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Physics and Metaphysics: a Sellarsian project ... sort of

**5 – Individuals, or
what is left**

1. The failure of the composition hypothesis in physics

From change to stuff that changes

2. Dynamical laws and individuality

Modality, change of modality, timeless physics and individuals

3. Genidentity, the solution

From mereology to process individual

4. Concluding remarks

What is the point?



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1. The failure of composition hypothesis in physics



Oppenheim and Putnam:
When we come to branches with different universes [of discourse]—say, physics and psychology—it seems clear that the possibility of reduction depends on the existence of a structural connection between the universes by the “Pt” relation. (1958, p. 8)

1. The failure of the composition hypothesis in physics



If the “part-whole” (“Pt”) relation is understood in the wide sense, that $x \text{ Pt } y$ holds if x is spatially or temporally contained in y , then everything, continuous or discontinuous, belongs to one or another reductive level; in particular, to level 1 (at least), since it is a whole consisting of elementary particles. (p. 11)

1. The failure of the composition hypothesis in physics

The compositional hypothesis (Healey 2013):

- (1) The physical world does have some kind of compositional structure.
- (2) It is the business of physics to investigate this structure, and specifically to seek out its lowest level, if any.
- (3) Available candidates for mereological atoms include elementary particles and fundamental field values.



1. The failure of the composition hypothesis in physics

This program has met many difficulties!

- The interpretation of quantum entanglement.
- The status of particles and fields in QFT -> Particles and fields are not part of the basic ontology of physics.
- The notion of effective theory -> The ontology is contextual.

If physics is not about these fundamental parts, it is about what?

1. The failure of the composition hypothesis in physics



Back to basics

Physics is the study of change. It is about capturing what does not change in change, the principles responsible for change (order).

But physics is less and less about matter.

Still we can ask if there is a subject of change?

1. The failure of the composition hypothesis in physics

Matter of individuality

The individual as the product of an act of demonstrative reference or of the interpretation of quantification (Quine).

Cognitive individuation as an act of the mind (Strawson).

Realist ontological individuation
(independence/autonomy, can be counted,
diachronic identity, permanent differentiation)

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Possible modal sources of change

Governism, Essentialism, Primitivism and Regularism

New constraints

- Multi-level modality
- Timeless physics
- Emergence (change of modality)

Since essentialism is strongly incompatible with emergence and multi-level modality, I will put this position aside.



Governism

Entities are subjected to change. Change is enacted upon them.

It is possible to have the same properties but different laws.

A law, for example $N(F,G)$, is a nomic/necessitation relation among universals.

What could be the bearers of these properties (special case of discrete particulars): particles, states of affairs, space-time points...?

2. Dynamical laws and individuality



First approach: Reductionism

Individuals are defined by a unique set of properties U (individuality profile)

2. Dynamical laws and individuality



Thesis

There is no two distinct individuals with the same U



Principle of identity of indiscernibles (PII)

Which principle?

PII(1) : it is not possible for two distinct individuals to share all the same properties at the same moment.

PII(2) : it is not possible for two distinct individuals to share all the same properties at the same moment, if we put aside the spatio-temporal properties.

PII(3) : it is not possible for two distinct individuals to share all the same monadic properties at the same moment.



We are talking of synchronic individuality here.

PII(1) requires an impenetrability hypothesis (IH).
PII(2) and (3) do not depend on IH.

If there exist two distinct individuals in principle indistinguishable, then PII(3) is false.

What is the justification of IH?

Some entities seem to be able to occupy the same position at the same time (wave, light...)

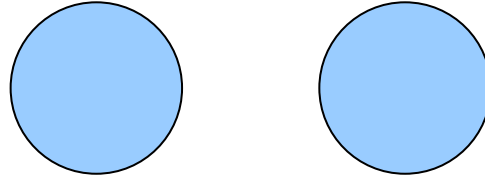
Maybe we could justify IH by a theory of matter (specific properties) or a theory of substance (the grounding of properties).



For PII(1) and (2) relational properties could be part of the individuating set.

All relation presupposes numerical diversity. In consequence, it cannot explain it.

This difficulty could be major or not depending on the fact that countability is a requirement or not of individuality.



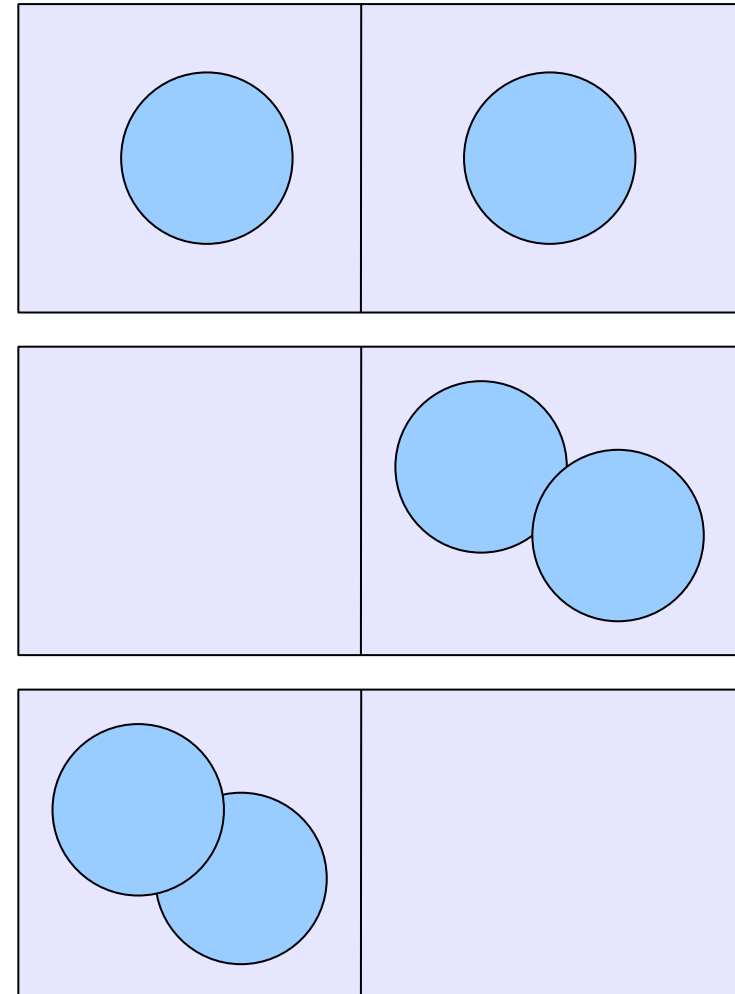
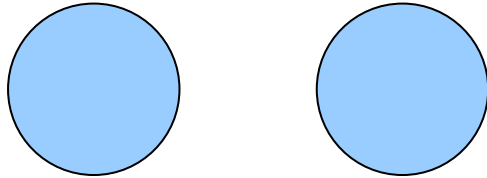
The problem of Black's symmetric worlds

Two identical “atoms” seem to share all the monadic and relational properties.

The existence of nomological regularities justify this possibility.

If they are distinct individuals, PII(2) and (3) are falsified.

2. Dynamical laws and individuality



Preliminary conclusion

- These atoms cannot be individuals or
- There is no such thing as a symmetrical world

Return to the manifest image?

According to Quine and Saunders, two entities are

- Absolutely discernible (AB) if there exists a one variable formula true for one and false for the other.
- Relatively discernible (RD) if they are not AB and there exists a two variables formula that applies to them but only in a certain order.
- Weakly discernible (WD) if they are not AB or RD and they satisfy an irreflexive relation. Examples: symmetrical worlds.
- Indiscernible otherwise.



2. Dynamical laws and individuality

Saunders, Muller and Seevinck

PII(4): if two entities share all their monadic properties and do not participate in an irreflexive relation, then they are the same entity.

In other words, weak discernibility is sufficient for (weak?) individuality.

According to these authors, ask for more would go against naturalized metaphysics.



2. Dynamical laws and individuality

Ladyman and French

Weak discernibility of quantum particles is a reason to believe that the real entities are the relations, the structure (position defended by Eddington, Weyl and Poincaré).

In consequence, particles are derived entities.



Summary of the reductionism approach

This approach only manages to define a weak synchronic identity.

In the context of reguralism, it would only provide a weak synchronic identity of the facts constituting the mosaic.

In the context of primitivism, it would only provide a weak synchronic identity of spacetime points or regions.

Remember the classical causality definition

For natural Lagrangians: L is equal to the difference between kinetic and potential energy.

CQ1'. A causal process is a continuous (or almost continuous) series of spacetime events governed by kinetic terms in L , conserving basic quantities, like energy.

CQ2'. A causal interaction is a way the causal processes can interact with each other. This interaction is governed by the interaction terms of L .

Can CQ1' identify/detect individual?



N mass points interacting via the Newtonian gravitational force

$$L = \sum_{i=1}^N \frac{m_i v_i^2}{2} - \sum_{1 \leq i < j \leq N} \frac{G m_i m_j}{\| \vec{r}_i - \vec{r}_j \|}$$

- According to CQ1', the kinetic terms determine what are the causal processes between interaction or more generally in the absence of interaction.
- According to CQ2', the interaction terms determine how the causal processes are transformed. In this case all interactions are symmetric.

2. Dynamical laws and individuality



Two interpretations

- 1) A causal process can help to identify the individual.
- 2) A causal process is a kind of individual.



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History of genidentity

- [Kurt Lewin \(1922\)](#): the concept of genidentity, a way to better understand identity through time, “across sciences”, especially for both physics and biology.
- [Reichenbach \(1956\)](#): different conceptions of genidentity, but his view remains imprecise (French and Krause 2006: 49).
- Recently, a few philosophers resorted to the concept of genidentity, especially to reflect on mereology ([Mulligan and Barry-Smith, 1982](#)) or to understand biological entities (e.g., [Boniolo and Carrara 2004](#), [Guay and Pradeu 2016](#)).

Kurt Lewin's genidentity (1922)

- Temporally extended objects are multiplicities of successive entities.
- The relation between these entities is called genidentity.
- The concept of genidentity that is relevant in physics is distinct as the one relevant in biology.

Partial and complete (physical) genidentity

- An amputated limb is simply genidentical with the whole past body.
 - The relation of complete genidentity holds only between the whole body and the totality consisting of mutilated body, limb and residue.
- “Complete genidentity is thus simply an expression of the physicist's attempt to isolate his experiments from extraneous disturbances”
(Smith & Mulligan 1982)

Relation among objects

The law of conservation of mass: if two or more physical formations are completely genidentical with each other, then they are of identical mass.

Relation among events

The law of conservation of energy: if two or more physical events are completely genidentical with each other, then they have the same energy.

Smith and Mulligan formalization

$$a^{p\equiv} b := \neg \exists x (x/a \wedge x^{p=} b) \wedge \neg \exists x (x/b \wedge x^{p=} b)$$

$$a^{p\equiv} b \rightarrow \forall x (x/b \rightarrow a^{p\neq} x) \wedge \forall x (x/a \rightarrow b^{p\neq} x)$$

$$a^{p=} b \rightarrow \exists a' \exists b' (a' \leq a \wedge b' \leq b \wedge a'^{p\equiv} b')$$

Thus if a piece of metal falls into an acid, then we know that the metal must be present in some form in the liquid.

Individual-genidentity

$$a^i = b \rightarrow \exists xy...x' y' ... ([a, x, y, ...]^i \equiv [b, x', y', ...])$$

Individual-genidentity is a transitive relation.

It is continuous but contrary to physical genidentity it allows for a youngest section and an oldest section.



3. Genidentity, the solution



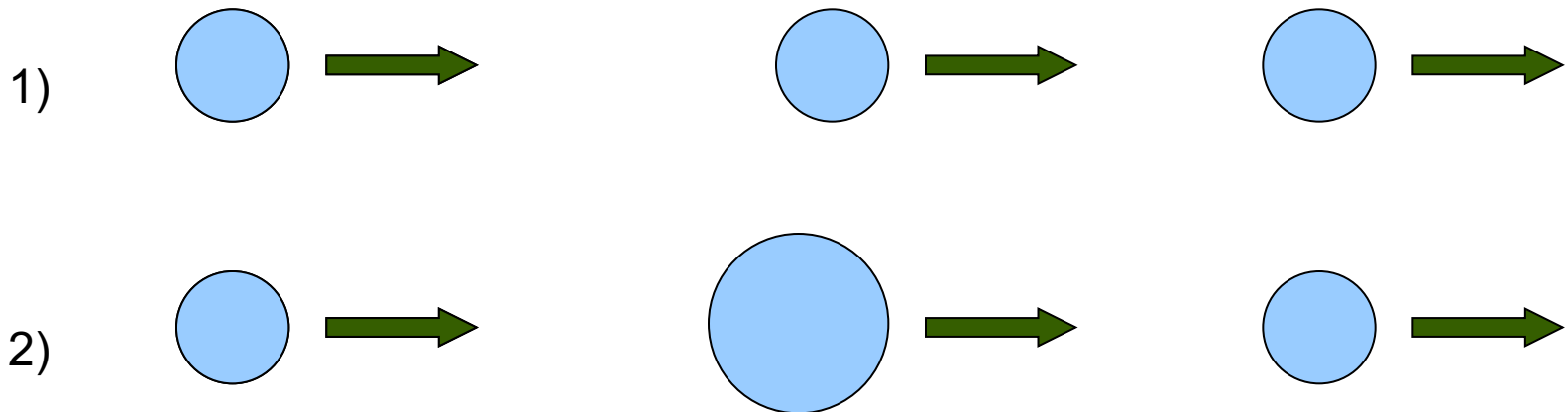
Hans Reichenbach (1956)

“The *physical identity* of a thing, also called *genidentity*, must be distinguished from logical identity. An event is logically identical to itself; but when we say that different events are states of the same thing, we employ a relation of genidentity holding between these events.”

Material genidentity

Necessary, but not sufficient, criteria:

- Continuity of change
- Spatial exclusion
- Permutation is a verifiable change

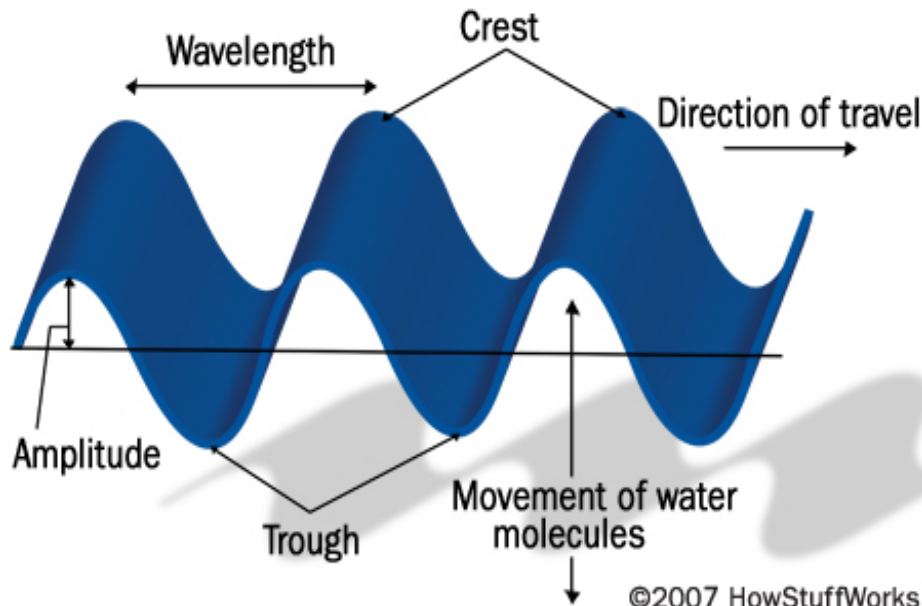


Functional genidentity

Not clearly defined by Reichenbach.

The paradigmatic example is a transverse wave in water

Transverse Wave

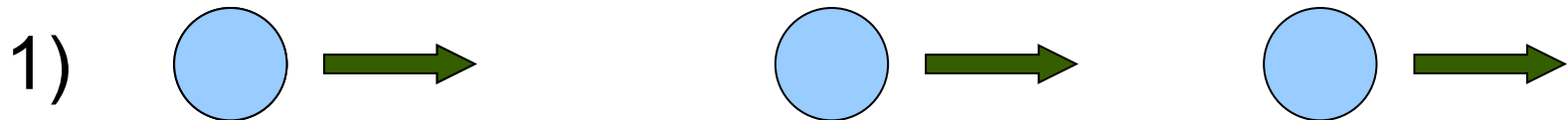


No propagation of matter.

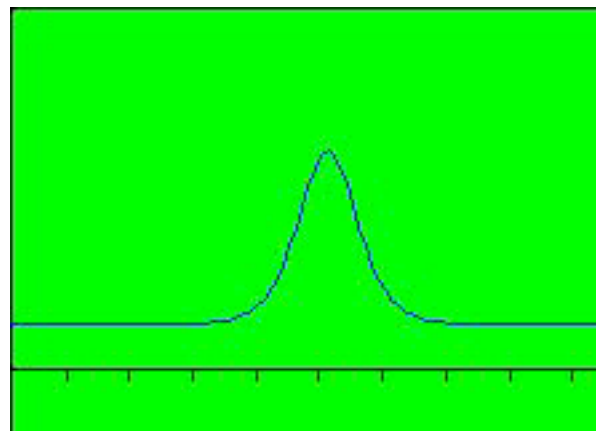
But continuous propagation of energy and momentum.

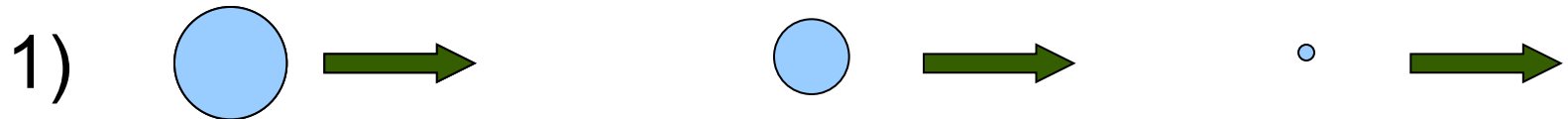
Material vs. Functional genidentity

A soliton is a self-reinforcing solitary wave.
It has a similar functional genidentity as the particle but violates material genidentity.



2)





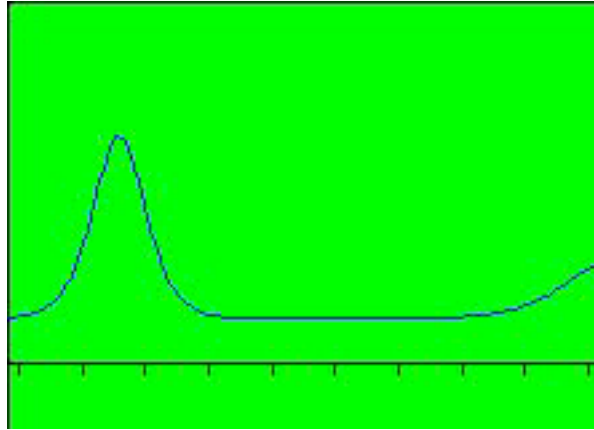
2) A dissipating wave

Changing process/individual

In the first case, matter is not conserved. In the second, amplitude is not conserved.

In both cases, energy is not conserved.

If the energy dissipation is not too fast, the continuity of change allows the process to keep its identity for a while.

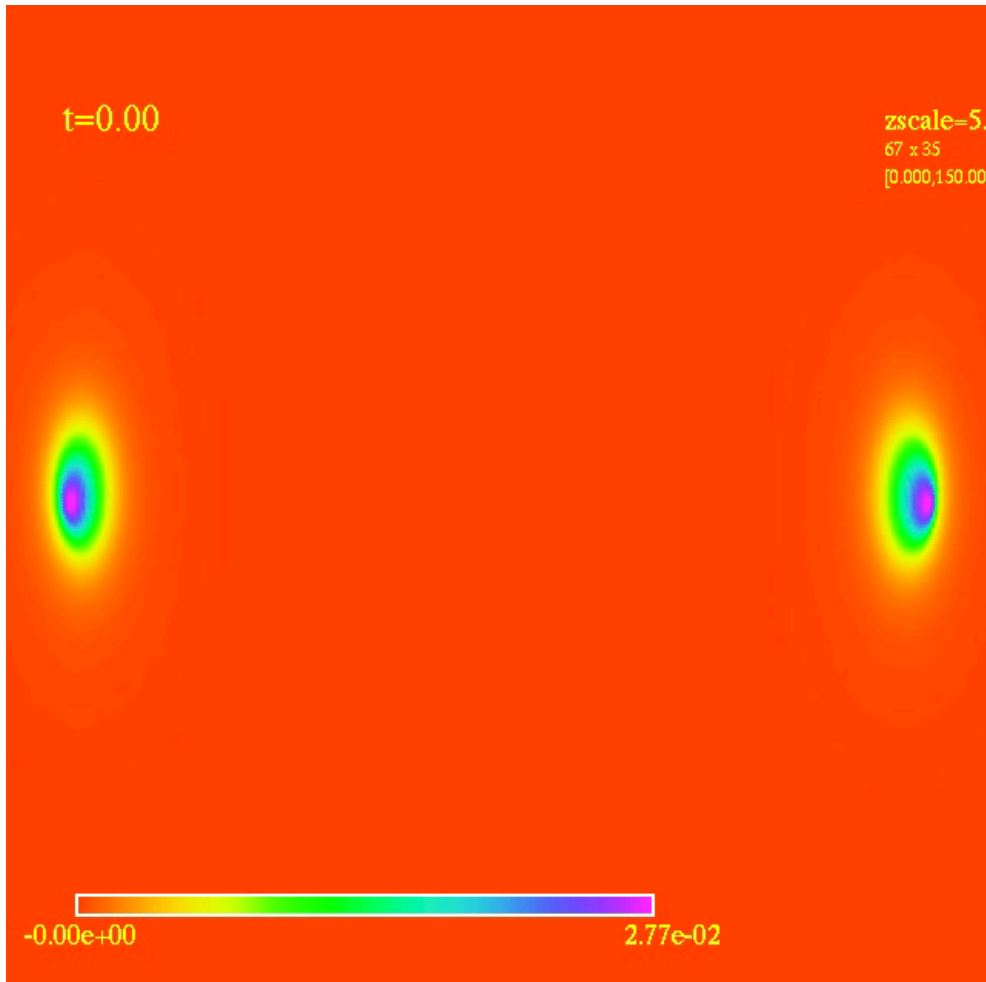


Interacting functional individuals

Two possible descriptions of this interaction: 1) the solitons pass each other or 2) they bounce on each other and the one on the left is transferring most of its energy to the one on the right.

It is our understanding of the interaction that allows us to choose between both possibilities.

3. Genidentity, the solution



A collision of baby skyrmions

During interaction, the BS form a torus before separating.

The identity of each BS is lost. New baby skyrmions are created after interaction.



Some lessons about these physical examples

- 1) It is possible, even in a field theory, to define a fairly strong notion of genidentity. Conservation of matter/substance is not necessary.
- 2) It is possible to develop a weaker functional genidentity that can accommodate changings/interaction individuals.
- 3) The conservation of the genidentity in interacting situations depends on the details of the interaction.
More precisely, how much the interaction is modifying the entities' identity as defined in 2.

What about quantum physics?

- You follow the wave function or its equivalent
- You follow a combination of classical process
(quantum modal causality)

Processes

- We suggest to adopt an epistemology of processes: to answer to the conundrum of individuality, the pertinent question is **How should we follow scientific processes?**
- This epistemology of processes suggests the inclusion of processes in the scientific ontology. These processes tell us what makes the identity of an individual through time.

John Locke's conception of identity as continuity

Principium Individuationis. From what has been said, it is easy to discover what is so much inquired after, the *principium individuationis*; and that, it is plain, is existence itself; which determines a being of any sort to a particular time and place, incommunicable to two beings of the same kind. (Locke, *Essay* II, 27)

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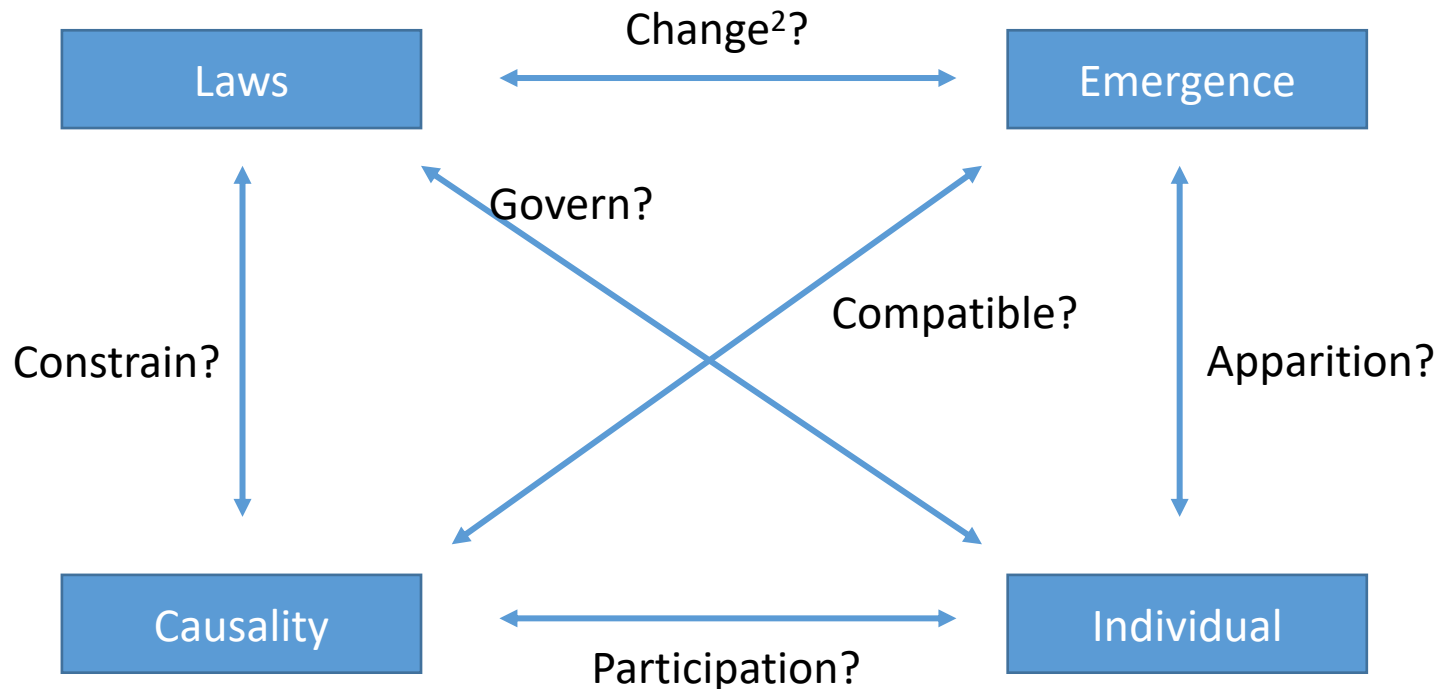
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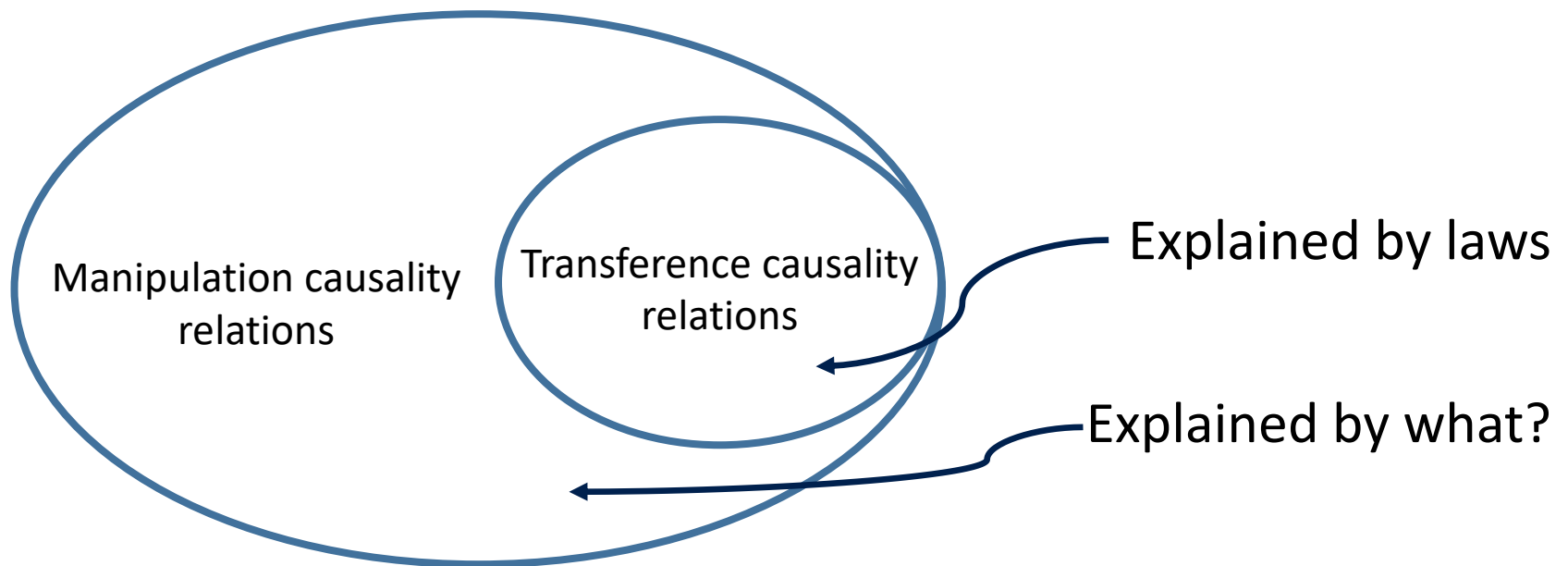
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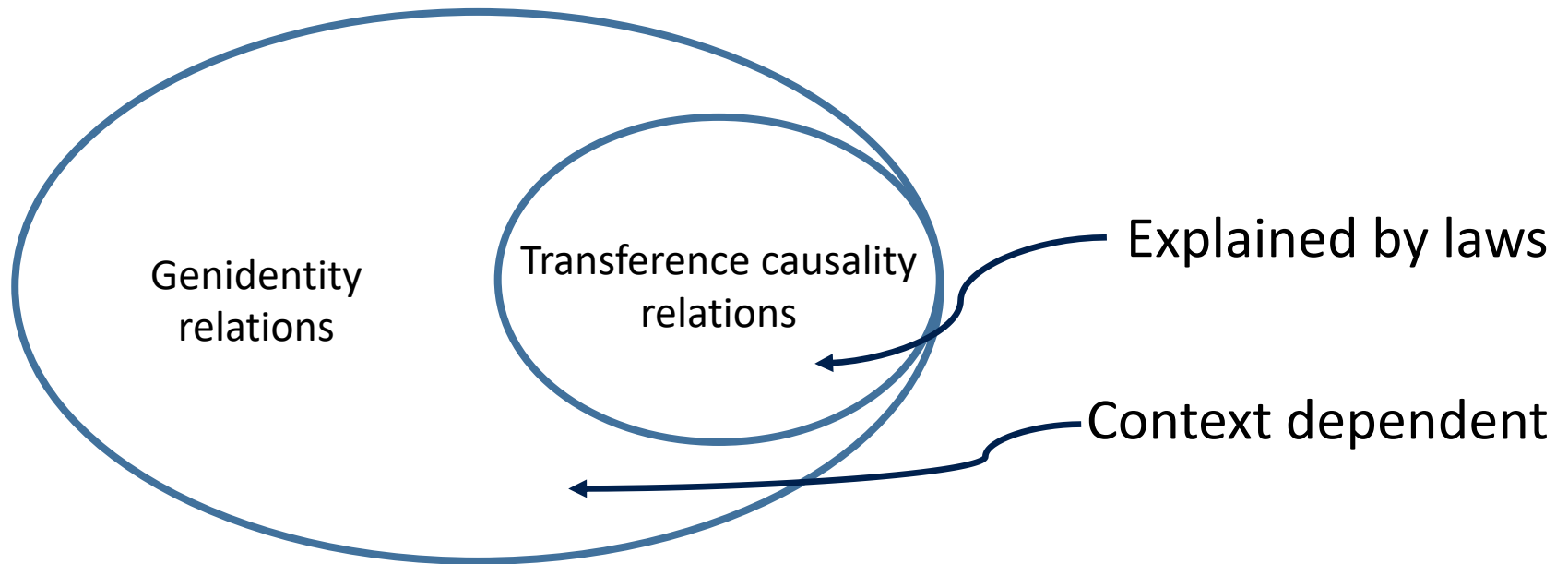


Let us now return to the diagram I showed in the first lecture.

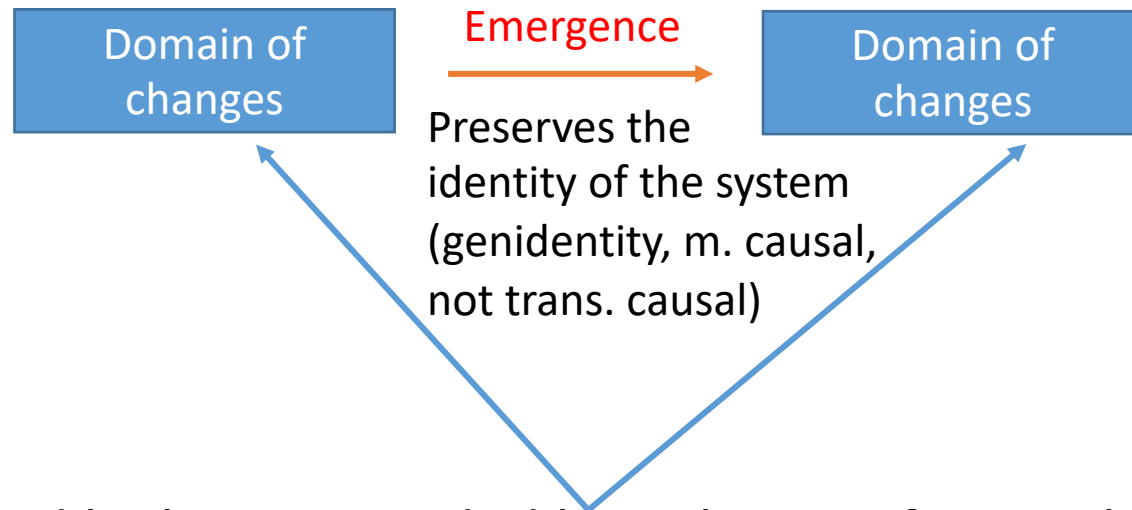
What have we learned?







Could genidentity relations help to explain why a manipulation causality relation hold?

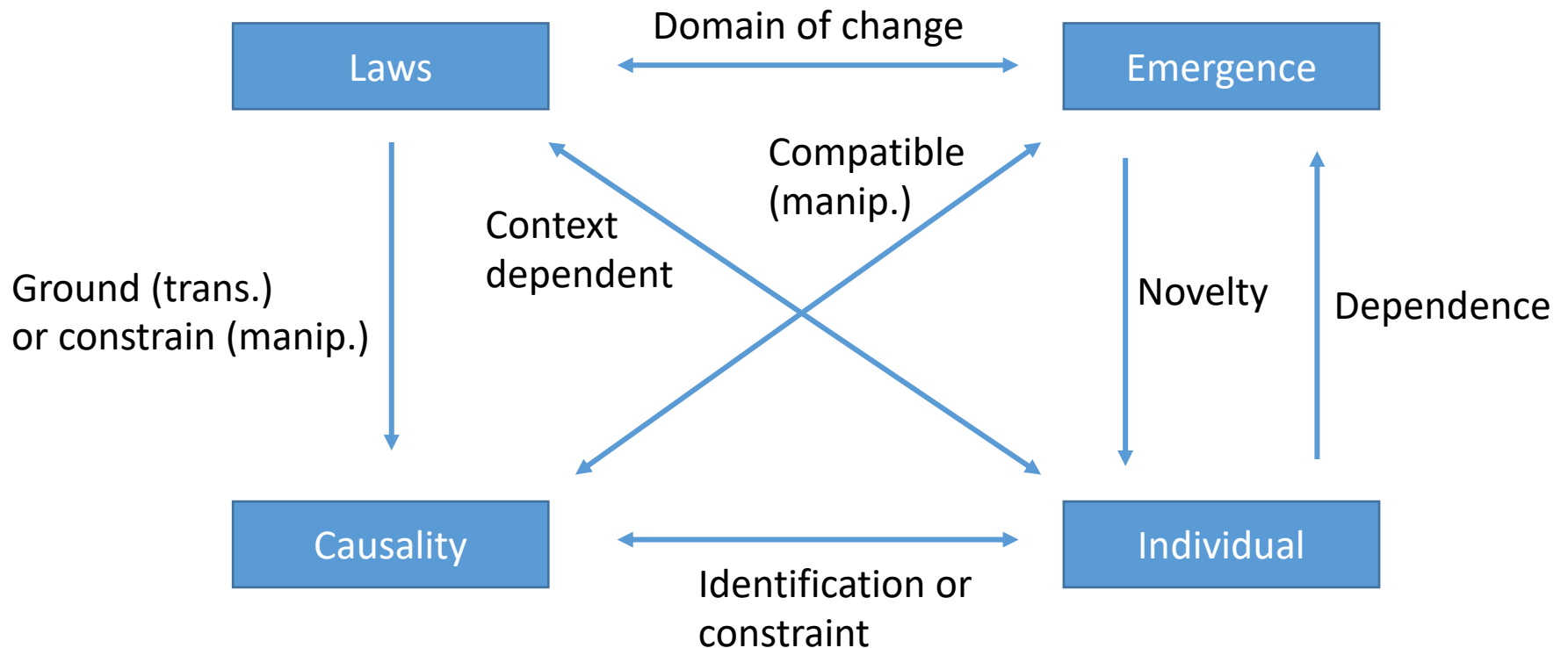


Explained by laws grounded by a theory of natural necessity

Because of the structure of laws, there is a necessity for a science of emergence.

This science of emergence would help to understand the link between manipulation causality and genidentity in the specific context of the preservation of the identity of a system.

The metaphysics of emergent necessity would explain how the different nomological realms are related and how new stuff can appear during history.





Thomas Pradeu



Johannes Martens