

Title: No entailing laws, but enablement in the evolution of the biosphere

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Abstract: Biological evolution is a complex blend of ever changing structural stability, variability and emergence of new phenotypes, niches, ecosystems. We wish to argue that the evolution of life marks the end of a physics world view of law entailed dynamics.

# THE END OF A PHYSICS WORLDVIEW AT THE WATERSHED OF EVOLVING LIFE

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- PERIMETER INSTITUTE
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## I. THE NEWTONIAN PARADIGM

- Newton, laws of motion in DE form, initial and boundary conditions, then integration to yield trajectories in a pre-stated phase space.
- Canonical example: billiard balls on billiard table, Newton's 3 laws of motion given for balls, initial conditions of position and momentum and the boundary conditions define the phase space of all possible positions and momenta. Phase space is space of all possible states.
- Integration of ODEs yields entailed trajectories on balls in pre-stated phase space.
- Partial differential equations are same thing



- Classical physics is determinism ie classical mechanics, Maxwell's equation, Special and General Relativity.
- Exception statistical mechanics due to ergodic hypothesis, microstates and macrostates and second law but still in a prestated  $6N$  dimensional phase space.
- Open box and particle flow in and out, same framework.
- Probability e.g. dice throws is MERELY EPISTEMIC in a prestated phase (sample) space. We have probability measure and can define random because we know the sample space. Assume fair dice.



- QUANTUM MECHANICS: CRISIS IN PHYSICS

Planck, the quantum of action, and the advent of quantum mechanics.

- Ontological indeterminism e.g. in quantum jumps between energy levels of sodium (take care re Bohm deterministic but non local)
- Vast debate: Einstein refuses, “God does not play dice”
- Recovery of Newtonian Paradigm”
- Schrodinger equation, linear partial differential wave equation

- So Quantum Mechanics is still within the Newtonian Paradigm.
- IE in QM still in a pre-stated phase space and deterministic trajectory in that phase space.
- Feynman path integrals is same thing.
- Same for quantum field theory generated by particles by and symmetries.
- Standard Model of particle physics.
- THIS IS THE REDUCTIONIST DREAM OF A FINAL THEORY.



- DOUBTS ABOUT REDUCTIONISM:
- NOBEL PHILIP W. ANDERSON, “MORE IS DIFFERENT”, SCIENCE 1977
- NOBEL ROBERT LAUGHLIN “THE UNIVERSE FROM THE BOTTOM DOWN”.
- DERIVING NAVIER STOKES FROM CELLULAR AUTOMATA AS EXAMPLE OF NEW LAWS EMERGING AT HIGHER LEVELS AND THEY NEED NOT BE REDUCED TO LOWER LEVEL LAWS. SO REDUCTIONISM MAY BE INVALID
- AGAIN, NEW LAWS MAY NOT BE REDUCIBLE TO THE FUNDAMENTAL LAWS. IF SO, REDUCTIONISM FAILS AND EMERGENCE IS REAL.
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- A NEW LARGER CRISIS FOR THE PHYSICS WORLD VIEW:  
NO ENTAILING LAWS AT ALL FOR EVOLVING BIOSPHERES  
ANYWHERE IN THE UNIVERSE
- At least above there are LAWS that may or may not be  
reducible to the fundamental laws, i.e. to Particle  
Physics and General Relativity
- We are about to say there are NO ENTAILING LAWS AT  
ALL FOR EVOLVING BIOSPHERES.

A NEW BIGGER CRISIS FOR THE PHYSICS WORLD VIEW:

NO ENTAILING LAWS AT ALL FOR THE EVOLUTION OF THIS  
OR ANY BIOSPHERE IN THE UNIVERSE

NB :

WITH AN ESTIMATED 20 TO 22 SOLAR SYSTEMS IN THE  
UNIVERSE, THERE MAY BE ON THE ORDER OF 10 TO 22  
BIOSPHERES.

THERE ARE NO ENTAILING LAWS FOR ANY OF THEM

“WORLDS (dependent upon but) BEYOND PHYSICS”



- The universe is NON ERGODIC (NE) above the level of atoms, 500 Daltons Vattay 2019.
- Big Bang -> nucleosynthesis of 100 stable atoms -> formation of simple then ever more complex molecules.
- Consider all possible proteins length 200 amino acids: There are 20 to 200 or 10 to 260 of these.
- At Planck time scale of 10 to  $10^{-43}$  seconds and with 10 to 80 particles, it would take 10 to 37 times the lifetime of universe to make all possible proteins length 200 just ONCE!
- CRUX: MOST COMPLEX THINGS WILL NEVER EXIST!

THE UNIVERSE EVOLVES INTO ITS EVER NEW ADJACENT POSSIBLE AT THE LEVEL OF MOLECULES AND LIVING THINGS.



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- Most complex things will not exist
- One way to exist in Non Equilibrium Universe, NE, is to be a Kantian Whole
- Define Kantian whole:
- The Whole exists for and by means of its parts
- Collectively autocatalytic set as an example, eg Ashkenasy with 9 peptide autocatalytic set



- Definition: THE FUNCTION OF A PART IS ITS CAUSAL ROLE IN SUSTAINING THE WHOLE
- Function is a SUBSET OF CAUSAL CONSEQUENCES, SO NOT REDUCIBLE TO PHYSICS. Physics has ALL the causal consequences, cannot pick out a subset.
- The FUNCTION of heart is to pump blood, not jiggle water in pericardial sac.

- Vertebrates have hearts but most complex things will not exist.
- So: Why do Hearts exist in the universe?
- Vertebrate organism, e.g. a human, is a Kantian Whole. You exist for and by means of your heart. You are a Kantian Whole
- Darwin's account of the evolution of the heart, selective advantage
- But Darwin also accounts for WHY HEARTS EXIST AT ALL IN THE NON ERGODIC UNIVERSE ABOVE THE LEVEL OF ATOM! Life emerged, hearts evolved to sustain Kantian Wholes.
- The coming into existence of hearts, flagellar motors, feathers, hearing and sight are PART OF THE BECOMING OF THE UNIVERSE.



- The Phase Space of biological evolution MUST INCLUDE functions of Parts in sustaining their Whole” (e.g. hearts pumping blood sustain you), BECAUSE FUNCTIONS EXPLAINS WHY/HOW THESE “THINGS” ( HEARTS) COME TO EXIST IN THE NON ERGOIC UNIVERSE ABOVE LEVEL OF ATOMS.
- DIACHRONIC VERSUS SYNCHRONIC SCIENCE: The evolution of life in the past 3.7 billion years is diachronic versus how your heart works now. Now is synchronic. The latter can be explained by physics. But the coming into existence of hearts in the non-ergodic universe cannot be explained by physics alone.
- A World Beyond Physics.



- WE CANNOT PRESTATE FUNCTIONS!
- JURY RIGGING AS AN EXAMPLE USING THINGS TO ACCOMPLISH TASKS FOR WHICH THEY WERE NOT DESIGNED. i.e. USE OF UNUSED CAUSAL CONSEQUENCES OF THINGS
- TRACTOR EXAMPLE

- HOW MANY USES OF A SCREW DRIVER TODAY IN TORONTO? SCREW IN A SCREW, SCRAPE PUTTY FROM A WINDOW, PROP WINDOW OPEN, SCRATCH BACK, TIE TO STICK AND SPEAR FISH, RENT SPEAR FOR 5% OF THE CATCH...
- IS THE NUMBER OF USES DEFINITE, EG 67, INFINITE, OR INDEFINITE?
- THE NUMBER OF USES IS INDEFINITE.
- MATHEMATICAL SCALES: NOMINAL, PARTIAL ORDER, INTERVAL, RATIO SCALE
- USES OF SCREW DRIVERS IS A NOMINAL SCALE SO NO ORDERING RELATION AMONGST THESE USES
- THUS NO ALGORITHM CAN COMPUTE ALL THE USES OF A SCREW DRIVER NOR THE NEXT NEW USE OF A SCREW DRIVER.
- BUT WE FIND NEW USES OF SCREW DRIVERS ALL THE TIME. EG JAMES BOND IN A CRISIS USES A SCREW DRIVER TO DO....WHAT?
- BUT THESE NEW USES ARE TYPICALLY “UNPRESTATABLE”! Not “UNPREDICTABLE”, BUT “UNPRESTATABLE”



- EVOLUTION FINDS NEW USES OF “SCREW DRIVERS” ALL THE TIME. THESE ARE DARWINIAN “PREADAPTATIONS”, OR “EXAPTATIONS”.
- BUT DARWINIAN PREADAPTATIONS NOT PRESTATABLE
- Some fish evolved swim bladders which tune neutral buoyancy in the water column and evolved from lungs of lung fish.
- “Neutral buoyancy” is a new function that arises in evolution.
- It is NOT POSSIBLE TO PRESTATE THE EMERGENCE OF THIS NEW FUNCTION
- SO THE SPECIFIC EVOLUTION OF THE BIOSPHERE IS NOT PRESTATBLE.

- THE EVOLUTION OF THE BIOSPHERE CREATES ITS OWN FUTURE POSSIBILITIES OF BECOMING WITHOUT SELECTON ACHIVING IT.
- Once a swim bladder exists, a worm species or bacterial species might evolve to live only in swim bladders.
- So the swim bladder is an “empty adjacent possible niche” into which a worm or bacterium may come to live.
- (NB. This new swim bladder niche does not CAUSE but ENABLES the worm or bacterium to come to live in it. Quantum random indeterminate mutations then selection.)



- Selection presumably “acted” to fashion a functioning swim bladder.
- But did selection “act” to create the swim bladder in order to create an “empty adjacent possible niche?”
- NO!
- SO WITHOUT SELECTION “DOING IT” EVOLUTION IS CREATING ITS OWN FUTURE PATHWAYS OF UNPRESTABLE BECOMING.

- Therefore we cannot prestate the relevant variables or functionalities in the evolution of the biosphere: neutral buoyancy, flagellar motors, feathers evolved for thermoregulation and co-opted for flight.
- THE PHASE SPACE OF EVOLUTION, WHICH INCLUDES FUNCTIONS OF PARTS, CHANGES IN UNPREDICTABLE WAYS .
- We cannot prestate what is IN the adjacent possible of the evolution of the biosphere
- Therefore we do NOT know the sample space of this process
- Therefore we have no Probability measure at all
- Therefore we cannot define RANDOM with respect to a probability measure.
- Therefore we cannot do statistics in any normal way



- WE DO NOT KNOW THE RELEVANT VARIABLES, THUS WE CAN WRITE NO LAWS OF MOTION FOR THE EVOLVING BIOPHERE
- WE ALSO CANNOT PRESTATE THE BOUNDARY CONDITIONS NON- CIRCULARLY. THE UNPRESTATBLE NICHE IS THE BOUNDARY CONDITION.
- THEREFORE WE CANNOT INTEGRATE THE EQUATIONS OF MOTION WE DO NOT HAVE AND COULD NOT INTEGRATE EVEN IF WE HAD THEM AS WE CANNOT PRESTATE THE BOUNDARY CONTIONS.
- NO LAWS AT ALL ENTAIL THE EVOLUTION OF THIS BIOPHERE OR ANY BIOSPHERE IN THE UNIVERSE.

- FOR THE FIRST TIME IN 350 YEARS SINCE NEWTON WE ARE FORCED BEYOND THE NEWTONIAN PARADIGM OF LAWS OF MOTION, INITIAL AND BOUNARY CONDITIONS, THEN ENTAILED TRAJECTORIS IN PRESTATED PHASE SPACES.
- THERE ARE NO “PRESTATED” PHASE SPACES FOR EVOLVING BIOSP[HEREs HERE AND ON 10 TO 22 PLANETS.
- WORLDS (that depend upon physics but) BEYOND PHYSICS. PERHAPS AS VAST IN THE UNIVERSE AS PHYSICS. IS MOST OF THE COMPLEXITY OF THE UNIVERSE IN ITS LIFE FORMS?
- THERE IS A POSSIBLE 4<sup>TH</sup> LAW: “THE ADJACENT POSSIBLE PHASE SPACE OF OUR UNIVERSE TENDS TO INCREASE.”
- IF A 4<sup>TH</sup> LAW IS TRUE, WHY WOULD IT BE TRUE IN THIS UNIVERSE? ARE THERE MULTIPLE UNIVERSES AND WE THE LUICKY? OR SMOLIN AND PRECEDENCE SELECTS THIS UNIVERSE, LAWS AND CONSTANTS SUCH THAT THIS UNIVERSE BECOME COMPLEX, WITH A 4<sup>TH</sup> LAW? DARWIN ALL THE WAY DOWN?





THANK YOU