

On the Origin of Force

change evolves by natural selection

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A novel approach is proposed. Known microscopic time-symmetrical laws of physics, or phenomena underlying them, are a source of variation for natural selection mechanism that is driven by information-related criteria. From this evolutionary mechanism entropic force emerges. This force not only implies second law of thermodynamics but may be interpreted as the origin of other forces found in nature, including gravity. Therefore, I argue that force is an emergent phenomenon and also show evidence suggesting that indeed laws of nature may be reformulated as purely entropy-driven.

Evolution of species, in practice, cannot be predicted or explained only by methods employing microscopic models. There is still no well-established complete mechanism of how first cellular life evolved and theory of evolution was conceived before genes were discovered as carriers of precise information. Discovery of Darwinian evolution is an indication that bottom-up approach alone cannot explain immensely complex emergent phenomena and for a complete understanding it must be accompanied with a top-down perspective. One proponent of theory famously defended it against strong criticism by observing that:

"nothing in biology makes sense except in the light of evolution." [1]

There is a longstanding conundrum how to explain that perceived entropy of the universe does not decrease. The source of this trouble is the apparent impossibility to deduce irreversible phenomena from time-symmetrical laws yet it seems to happen all the time – this is the essence of the Loschmidt's paradox [2]. Furthermore, explicit correspondence was recently found between *emergent* quantum mechanics and the classical theory of irreversible thermodynamics

that provides evidence that quantum mechanics is not a fundamental theory [3]. Therefore, it is increasingly important to explain mechanism by which entropic force emerges. That is what I intend to do.

In the next section I introduce the problem of time invariance then I give a brief overview of proposed evolutionary mechanism, relate it to the emergence of force, show that major laws of nature may be successfully reformulated as entropy-driven, comment on time, definition of entropy and finally I end with a summary.

Time Invariance of Events. The essence of various formulations of second law of thermodynamics is that the entropy of an isolated system tends not to decrease. This is in apparent contradiction with the fact that fundamental laws of physics are time-symmetrical². To understand this apparent contradiction, it must be appreciated that for every event E during which entropy increases with the following state transitions in time:

$$t1 \rightarrow t2 \rightarrow t3$$

we can define event E' that is the reverse of E, entropy during this reverse process decreases with time and it represents following state transitions:

$$t3' \rightarrow t2' \rightarrow t1'$$

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² if rare C and P violations are omitted that render only postulated CPT symmetry undisputed

State tx' is a state tx with momenta reversed (a simplified application of symmetry for clarity of argument). It can be imagined that superobserver made pictures of this process in all three states without affecting universe in any way. An uncorrelated with this event another observer was shown pictures of three states of the event E/E' . Pictures for both events look the same as they lack precise information about momenta and information whether pictures represent states $t1, t2, t3$ or $t1', t2', t3'$. They are precise to some arbitrary accuracy and some features of the system are distinguishable. By looking only at the picture of intermediate state of this process, this observer may be tempted to conclude that the entropy increased during this event – that this picture represents state $t2$ and not $t2'$. However, after careful consideration, she must realize that it is not known if the picture shows state $t2$ or $t2'$. It cannot be solved by saying that there are more ‘ways’ to be in state $t3$ than in state $t3'$. Evolution of this event is predetermined by the actual parameters of all the particles (interactions) involved in the event. *Another way* of looking at this problem is to imagine a state of low entropy. Because of time-symmetry of known fundamental laws it should evolve in a similar way in both directions in time. Evolution from this state of low entropy in the direction pointed by thermodynamical arrow of time is stable. It tends to evolve into state of higher entropy despite external perturbations during the process. However, if it were to evolve in the opposite direction of time, the process would be unstable despite time-symmetrical known fundamental laws. Hence, there is asymmetry. To avoid issues related with time, instead of considering event evolving in the opposite direction of time, one may simply imagine symmetrical situation (with momenta reversed) evolving in the same direction of time and then consider if it is immune to small perturbations.

Metatemporal Evolution. Aforementioned reasons suggest that for any event (process) that is evolving, the value of entropy does not necessarily increase but may oscillate (increase, decrease or stay constant). This result is reconciled with common intuitions in next section. Those oscillations are *determined* by

microscopic state of a system and, if precise information is unavailable, may be *approximated* by changes in entropy value resembling a variant of random walk as there is no preferred direction.

Such approach still requires some source of variation (change) for underlying theory. If hypothesized expansion of space itself is true, then this is one possible source of variation. If not, some other source of variation should exist. Alternatively, entropic force may be a source of variation for itself if there is some mechanism that would enable it to perpetuate (similarly to electromagnetic wave propagation). Furthermore, it is possible that there are multiple sources of variation. In any case, further research is needed.

Metatemporal Natural Selection. During metatemporal evolution of an event, as described in previous section, event evolves as determined by microscopic state of a system. For human scale, microscopic state could mean a particular configuration of molecules, for quantum mechanics it could be a microscopic state in more fundamental underlying theory [3]. However, only recently it was shown using quantum mechanical framework, that a process decreasing entropy of a system *necessarily* is accompanied by erasure of all information about itself rendering it virtually non-existent [4][5][6][7]. Similar conclusions about memory were recently reached, without use of quantum theory, for classical mechanics [8]. In essence, only if environment (“causal surroundings”) of an event can effectively act as a memory the event can escalate. Therefore, event that only results in decrease of entropy *goes extinct by necessity and does not escalate*.

Metatemporal Mating. This mechanism can be best described by considering three events that happen in three correlated systems as shown in Figure 1:

- A. Event happens in ES and results in increase of entropy of system ES. A record of this event may be stored in system OS, but even if it will not be immediately stored in system OS, a record is made in ES about this event happening so that it may be

recorded later by system OS. This event does not go extinct.

- B. Event happens in ES and results only in decrease of entropy of system ES before this event is recorded in observer system, therefore OS will have no record of it happening and all trail after this event happening will be removed also from system ES. The result is that this event was highly unsuccessful as it went extinct in system ES and left no trail in any system. Decrease of entropy in ES was necessarily accompanied by erasure of all records about this event happening in ES.
- C. Event happens in ES and results in decrease of an entropy of ES. However, it is accompanied by event in OS that records it and in doing so increases entropy in OS (it escalates from event in ES to event in ES+OS). If this results in increase of an entropy of combined system ES+OS it does not go extinct and it may further escalate and be recorded by system EES (escalating to an event in combined system ES+OS+EES). On the other hand, if event results in decrease of entropy in combined system ES+OS and is not recorded in system EES (increasing entropy of EES) then it goes extinct by natural selection because event only decreasing entropy of system ES+OS must be accompanied by erasure of all information about this event happening.

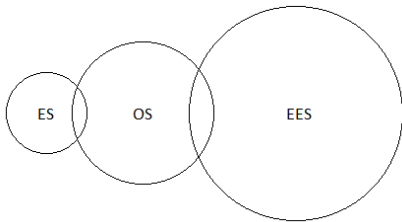


Figure 1. Event System (ES), Observer System (OS) and External Environment System (EES)

Therefore, events escalate by engaging successive systems and may go extinct by natural selection at the stage that also depends on the correlations with other events (mating).

Time. The word ‘metatemporal’ was chosen to describe this evolutionary process for two reasons: (a) only successful branches may be directly observed,

not all of the evolution and (b) some approaches to time define it in relation to an amount of change. Point (a) does not need further explanation. Concern regarding (b) is related to the fact that some interpretations of time require change to be observed. Therefore, in such approaches, one would need to carefully consider if events that finally went extinct contribute to the passage of time [9][10].

Implementations. The theory was described in a way that avoids unnecessary and potentially misguided assumptions about space. Moreover, because of the fact that many definitions of entropy exist, it is a matter of further research to decide which entropy definition results in best description of observed phenomena by the model and whether there is one or many heat baths (or alternatively more dimensions). I assumed definitions as in publications referenced in natural selection section. Darwinian theory of evolution was published in 1859 but molecular structure of DNA was identified almost hundred years later – in 1953 [11]. And even nowadays, it is an intriguing endeavor to research evolution of the eye or flagellum. Darwinian theory of evolution, when published, did not explain precisely how flagellum evolved or how information is transferred. Therefore, this approach seems justified. More precise theory should be an implementation of metatemporal evolution.

Emergence of Force. Theory presented in previous sections describes a process by which entropic force emerges. In particular, it can be described by equation:

$$1/T = \partial S / \partial E$$

It is worth noting that recent developments of entropic force approaches are promising. Moreover, evidence that even gravity may be reinterpreted in such a way arises from AdS/CFT correspondence. And indeed, it was proposed that models based on assumption that entropic force is fundamental can be used to successfully derive, in particular: laws of Newton, Einstein’s equations [12][13][14][15], Brownian motion [17][16], Hook’s law, Curie’s law, Langevin-Debye equation [17], Lovelock gravity [18], Coulomb’s Law [19][21][20], Poisson equation, Maxwell

equations [21] and even electroweak and strong forces [22]. It was also argued that entropic force approach could explain dark matter, dark energy and Pioneer 10/11 apparent anomalies [23]. These methods are based on assumption of holographic principle to justify existence of entropic gradient, but do not explain the origin of entropic force. In fact, holographic principle shares some aspects with the presented method of evolution as central point of both approaches is related to information. Therefore, holographic principle appears to be a notion that is auxiliary to the presented mechanism of metatemporal evolution. Some of the most often used examples to demonstrate entropic origin of forces are freely-jointed polymer immersed in heat bath [24][12] and hydrophobic force.

Emergence of Physical Structures. Metatemporal mechanism suggests that entropic traps lead to existence of stable physical structures and that such traps may be overcome by increasing temperature. For example, riderless bicycles are self-stable at certain speeds. Such bicycles even after a surprisingly strong lateral perturbation can spontaneously steer themselves back to the vertical position [25][26]. Another example is that electromagnetism and weak interaction merge when an appropriate temperature is reached into an electroweak force.

Furthermore, described mechanism seems to be scale invariant. Therefore, it suggests that physical structures and laws evolve *in scale*. Not necessarily only into larger structures (solar systems, galaxies), but it seems that metatemporal evolution allows for new structures to evolve on smaller scales (subatomic and beyond). Moreover, it is not necessary for human scale to have a special status. Similarity between large and small structures is a further evidence in support of the theory. In particular, elementary particles share many similarities with black holes [27][28][29]. In addition to already mentioned explicit correspondence between emergent quantum mechanics and classical theory of thermodynamics [3], it is interesting to point out that Heisenberg's uncertainty principle is not a unique property of quantum systems but, as it was shown, a principle inherent in the properties of all wave-like

systems. [30] Furthermore, universal principle of entropic uncertainty is a stronger extension of classical uncertainty principle. [31]

Conclusions

Presented theory claims that apparent strength of forces is not their intrinsic property but the outcome of inevitability of natural selection. Forces are merely our tools in predicting behavior that both leads to increase of entropy and is allowed by existing entropic barriers. Their consequences evolve by imminent change intrinsic to microscopic phenomena (bottom-up approach) and then are naturally selected by information-related phenomena (top-down approach). Metatemporal evolution theory explains how this mechanism works and assures that *prima facie* all states seem to have their origin purely in microscopic phenomena.

Darwinian theory of evolution may share not only this characteristic with metatemporal evolution theory. Interestingly, even counting only species and not individual organisms, it is estimated that 99.9% of them are extinct by now [32].

When it was noticed that electroweak and strong forces can be interpreted as of entropic origin, author observed:

"[...] This suggests a picture with no fundamental forces or forms of matter whatsoever" [22]

providing further support for the presented metatemporal evolution theory.

"But the one field which has not admitted any evolutionary question is physics. Here are the laws, we say. But how did they get that way, in time?" [33]

It turns out, every new moment is a result of complex evolution by natural selection.

Summary and Conjectures

1. metatemporal evolution theory describes physical phenomena
2. it is scale invariant
3. new moments evolve by natural selection
4. physical laws and structures evolve also *in scale* (metaevolution [34])
5. all forces in nature have entropic origin

6. forces are part of our pattern recognition framework for predicting behavior that a) leads to increase of entropy and b) is allowed by existing entropic barriers

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