing the concept of entropy revisited from the concepts of conservative systems and environment, which resembles the classic formulations of entropy by Shannon and Boltzmann for particular cases. This general framework stems from the premise of conservative systems by defining entropy regardless of knowledge realms, thus, to be applicable on whatever conservative, identifiable system, and environments. The entropy metric is an array of numbers that represent changes in a conservative system, which describe either an increase or a decrease in the entropy variation if one disregards environment. The entropy variation in a system enables calculating quantities to maximize efficiency of the entire system, which for instance economic policymakers can use as references to make comparisons of an economic sector over time, or among economic sectors within a country or region. In addition, this paper illustrates the use of the ever-increasing overall entropy to forecast the energy map by the 2041 decade in the USA.

Keywords: energy; entropy; environment; systems

Corresponding Author E-Mail: vicentefachina@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5–7, 2024 I Boone, NC, USA

T2.0:2024-0109

HOLISTIC relation OF ÉTENDUE and entropy:
an application for solar energy systemss

Eduardo González-Mora

Universidad Autónoma del Estado de México, Toluca, Estado de México, México

Abstract

The étendue, a vital parameter in geometrical optics, measures the space available for the movement of light within an optical system. It encapsulates the extent to which light disperses spatially and angularly. Beyond this geometric interpretation, one can also conceptualize étendue as the power that a light beam carries while traversing the optical system. This dual nature renders étendue a particularly intriguing parameter, especially in applications such as solar concentration systems. Solar concentrators are crucial for harnessing solar energy for thermal and photovoltaic conversions. These optical devices, utilizing mirrors or lenses, capture and redirect solar radiation towards a receiver. The étendue, therefore, becomes a focal point in the analysis, optimization, and design of solar concentrators. Enhancing our understanding of étendue's role contributes to advancements in concentrator geometry and the development of novel optical systems.

The formalization of the étendue gained momentum with the advent of non-imaging optics in the late 1960s. Over the past six decades, non-imaging optics has elucidated numerous optical phenomena, revealing the limitations of classical optics in achieving the thermodynamic concentration limit. While the last decade has seen increased attention on the thermodynamic origins of non-imaging optics, its intricate relationship with entropy remains underexplored. This research aims to extend the étendue-entropy analysis beyond existing frameworks, with a particular emphasis on concentrating solar systems. Although a preliminary étendue-entropy analysis exists for Compound Parabolic Concentrators (CPCs), there is a need to broaden the discussion to encompass various concentrator types. Here, I examine and generalize the holistic relationship between étendue and entropy. Introducing a new dimensionless group, we aim to provide a more nuanced understanding that facilitates the assessment of concentrator system performance. Through this research, I anticipate uncovering valuable insights that could drive advancements in solar concentration technologies.

Keywords: Étendue, entropy, solar energy, solar concentrator

Corresponding Author E-Mail: egonzalezmo@uaemex.mx

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5–7, 2024 | Boone, NC, USA

T2.0:2024-0126

GRAVITY IN NON-EQUILIBRIUM THERMODYNAMICS

Máté Pszota[1,2], Péter Ván[2,3,4], Sumiyoshi Abe[5,6,7]

[1]Eötvös Loránd University, Institute of Physics, Budapest, Hungary
[2]HUN-REN Wigner RCP, Department of Theoretical Physics, Budapest, Hungary
[3]BME, Department of Energy Engineering, Budapest, Hungary
[4]Montavid Thermodynamic Research Group, Budapest, Hungary
[5]Department of Physics, College of Information Science and Engineering, Huaqiao University, Xiamen, China
[6]Institute of Physics, Kazan Federal University, Kazan, Russia
[7]Department of Natural and Mathematical Sciences, Turin Polytechnic University in Tashkent, Tashkent, Uzbekistan

Abstract

An extension of Newtonian gravity is presented, which is derived in the framework of non-equilibrium thermodynamics with weakly nonlocal internal variables.

In the theory, (P. Ván & S. Abe, Physica A 588 (2022) 126505), a scalar field and additionally, its gradient-squared term contributes to the internal energy. The second law of thermodynamics constrains this scalar field to be only gravity. Then standard and rigorous methods of Rational Mechanics and nonequilibrium thermodynamic framework (such as Liu's procedure) allow a set of evolution equations to be derived for the gravitational field and the derivation of thermodynamic forces and fluxes. The positive definiteness of the entropy production rate density is ensured via linear Onsagerian equations. The resulting nondissipative gravitational field equation differs from the classical Poisson equation form by an additional square-gradient term:

$$\Delta\varphi = 4\pi G\rho + K(\nabla\varphi)^2,$$

resulting in modified gravity. Analytical solutions show a double crossover, allowing for different gravitational behaviour on different size scales (S. Abe & P. Ván, Symmetry 2022, 14, 1048(7)). This property presents a possible approach to explain dark matter-related phenomena on galactic scales, and different dynamics on extragalactic scales. Its application for the explanation of galactic rotation curves with only baryonic matter and no dark matter is presented.

Keywords: non-equlibrium thermodynamics, gravity, dark matter, galactic rotation curves

Corresponding Author E-Mail: pszota.mate@wigner.hu

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5-7, 2024 I Boone, NC, USA

T2.0:2024-0125

Inverse Darwinism: Evolution As thermodynamic work

Terrence W. Deacon

University of California, Berkeley

Abstract

Natural selection (NS) theory, while agnostic about the thermodynamics of living processes, is implicitly based on it. The competitive elimination of less fit individuals stems from their reduced ability to access resources critical for maintaining and reproducing their far-from-equilibrium constitution. Staying ahead of the second law of thermodynamics necessitates producing excess replacement parts and offspring. The generation of organism features is a physical process, requiring physical work to generate each variant. Thus, while natural selection's subtractive logic can be analyzed without thermodynamics, the generative side of evolution cannot.

The Inverse Darwinian perspective provides the necessary generative complement to natural selection, inverting only the selection aspect while remaining consistent otherwise. It capitalizes on the generative biological processes that typically involve duplicating functional structures or processes in a protected context. A process is defined as Inverse Darwinian if it follows these stages of modular functional change:

1. Duplication / functional redundancy
2. Degeneration / fractionation / redistribution
3. Complementation / codependence
4. Irreversibility / elimination / hierarchic transition

Gene duplication is a clear example. Though generating a duplicate gene has a slight thermodynamic cost, the resulting functional redundancy relaxes selection, allowing degenerative effects to accumulate. This degeneration, an expression of the second law, has minimal fitness cost due to redundancy, increasing the sampling of interaction effects between sibling genes and the probability of uncovering synergistic combinatorial effects that can selectively replace less efficient non-synergistic effects.

This perspective aids in exploring the complex issue of the origin of molecular information processes, proposing an origin that effectively inverts the central dogma of molecular biology: protein-like catalysts precede nucleotide synthesis, which precedes 3D RNA structures, 1D RNA sequence replication, and DNA preservation of information.

Keywords: Evolution, Darwinism, Thermodynamics, molecular biology

Corresponding Author E-Mail: deacon@berkeley.edu

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5–7, 2024 I Boone, NC, USA

T2.0:2024-0104

VARIATIONAL THERMODYNAMICS:

It's history, and applications to physical cases and social sciences exam

Mark Ciotola

San Francisco State University

Abstract

Previous work in variational thermodynamics by Biot, Paltridge, Jaynes, Dewar and others is reviewed. Why semantics matters: the history and meaning of Minimum Entropy versus Maximum Entropy and Maximum Power principles is discussed along with implications. Examples of variational thermodynamics as applied to thermal energy transport and entropy increase using examples from heat conduction, mining and agriculture. (Some of these examples are hypothetical and have not yet been experimentally verified). Application of variational thermodynamics to the social sciences. Several open questions are identified, including whether there is a time value of entropy achievement and applied challenged to variational approaches.

Keywords: Variational thermodynamics, Minimum Entropy, Maximum Entropy, Boit, Jaynes, social sciences

Corresponding Author E-Mail: ciotola@sfsu.edu

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5–7, 2024 I Boone, NC, USA

T2.0:2024-0111

Economic Forces, variational principles and the bending of spacetime

Sam Baker
Global Frontiers LLC., Manchester, VT 05155

Abstract

What we propose in this paper is that the interaction of "independent particles" in the form of human agents may be expected to result in a spontaneous curvature of spacetime, thus resulting in the launch and growth of a human economy. According to the theory of general relativity, the gravitational force is not a physical force; rather, the apparent force we call gravity results from the spontaneous bending or curving of spacetime interacting with a celestial body.

What if economic forces are like the gravitational force: each concept using "force" as a convenient metaphor to describe what in both cases is actually a spontaneous curvature of spacetime? To help explore this question, we will posit a mechanism behind the curving of spacetime that is common to the gravitational force (and the four fundamental forces more broadly) as well as economies.

Let us note here that the gravitational force plus the 3 other fundamental forces, are now commonly referred to as the 4 fundamental interactions due to the discovery that each "force" is related to the mediation or interaction of specific pairs of subatomic particles.

We propose an analogy between the 4 fundamental interactions and economic forces, such that in each case specific interactions between free particles or "agents" result in what appear to be "forces". In the case of economics, we propose that it is the free interaction of humans exchanging with each other in market settings that results in what we describe as an "economy" or our preferred term a "catallaxy." In this way, we can understand how economies launch and then evolve as the result of an ongoing spontaneous bending of spacetime that can be explained as the result of a process of market interaction or exchange. It is not coincidental that the four forces as well as the human economy can be described by the optimization mathematics of variational principles.

This analogy may offer a useful physical model for the new natural science of economics, based on the Law of Maximum Entropy Production (LMEP) that we outlined in the extended abstract we presented at IAISAE 2020.

Keywords: law of maximum entropy production (LMEP), variational principle, new natural science of economics, macroeconomics, entropy, catallaxy, Catallactics

[1]Gravitons have yet to be conclusively identified, but the other 3 subatomic particle interactions for the strong, weak and electromagnetic forces are well known.

[2]After being discussed by Ludwig von Mises the term catallaxy was later made popular by Friedrich Hayek who defines it as "the order brought about by the mutual adjustment of many individual economies in a market". Wikipedia

[3]See Jean-Louis Basdevant, Variational Principles in Physics: "In a certain sense, owing to their universality, variational principles can appear as a general "metatheory" of physics and perhaps, one day, of other branches of science such as biology, psychology, and social phenomena. They play a central role in economics."

*[4]See A New Natural Science of Economics by Sam Baker: Proceedings of the IAISAE 2020 International Conference on Thermodynamics 2.0, June 22-24, 2020 I Worcester, MA, USA ICT2.0:2020-W18*1

Corresponding Author E-Mail: spb802@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5-7, 2024 | Boone, NC, USA

T2.0:2024-0114

Life And Intelligence As We Do Not Know It

Soumya Banerjee

University of Cambridge, Cambridge, United Kingdom

Abstract

Information plays a critical role in complex biological systems. This article proposes a role for information processing in life, life-like systems and intelligence. I hypothesize that carbon-based life forms are only one amongst a continuum of life-like systems in the Universe. Investigations into computational substrates that allow information processing is important and could yield insights into novel non-carbon based computational substrates that may have "life-like" properties.

I hypothesize that the key components of a computational view of life, life-like systems and intelligence are: 1) Information processing, 2) information storage (memory), 3) a physical substrate (hardware), 4) information transfer (across both physical space and time), 5) persistence of information across space and time (selection and heredity), and 6) availability of energy. Organisms also interact with their environment and can modify it. Organisms also interact with each other. This forms the basis for different behaviour, leading to the emergence of collective intelligence. It is conceivable that the "ghost in the machine" might be related to collective intelligence and information processing in complex systems.

Life may exist as a continuum between non-life and life, and we may have to revise our notion of life and how common it is in the Universe. Looking at life-like phenomena and intelligence through the lens of computation may yield a broader view of life and intelligence.

Keywords: Information processing, Life-like systems, Computational substrates, Collective intelligence

Corresponding Author E-Mail: neel.soumya@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA

T2.0:2024-0129

LIFE AS I UNDERSTAND IT

Xinyan Zhang

Abstract

In this talk, I will argue that life is as fundamental as matter and energy, and they may only be defined and explained together. Without such defined matter, energy, and life, a unified explanation of the origin and evolution of species is impossible.

Keywords: evolution; definition; life; origin; natural selection

Corresponding Author E-Mail: neel.soumya@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 5-7, 2024 | Boone, NC, USA

T2.0:2024-0107

Variational principles in non-equilibrium thermodynamics and applications

Francois Joachim Marcel Gay-Balmaz

Abstract

One of the most fundamental principles in physics is the Principle of Critical Action. Maxwell's equations in electromagnetism, Newton's equations of motion in classical mechanics, Schrödinger's equations in quantum mechanics, and Einstein's equations in general relativity can all be obtained by extremizing a quantity, called action functional, encoding all the properties of the system.

In this talk, I will present an extension of this principle to the realm of nonequilibrium thermodynamics in its macroscopic description. The resulting variational formulation is an extension of Hamilton's principle which incorporates irreversible processes such as friction, heat and matter exchange, and chemical reactions. The structure of the variational formulation is reminiscent of the Lagrange-d'Alembert approach and allows the treatment of both closed and open thermodynamic systems. Several examples will be treated, such as thermomechanical systems, matter and heat transfer as well as reacting fluid flows.

Comments will be given towards applications of the variational formulation to thermodynamically consistent modeling and numerical discretization, as well as to extended irreversible thermodynamics.

Keywords: Nonequilibrium thermodynamics, variational principle, Lagrangian formulation, irreversible processes, heat and matter transfer, discretization.

Corresponding Author E-Mail: francois.gb@ntu.edu.sg

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0115

Understanding Motion and Work in Engineering Thermodynamics

Terry Bristol

Abstract

The aim of this essay is to distinguish two formulations of thermodynamics by contrasting their characteristic ways of conceiving motion and work. In classical thermodynamics motion proceeds in a straight-line by infinitesimal straight-line steps. This classical Newtonian-based motion is describable by differential equations and is time-reversible. By contrast, in engineering thermodynamics motion is irreducibly composite with both a linear (translational) and a circular (rotational) component. In engineering thermodynamics motion proceeds by irreversible finite-size and finite-duration steps.

Work in classical thermodynamics is expressed as fds, the result of an external force applied in a straight-line over a distance. The result is both path-independent and time-independent. By contrast, in engineering thermodynamics work is the result of a composite 'action', that actualizes a potential. The result of engineering work is path-dependent and time-dependent.

Keywords: Motion, Irreversible, Work, Engineering thermodynamics

Corresponding Author E-Mail: bristol@isepp.org

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0123

Infodynamics, a Review

Klaus Jaffe

Universidad Simon Bolivar, Caracas

Abstract

A review of studies on the interaction of information with the physical world found no fundamental contradiction between the eighth authors promoting Infodynamics. Each one emphasizes different aspects. The fact that energy requires information in order to produce work and that the acquisition of new information requires energy, triggers synergistic chain reactions producing increases of negentropy (increases in Useful Information or decreases in Information Entropy) in living systems. Infodynamics aims to study feasible balances between energy and information using empirical methods. Getting information requires energy and so does separating useful information from noise. Producing energy requires information, but there is no direct proportionality between the energy required to produce the information and the energy unleashed by this information. Energy and information are parts of two separate realms of reality that are intimately entangled but follow different laws of nature. Infodynamics recognizes multiple forms and dimensions of information. Information can be the opposite of thermodynamic entropy (Negentropy), a trigger of Free Energy (Useful or Potentially Useful), a reserve (Redundant Information), Structural, Enformation, Intropy, Entangled, Encrypted Information, Synergic or Noise. These are overlapping functional properties focusing on different aspects of Information. Studies on information entropy normally quantify only one of these dimensions. The challenge of Infodynamics is to design empirical studies to overcome these limitations. The working of sexual reproduction and its evolution through natural selection and its role in powering the continuous increase in information and energy in living systems might teach us how. https://www.qeios.com/read/2RBRWN.4

Keywords: Infodynamics, Negentropy, Information Entropy, Energy, Empirical methods

Corresponding Author E-Mail: kjaffe@usb.ve

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA

T2.0:2024-0120

System Science in Politics - Europe and the War in Ukraine

Jürgen Mimkes

Physics Department, Paderborn University, Germany

Abstract

Peace means order, and war brings disorder and chaos to any society. But order and disorder are not only found in wars, in many systems they are the dominant property. Understanding order and disorder enables us to understand the structure of systems. Since order and disorder are also part of the Lagrange Principle and statistics is valid in all systems, we may regard Lagrange statistics as a mathematical basis for the structure of all system. Two systems out of natural and social science are compared: materials of trillions of atoms and politics of millions of people.

Lagrange statistics leads to three phases of homogeneous systems: in materials we have the states: solid, liquid, gas, depending on two Lagrange parameters, temperature T (the mean energy of atoms) and pressure p. In politics we have three states: autocratic, democratic, global, depending on two Lagrange parameters, standard of living T (the mean capital of people) and political pressure p.

The three phases of each system are compared in the p-T phase diagram: Different phases of one system cannot coexist as nearest neighbors: Water will dissolve ice by exchange of atoms and heat. This leads to the present climate crisis. Democracies will dissolve autocracies by exchange of goods, ideas, and people like guest workers. This is the peaceful history of the EU and has led to the aggressive reaction of Russia in the GDR, Hungary, ČSR, and now in the Ukraine. At the end of war peaceful coexistence will not be possible between Russia and Ukraine. Only separation by a new Iron Curtain guaranteed by NATO can lead to a long-time armistice.

Keywords: peace, war, order, entropy, autocracy, democracy, coexistence

Corresponding Author E-Mail: juergen.mimkes@upb.de

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA

T2.0:2024-0124

Constructing A Framework For A Thermodynamic Grand History

Phillip R. Johnson
Physics Department, Paderborn University, Germany

Abstract

While thermodynamics has historically analyzed the physical sciences, it has shown promise in addressing questions related to socio-economic phenomenon in the past decades. Recently, the constructal law was used to explain complex phenomena such as socio-economic or politico-cultural shifts. While these topics can be studied in a somewhat isolated fashion, there is a benefit to seeing all such processes comprehensively. One such circumstance is the city of Ephesos in Asia Minor. Here, a brief history of the city will be recounted with emphasis on processes and events which shaped the city and its trajectory with analysis according to constructal theory. Physical aspects of this analysis will focus on the Meander River, the harbor at Ephesos and its silting. Economic analysis will inspect commerce on the water-based highways and the linkage of the city with various empires. Cultural reflections will observe temples dedicated to Artemis, Hadrian, and St. John the Theologian and the role that various religions played in the city's life as a pilgrimage destination. Finally, the cutting off of flow from all layers observed played a role in the demise of the city – a phenomenon which is also explained via the constructal law. It is demonstrated that many such flows are interconnected with feedback-like behavior, yet still retaining constructal features.

In further development of these themes, similar examples will be given via glosses on cities in the Mediterranean world during antiquity which showed divergent trends of either growth or decline. Attention will be given to the larger network that these cities were involved in and which formed the prosperous Roman trade network. Particular attention will be given to how the prosperity of the eastern Mediterrean led to the political and economic transformation of the Roman Republic to its imperial system and the crises of late antiquity. Analogies will be drawn to physical systems which display high energy gradients with evolving flow structures and emerging dissipative structures.

Keywords: thermodynamics, constructal theory, history, economics

Corresponding Author E-Mail: phillip.johnson.research@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0106

"THE VERY BEAUTIFUL PRINCIPLES OF NATURAL PHILOSOPHY": Michael FarADAY AND THE PHYSICS of organic forms

Robert Pepperell[1]

[1]Cardiff Metropolitan University, Cardiff, UK

Abstract

In 1854, Michael Faraday wrote to thank an author who had sent him a book on the art of paper marbling. In the letter, Faraday referred to "the very beautiful principles of natural philosophy" that the process of dropping ink on thickened water involved. Faraday was intimately familiar with paper marbling as it was widely used in the bookbinding trade in which he appreciated as a young man. What are the "beautiful principles" that Faraday referred to? How are they expressed in physical processes like marbling? And why are they beautiful?

In this talk I will consider some of the physical processes that occur in paper marbling and how the patterns that emerge are governed by fundamental principles of nature, in particular the tendency for physical systems to minimize their free energy and maximize their entropy. These same principles seem to govern the structure of forms at all scales, from the microscopic to the cosmologic. More specifically, I will consider the formation of cellular structures, which so often resemble the forms created in paper marbling and draw some more general conclusions about the role of thermodynamics in the creation of natural forms and in our aesthetic appreciation of them.

Keywords: energetics, aesthetics, thermodynamics, physics, art, entropy

Corresponding Author E-Mail: rpepperell@cardiffmet.ac.uk

**Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA**

T2.0:2024-0113

Thermodynamics: beauty, art, humor (Philosophical problems of thermodynamics)

Alec Groysman

Technion (Israel Institute of Technology), Haifa, Israel

Abstract

The goal of this work is to show philosophical principles of interaction between thermodynamics and beauty, art, and humor. The three last phenomena are important for our existence and relate to education in thermodynamics. I show my experience in searching for this important interaction and teaching this “dull” discipline under the name of “thermodynamics”.

In the first part, I analyze the concept of beauty and how we can relate it to different aspects of thermodynamics. In the second part, I describe examples of how people of art use thermodynamics in art, including painting, literature, poetry, music, and songs. In the third part, I show how humor can be used in teaching of thermodynamics.

Keywords: thermodynamics, beauty, art, music, humor

Corresponding Author E-Mail: alecgroysman@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0112

THE PRINCIPLE OF LEAST ACTION: APPLICATIONS TO THE LAW OF MAXIMUM ENTROPY PRODUCTION AND A NEW NATURAL SCIENCE OF ECONOMICS

Sam Baker

Global Frontiers LLC., Manchester, VT 05155

Abstract

What is the "natural mechanism" that explains how LMEP works. Posing and at least beginning to answer this question will help provide a deeper and more satisfying intuition for my new natural science of macroeconomics framework. Let's begin by looking at the definition of the law of maximum entropy production (LMEP) formulated by Rod Swenson in 1989:

"A system will select the path or assemblage of paths out of available paths that minimizes the potential or maximizes the entropy at the fastest rate given the constraints."
-Rod Swenson

Swenson's definition of LMEP is formulated in the language and logic of variational principles (specifically the principle of least action), as it clearly "presents natural phenomena as a problem of optimization under constraints." [see Jean-Louis Basdevant, Variational Principles in Physics]. Variational principles have yet to achieve their full promise as suggested by Jean-Louis Basdevant in his modern text Variational Principles in Physics:
"In a certain sense, owing to their universality, variational principles can appear as a general "metatheory" of physics and perhaps, one day, of other branches of science such as biology, psychology, and social phenomena. They play a central role in economics"

When Basdevant says "[variational principles] play a central role in economics" we assume he is referring to traditional macroeconomics modeled on a general equilibrium result solved for a set of linear differential equations. Our new natural science of economics classifies modern economies as non-linear far from equilibrium systems, specifically as per Rod Swenson's taxonomy, economies are natural autocatakinetic systems. Interestingly enough, in a pre-conference talk for the 2022 IAISAE Thermodynamics 2.0 conference, Francois Gay-Balmaz presented a Lagrangian variational formulation for non-equilibrium thermodynamics that goes beyond the reach and explanatory capability of previous efforts in this area. Perhaps Gay-Balmaz's work may be applied to modelling LMEP and eventually to modern economies.

Such modelling would eschew the specific point forecasting of modern macroeconomics, thus avoiding the false sense of control provided to policy makers by traditional macro modelling approaches, thus motivating a more humble approach to policy interventions.

Keywords: law of maximum entropy production (LMEP), least action principle, variational principle, new natural science of economics, macroeconomics, non-equilibrium thermodynamics, entropy

[5]see A NEW NATURAL SCIENCE OF MACROECONOMICS by Sam Baker: Proceedings of the IAISAE 2020 International Conference on Thermodynamics 2.0, June 22-24, 2020 | Worcester, MA, USA ICT2.0:2020-W181

Corresponding Author E-Mail: spb802@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0118

'Joint Kinetics': A New Approach in Bridging chemical Kinetics and Thermodynamics

Gregory S. Yablonsky

Washington University in St Louis, McKelvey School of Engineering

Abstract

Chemical kinetics is a multidisciplinary field integrating chemistry, physics, chemical/biochemical engineering, and mathematics. Recent advancements have introduced Joint Kinetics (JK), a new paradigm validated through experimental work on complex esterification reactions in batch reactors. JK involves conducting kinetic experiments with specific initial compositions and analyzing the data rigorously. This approach introduces novel concepts such as "events" and "maps of events," along with new invariances, both thermodynamic and non-thermodynamic. JK is effective in elucidating detailed reaction mechanisms, determining kinetic coefficients, and proposing innovative principles for chemical reactor design.

A notable concept within JK is "Conservatively Perturbed Equilibrium" (CPE), identified in studies involving linear and nonlinear reaction mechanisms. In CPE, initial concentrations in a closed chemical system are replaced by their equilibrium values while maintaining the total amount of each chemical element and a fixed temperature. Key properties of CPE include: substances with equilibrium initial concentrations exhibit concentration extremes toward equilibrium; these extremes can transiently establish partial equilibrium within certain steps of the mechanism; and the occurrence time of these extremes can be independent of the initial perturbation.

This study systematically explores these properties across various model mechanisms and industrial reactions, such as methane reforming. The diverse transition regimes observed, particularly in distinguishing "unperturbed" versus "perturbed" substances, provide valuable insights into these mechanisms. Applying the CPE phenomenon in catalytic methane reforming processes demonstrates two significant improvements: achieving over-equilibrium product concentrations and doing so in shorter reactor lengths than typically required for complete equilibrium.

Keywords: Chemical kinetics, Joint Kinetics (JK), Conservatively Perturbed Equilibrium (CPE), Reaction mechanisms

Corresponding Author E-Mail: gregoryyablonsky@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA

T2.0:2024-0122

ENDOREVERSIBLE DESCRIPTION OF RADIATIVE VUILLEUMIER REFRIGERATION MACHINES

Eduardo González-Mora[1], Ma. Dolores Durán-García, Ram Poudel[2]

[1]Universidad Autónoma del Estado de México, Toluca, Estado de México, México
[2]Appalachian State University, Boone, North Carolina, USA

Abstract

Refrigeration machines are essential for various applications, primarily generating artificial colds for diverse purposes. Vuilleumier refrigerators are standout solutions for low-temperature cooling among proposed thermodynamic cycles. In contrast to Stirling engines, Vuilleumier refrigerators feature two "displacers" connected by a mechanical linkage, where the hot displacer surpasses the size of the cold displacer. These devices transfer heat from a hot bath to a cold bath, serving as heat pumps, refrigerators, or cryocoolers at lower temperatures. Given that the sole input for Vuilleumier refrigerators is a heat source, solar energy emerges as a promising option to power these machines. The refrigerator's efficiency, reflected in its Coefficient of Performance (COP) and cold production, improves with a higher temperature heat source. Solar concentrators become instrumental in achieving elevated temperatures, making them a viable component for this application. Consequently, a comprehensive analysis is essential to understand the intricacies of coupling a solar concentrator with a Vuilleumier refrigerator.

In this context, we propose formally analyzing the integration of a solar concentrator with a Vuilleumier refrigerator, providing an initial description within the framework of endoreversible thermodynamics. The generalized expressions from this analysis deepen our understanding of the system and serve as practical tools to promote the utilization of these efficient machines. Through this research, we aim to pave the way for advancements in sustainable refrigeration technology, harnessing the potential of solar energy for enhanced environmental and energy efficiency.

Keywords: Vuilleumier cycle, solar concentrators, endoreversible thermodynamics, refrigeration

Corresponding Author E-Mail: egonzalezmo@uaemex.mx

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0105

UNIFIED MACROSCOPIC PHYSICS

Katalin Martinás

Abstract

There is a logical discrepancy in physics. Energy in the scientific language and in the colloquial language have different meanings. Energy in physics is an objective conserved quantity, Colloquial energy is the capacity for work, but it is not conserved. More, it usually contains subjective elements, as it is related to the use, usefulness of energy. The colloquial energy can be produced, if the energy of coal is transformed to electric energy. Colloquial energy is useful quantity, but there is no objective mathematical representation for it.
We start the search for the objective colloquial energy with the objective capacity work in physics.
Randt in 1956 proposed exergy, as the work capacity. Exergy is the maximum amount of mechanical work, which can be taken out from a system in a thermal reservoir (in constant temperature and pressure environment. This quantity is useful in engineering practice, and for environmental economics. The value of exergy varies with the environment. There ts an objective physical measure, which is independent of the environment. The maximum amount of work is measured by the height the weight is lifted by the work, and there is no other heat or work done by the environment.

This capacity of work was not important in physics. But it changes the narrative of macroscopic physics, as this capacity of work incorporates the mechanical work and thermodynamic one, so this concept unifies macroscopic physics. Energy of a macroscopic system will appear as the sum of capacity for work and the anergy (no work capacity).

United macroscopic physics is simpler. A simple and general proof for the existence of entropy is given. It reveals that entropy is a very good tool for mathematical physics, but for colloquial physics it is useless, meaningless.
For colloquial use a relative of entropy, called, extropy is introduced, which is the measure of the order, capacity for work and information.

Keywords: energy, entropy, information, economics

Corresponding Author E-Mail: kati.martinas@gmail.com

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0119

Stochastic Processes and Statistical Mechanics

Themis Matsoukas

Abstract

Statistical thermodynamics delivers the probability distribution of the equilibrium state of matter through the constrained maximization of a special functional, entropy. Its elegance and enormous success have led to numerous attempts to decipher its language and make it available to problems outside physics, but a formal generalization has remained elusive. Here we show how the formalism of thermodynamics can be applied to any stochastic process.

I view a stochastic process as a random walk on the event space of a random variable that produces a feasible distribution of states. The set of feasible distributions obeys thermodynamics: the most probable distribution is the canonical distribution, it maximizes the functionals of statistical mechanics, and its parameters satisfy the same Legendre relationships. Thus, the formalism of thermodynamics–no new functionals beyond those already encountered in statistical physics–is shown to be a stochastic calculus, a universal language of probability distributions and stochastic processes.

I will present an example that undergoes phase transition when the concavity of the microcanonical partition function is violated.

Keywords: Stochastic process; partition function, Gibbs and Boltzmann entropy

Corresponding Author E-Mail: txm11@psu.edu

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0108

Probabilistic description of thermodynamics third law

Angel Plastino

National University of La Plata, Argentina

Abstract

We review some intriguing recent results in the probabilistic description of thermodynamics' third law (Nernst law) so as to erect a classical scenario in which one encounters analogies to typical features associated to such quantum law. That is, we construct here a classical environment that is indeed a classical counterpart to that revolving around Nernst quantum one. The present construction is built up in terms of order-disorder quantifiers.

Keywords: Nernst law, order, disorder, thermodynamics

Corresponding Author E-Mail: plastino@fisica.unlp.edu.ar

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 | Boone, NC, USA

T2.0:2024-0103

CHARACTERIZING THE MICRO-HETEROGENEITY OF CHEMICAL SYSTEMS BY DETERMINING THEIR FUZZY ENTROPY

Pier Luigi Gentili

Department of Chemistry, Biology, and Biotechnology, Università degli Studi di Perugia, Perugia, Italy.

Abstract

A chemical system with non-uniform microscopic physicochemical features is termed micro-heterogeneous. This micro-heterogeneity can be characterized using stationary or time-resolved spectroscopic techniques. In time-resolved spectroscopy, transient signals (S(t)) monitor the system's relaxation to thermodynamic equilibrium or steady-state after a perturbation. There are two approaches to analyze S(t). The first approach interprets micro-heterogeneity using a large distribution of kinetic constants associated with exponential decay functions, determined by the Maximum Entropy Method (MEM). The second approach introduces a time-dependent rate coefficient in the linear differential equation describing the excited state's decay, resulting in stretched exponential or compressed hyperbola fitting functions. These functions are adjusted using the Levenberg-Marquardt algorithm to minimize chi-square.

These approaches have been applied to time-resolved spectrofluorimetric signals from photochromic and luminescent samples. Characterizing micro-heterogeneity through MEM allows the determination of Fuzzy Entropy, defined as:

$$H_{nor} = -\frac{1}{\log log\, N}\sum_{i=1}^{N} \mu_i \log log\, \mu_i$$

where N is the number of exponential terms, i is the weight of the i-th term, and 0≤Hnor≤1. Higher micro-heterogeneity corresponds to larger Fuzzy Entropy. Any distribution of lifetimes represents a molecular fuzzy set. Mixtures of selected chemical compounds can granulate physicochemical variables and process fuzzy logic at the molecular level, contributing to the development of Chemical Artificial Intelligence.

Keywords: Micro-heterogeneity, Time-resolved spectroscopy, Maximum Entropy Method (MEM), Fuzzy Entropy 5. Chemical Artificial Intelligence

[1] Ranko, R.; Blumen, A. Disorder effects on relaxational processes: glasses, polymers, proteins. *Springer-Verlag, Berlin Heidelberg,* 2012.
[2] Berberan-Santos, M. N.; Valeur, *B. J. Lumin.* 2007, 126, 263-272.
[3] Gentili, P. L. J. *Phys. Chem.* B, 2024, under review.
[4] Gentili, P. L.; Perez-Mercader, J. *Front. Chem.* 2022, 10, 950769.
[5] Gentili, P. L.; Stano, P. *Front. Robot.* AI 2023, 10, 1238492.
[6] Gentili, P. L.; Stano, P. *Front. Robot.* AI 2023, 10, 1266011

Corresponding Author E-Mail: pierluigi.gentili@unipg.it

Proceedings of the T2024
International Conference on Thermodynamics 2.0
August 05-07, 2024 I Boone, NC, USA

T2.0:2024-0102

Principium Luxuriæ: Multiscale Thermodynamics to Living and Non-Living Complex Systems

Patricio Venegas-Aravena
Pontifical Catholic University of Chile

Abstract

Multiscale systems, such as fractals or complex systems, are difficult to analyze because physical descriptions usually focus on macroscopic scales, ignoring reactions that can occur at smaller scales. This leads us to wonder if there is some type of principle that allows us to derive the dynamics of multiscale systems considering all these scales. Along these lines, the Principium Luxuriæ establishes that the efficiency of energy dissipation on a small scale determines the appearance of complex structures, while macroscopic dissipation is associated with emergent behaviors. The possible applications of this principle in physical and biological systems are discussed.

Keywords: fractal dimension, Principium luxuriæ, complex systems, multiscale entropy

Corresponding Author E-Mail: plvenegas@uc.cl