Distinctness Arrow of Time

by Sven Nilsen, 2022

In this paper, I argue that the arrow of time in fundamental physics is an emergent phenomena that can be modeled by distinctness of nodes under hypergraph rewriting in Wolfram models, consistent with the symbolic distinction hypothesis of consciousness, based on two recently discovered theorems in the ongoing research on Path Semantical Quantum Propositional Logic.

In the paper "The Symbolic Distinction Hypothesis of Consciousness"[1], I presented a hypothesis that consciousness is grounded in symbolic distinction. This hypothesis is approximate and based on some reasonable assumptions in an attempt to build a foundation for effective field theories[2] of physical consciousness. However, a propositional[3] interpretation supporting this hypothesis was lacking, until now.

The current intuition about fundamental physics[4] is that most of the stuff that happens in the universe is invisible to humans. Even with a theory of everything, it might not be easy to self-locate[5] within a model. With other words, any reasonable theory of everything is expected to produce a lot of predictions that might, or might not, be confirmed by scientific evidence[6]. Therefore, the ongoing effort to produce physical models is also focusing on effective field theories, which can be thought of as reasonable models of reality within some constraints of measurements.

In the approach of building effective field theories, one can not produce 100% certain propositional truth about reality. This means that the semantics of a deeper understanding of the computational properties of the universe requires an intuition about vagueness of language and bias in mathematics.

For example, when phycisists reason about the arrow of time[7], it can be presented as a four-dimensional vector on the background of a static four-dimensional space-time[8]. This simple model is meant to be approximate and a way of encoding meaning into the mathematical language used for particular purposes. The true nature of the arrow of time is expected to be much more complex, vague and depending on deeper computational properties of reality, something that might rely on stuff that is not directly measurable in scientific experiments.

While 100% certain propositional truth is impossible in practical effective field theories, it is possible to treat reality as a probability distribution[9] over all possible propositions. A proposition in this sense is a "theory" that can be constructed from an arbitrary complex logical expression. Thus, when an interesting theorem is found in logical research, it can be regarded as true in some contexts of reality and false in other contexts and thereby give some formal intuition of how fundamental physics works, without necessary pin-point the exact mechanism of predictive models.

It is through using this approach that I interpret physical significance of theorems in Path Semantical Quantum Propositional Logic (PSQ)[10]. To understand this development, one must first realise the importance of Propositional Calculus (PL)[3] in mathematics. PL might be considered as an analogue of Turing complete machines[11], but for logic instead of computer science. When working in theoretical computer science, it is common to reason about extended Turing complete machines, such as including a source of randomness[12]. This extension alters the computational properties of the landscape of possible programs, in such a way that heuristics[13] become more densely connected. Similarly, PSQ might be thought of as extending PL with a source of randomness. The theorems in PSQ are significant for physics because it is possible to express logical statements that otherwise would only be expressible in PL as a limit[14].

It is believed that physics has an internal language that favours reasoning about randomness directly, as reflected in the historical development of Quantum Mechanics (QM)[15]. However, since randomness has been up for much debate in mathematics, it is not clear how to proceed bridging the gap between mathematics and physics.

One argument is that when extending computational models, the extension should be simple[16], in order to minimize complexity of unintentional language bias. PSQ is an excellent example of a simple extension of PL, since it only adds a single unary operator `~` to the logic.

Although much work remains of interpreting PSQ in various ways, there has been some developed intuition in Path Semantical Classical Propositional Logic (PSL)[17] about a relation between the core axiom of Path Semantics and propositional semantics of time[18]. I believe that this intuition can be carried over to PSQ.

PSL is a language where time might be thought of as well ordered, similar to the Newtonian idea of universal time[19]. In PSQ on the other hand, time can be fractional and disordered by choice, thus an analogue of an emergent arrow of time on a background of non-linear space-time. Therefore, PSQ is more well equipped to model language biases that are recognised in General Relativity[20]. In short, when studying theorems in PSQ, one can better understand the nature of time as in relativistic theories, compared to PSL, which puts more constraints on the logical language.

With this in mind, one can consider the two following theorems in PSQ, using Pocket-Prover[21]:

Distinct value symbols:

```
imply(
    and!(
        ps_sym_core_eq(a, b, c, d),
        imply(a, c),
        imply(b, d),
    ),
    eq(hom_eq(2, a, b), hom_eq(2, c, d))
)
```

Identical value symbols:

```
imply(
    and!(
        ps_sym_core(a, a, c, d),
        imply(a, c),
        imply(a, d),
    ),
    eq(hom_eq(2, a, a), hom_eq(2, c, d))
)
```

The full source code can be found in “examples/quality_sym_core_eq.rs” under the Pocket-Prover’s project repository. I use the source in this paper because I find it important that readers can start experimenting on their own without needing to first translate from standard notation in logic.

$$\mathrm{ps\_sym\_core\_eq}(a, b, c, d) \wedge (a \Rightarrow c) \wedge (b \Rightarrow d) \;\Rightarrow\; (\mathrm{hom\_eq}(2, a, b) == \mathrm{hom\_eq}(2, c, d))$$

$$\mathrm{ps\_sym\_core}(a, a, c, d) \wedge (a \Rightarrow c) \wedge (b \Rightarrow d) \;\Rightarrow\; (\mathrm{hom\_eq}(2, a, a) == \mathrm{hom\_eq}(2, c, d))$$

The insight of these two theorems lies in their difference of assumptions required to prove equality of homotopy equivalence of level 2. For distinct value symbols, is it necessary to use a stronger version of the core axiom `ps_sym_core_eq`. For identical value symbols, it suffices to use a weak version of the core axiom `ps_sym_core`. The strength of the core axiom can be thought of as signalling whether direction of time can move both forwards and backwards in space-time.

Both these core axioms uses quality[22] and aquality[23], since the interest is the general nature of time and not to study bias differences of Seshatism vs Platonism[24]. Homotopy equivalence of level 2 as modeled in PSQ is still under investigation at the present moment. This means that how homotopy equivalence is interpreted in other mathematical languages, such as Homotopy Type Theory[25], might not match perfectly the intuition about PSQ. Therefore, the interpretation of homotopy equivalence in PSQ should be regarded as unique to that specific logic. The use of homotopy equivalence of level 2 here is related to the agnostic mechanism of bias over quality and aquality. This is a technical detail due to a theorem known as “Hom-2-Qual”[10]:

hom_eq(2, a, b) == ((a ~~ b) ∨ (a ~¬~ b))

It is known that quality and aquality can be made symmetric by choosing a core axiom that replaces quality with aquality and vice versa. Therefore, by using a symmetric core axiom that uses both quality and aquality `ps_sym_core`, one can reason about theorems that does not depend on perspective of single vs multiple languages. This is a special property of the quality operator, that is different from other operators in logic as it is not universally consistent, but relative to a single language[26]. By choosing symmetric core axioms, the agnostic mechanism of bias over quality and aquality coincides with homotopy equivalence of level 2.

These two theorems, of distinct value symbols and identical value symbols, hint at homotopy equivalence, of some sort, being a model of identity metaphysics[27].

With other words, when interpreting the difference of the two theorems as significant for fundamental physics, it implies that identity metaphysics of observer moments[5] can be “stretched out” over geometries of space-time where time can go both forwards and backwards. Or, to phrase this idea in the language of time travel[28]: Closed time loops collapses perception of causal time.

The telling insight of the difference of the two theorems, is precisely that it matches the intuition behind the symbolic distinction hypothesis of consciousness[1].

When some sort of homotopy equivalence is regarded as a foundation for identity metaphysics, it supports the propositional interpretation of symbolic distinction as foundational for consciousness. This result must be thought of as related to the “invisible stuff” that eventually might be modeled and predicted in a theory of everything as a Wolfram model[29].

Homotopy equivalence is a property in the language of topology[30]. This property matches very well phenomena that one can build intuition about consciousness in scientific experiments. Such as, whether a person is the “same” next day as the person who went to sleep the previous night. Identity metaphysics is the philosophical positions related to such thought experiments.

However, when considering homotopy equivalence at face value, it is impossible to tell whether physical reality corresponds to this model or not. To probe what happens in physical reality, one must make measurements at the length scale of Planck units[31], something that is outside human capability today. The result is that effective field theories by observables are often insufficient to predict most aspects of identity metaphysics.

A workaround this problem is to build intuiton around Seshatism vs Platonism bias[24], which generalises to generic philosophical positions. For example, when humans have intuition of a thing as in-itself as a concrete thing, contrary to a thing as information assembled in an abstract sense, it aligns with Seshatism as a philosophical position compared to Platonism. It happens that this bias can be studied in PSQ as choice of core axioms relative to quality and aquality. This in turn supports the intuition about homotopy equivalence and it all comes down to the study of a single operation.

The argument is therefore that the arrow of time emerges from non-linear backgrounds of space-time, where observer moments can be thought of as a density measure[32]. A lower density of observer moments in space-time is associated with closed time loops or high degree of repetition, perhaps even chaos in microstates[33]. A high density of observer moments can be thought of as a gradient where the emergence of the arrow of time is locally smooth and thus directional at the macroscale of physics.

Under hypergraph rewriting in Wolfram models, the intuition is that rules that matches to identical nodes, produces less density of observer moments as a result. This is because the propositional truth of homotopy equivalence propagates more easily over the multiverse-graph. When matching against distinct nodes, the rules produce higher density of observer moments. This is because the propositional truth of homotopy equivalence is directional in the form of set membership.

With other words, distinct nodes results in identity metaphysics that propagates though the multiverse as forms of observers that are related by Everett branches[34]. A single observer can make measurements that causes a "split" of the singleverse by quantum decoherence. Thus, the single observer becomes many observers over time experiencing separate worlds. This relation of observers reflects relations between sets. A set can contain multiple sets, like a tree without symmetries[35]. The set membership might be thought of as a homotopy equivalence defining the propositional truth of an observer in a moment, implying a homotopy equivalence defining the propositional truth of an observer in the next moment. As quantum decoherence[36] separates observers of same origin, the relation between propositional truths of observers become directional. This is the emergent arrow of time at the macroscale in physics.

Identical nodes, on the other hand, results in identity metaphysics that propagates through the multiverse as forms of observers in a coherent quantum state. Such observers might be regarded as belonging to a single physical state, or a physical state as superposition. Because the perception of the arrow of time is cyclic in such states, where information does not pass through some boundary, it is possible to identify the propositional truth of observers in future moments with past moments. Thus, the intuition that this is a single physical state, aligns with identity metaphysics where perception of time is "stretched out" in space-time. This in turn produces lower density of observer moments.

In conclusion, modern scientific theories are compatible with identity metaphysics that uses some form of homotopy equivalence as foundation for consciousness. The specific computational nature of reality is unknown and must be carefully considered when designing effective field theories. It is the hope of the author that this paper might contribute to development of effective field theories that models and predicts properties of consciousness in physical systems.

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