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 explain that force is an emergent phenomenon and also show evidence that indeed laws of nature may be reformulated as purely entropy-driven.

Darwinian 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 even 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."[2]

Does it sound like quantum mechanics? 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 [1]. 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 [2]. 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 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 and finally I end with a summary.

Metatemporal Evolution Theory

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-symmetrical[3]. 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 -> t2 -> t3

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[2] Dobzhansky, Theodosius (March 1973). "Nothing in Biology Makes Sense Except in the Light of Evolution". The American Biology Teacher (McLean, VA: National Association of Biology Teachers) 35 (3): 125–129. doi:10.2307/4444260.

[3] if rare C and P violations are omitted that render only CPT symmetry undisputed

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' -> t2' -> t1'

State tx' is a state tx with momenta reversed (a simplified application of symmetry for clarity of argument). Event E represents a subsystem of the universe more or less spatially distributed and probably this event occurs in deep space. 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 any 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 fundamental laws.

Metatemporal Evolution. Aforementioned reasons suggest that for any event (process/subsystem) that is evolving and changing its entropy, the value of entropy does not necessarily increase but may oscillate (increase, decrease or stay constant). Those oscillations *are not* constrained by second law of thermodynamics but are *determined* by microscopic state of a system. I *reconcile* this result with common intuitions in the next section. These oscillations, 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.

Metatemporal Natural Selection. During metatemporal evolution of an event, as described in previous section, entropy oscillates 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 [2]. However, only recently it was shown using quantum mechanical framework, that a process decreasing entropy of the system *necessarily* is accompanied by erasure of all information about itself rendering it virtually non-existent [3][4][5][6]. Similar conclusions about memory were recently achieved, without use of quantum theory, for classical mechanics [7]. In essence, only if environment (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 Heredity and 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.

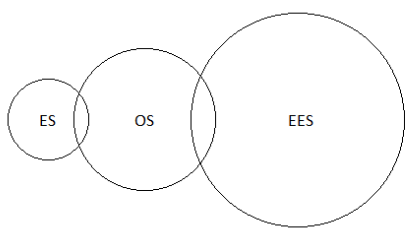

Figure 1. Event System (ES), Observer System (OS) and External Environment System (EES)

Therefore, events escalate by evolution by engaging successive systems and may go extinct by natural selection at the stage that 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 [8][9].

Entropy Definition. 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. I showed that it works with definitions as in referenced works.

Emergence of Force

Metatemporal Evolution Theory describes a process by which entropic force emerges. In particular, it can be described by equation:

$$F\Delta x = T\Delta S$$

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, models based on assumption that entropic force is fundamental were successfully used to derive, in particular: laws of Newton, Einstein's equations [10][11][12], Brownian motion [14][13], Hook's law, Curie's law, Langevin-Debye equation [14], Lovelock gravity [15], Coulomb's Law [16][18][17], Poisson equation, Maxwell equations [18] and even electroweak and strong forces [19]. It was also demonstrated that entropic force approach explains dark matter, dark energy and Pioneer 10/11 apparent anomalies [20]. Most of this 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 explicit examples that demonstrate purely entropic origin of forces are freely-jointed polymer immersed in heat bath [21][10] or hydrophobic force.

Conclusions

Presented theory shows that apparent strength of forces is not their intrinsic property but the outcome of inevitability of natural selection. 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% are extinct by now. [4]

When electroweak and strong forces were derived from entropic origin, author claimed:

"[..] This suggests a picture with no fundamental forces or forms of matter whatsoever" [19]

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?"[5]

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

[1] J. Loschmidt, Sitzungsber. Kais. Akad. Wiss. Wien, Math. Naturwiss. Classe, II. Abteilung 73, 128 (1876).
[2] D. Acosta, P. Fernandez de Cordoba, J. M. Isidro, J. L. G. Santander (2012), arXiv:1206.4941 [math-ph]
[3] L. Maccone, Phys. Rev. Lett. 103, 080401 (2009), arXiv:0802.0438 [quant-ph]
[4] D. Jennings, T. Rudolph (2009) arXiv:0909.1726
[5] L. Maccone (2009), arXiv:0912.5394 [quant-ph]
[6] O. Kupervasser (2013), arXiv:1304.7850 [quant-ph]
[7] L. Mlodinow, T. Brun, Phys. Rev. E (2014), arXiv:1310.1095 [cond-mat.stat-mech]
[8] J. Barbour (2009), arXiv:0903.3489 [gr-qc]
[9] J. Barbour, T. Koslowski, F. Mercati (2013), arXiv:1310.5167 [gr-qc]
[10] E. P. Verlinde (2010), arXiv:1001.0785 [hep-th]
[11] S. M. Carroll, G. N. Remmen (2016), arXiv:1601.07558 [hep-th]
[12] M. Chaichian, M. Oksanen, A. Tureanuar (2012), arXiv:1109.2794 [hep-th]
[13] R. M. Neumann (2015), arXiv:1506.05178 [cond-mat.stat-mech]
[14] N. Roos (2014), arXiv:1310.4139 [physics.gen-ph]
[15] A. Sheykhi, H. Moradpour, N. Riazi (2012), arXiv:1109.3631 [physics.gen-ph]
[16] S. H. Hendi, A. Sheykhi (2011), arXiv:1009.5561 [hep-th]
[17] D. di Caprio, J.P. Badiali, M. Holovko (2008) arXiv:0809.4631 [cond-mat.stat-mech]
[18] T. Wang (2010), arXiv:1001.4965 [hep-th]
[19] P. G.O. Freund (2010), arXiv:1008.4147 [hep-th]
[20] Zhe Chang, Ming-Hua Li, Xin Li (2011), arXiv:1009.1506 [gr-qc]
[21] Neumann RM. The entropy of a single Gaussian macromolecule in a noninteracting solvent. The Journal of Chemical Physics. (1977) 1977. 66. 2. 870. 10.1063/1.433923. 1977JChPh..66..870N.

[4] "A Modern Mass Extinction?". Evolution Library (Web resource). Evolution. Boston, MA: WGBH Educational Foundation; Clear Blue Sky Productions, Inc. 2001. OCLC 48165595. Retrieved 2016-03-01.
[5] R. Feynman in "Feynman: Take the world from another point of view (3/4)", YouTube, Retrieved 2016-03-01.