



Scientific Philosophy

Grupo de Astrofísica Relativista
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Ontology



Ontology is the part of philosophy that is concerned with the **most general features of reality**. It aims at providing the basic framework for science, offering the **best articulation of a worldview that emerges from the special sciences**.

Ontology also aims at clarifying key concepts as those of physical existence, thing, property, change, causality, chance, probability, state, time, space, law, structure, system, life, mind, society, and many more.

I will offer a specific ontology based on things that is

1. Realist
2. Materialist
3. Systemic
4. Deterministic
5. Emergentist

For an alternative ontology based on events see:
G.E. Romero, *Found. Sci.*, Vol. 18, pp 139-148,
2013 & *Philosophia*, vol. 44, 607, 2016

For details and similar views:

Bunge, M., *Treatise on Basic Philosophy*
Vols. 3 & 4, Kluwer, 1977-79, Spanish
version by Rafael González del Solar
(Gedisa).

Things and composition

O₁. There exist concrete objects named **things**. The set of all things is denoted by Θ

O₂. Things can **juxtapose** ($\dot{+}$) and **superpose** ($\dot{\times}$) to give new things according to the following definitions:

O₂D₁. A thing X is a physical sum or a juxtaposition of all individuals of a given set $\{X_i\}$, $i=1, 2, \dots, n$ iff every part of X is a part of at least one of the members of the set $\{X_i\}$

e.g.: the juxtaposition of the members of a family makes the social entity “family”, the juxtaposition of a number of bricks makes a wall, etc.

O₂D₂. A thing X is a physical product or a superposition of all individuals of a given set $\{X_i\}$, $i=1, 2, \dots, n$ iff every part of X is a part of every member of the set $\{X_i\}$

e.g. The superposition of waves or fields.

Juxtaposition and superposition are instances of **composition**: the association of things to form more complex things.

We differentiate just two ways of composition because our experience of the world suggests that things combine this way.

O₃. The ***null thing*** \diamond is a fiction introduced in order to give the structure of a Boolean algebra to the laws of composition of things.

$$X \dot{+} \diamond = X$$

$$X \dot{\times} \diamond = \diamond$$

O₄. Two things are ***separated*** if they do not superpose.

$$X \dot{\upharpoonright} Y \leftrightarrow X \dot{\times} Y = \diamond$$

Since modern science admits the existence of fields that fill the whole universe, there are not fully **isolated** things, i.e. things that are separated from all other things.

$$\neg \exists X (\forall Y \ X \uparrow Y)$$

O₅. Let T be a set of things. The aggregation of T ([T]) is the supremum of T with respect to the operation of composition.

O₆. The **universe** (\square) is the aggregation of all things.

$$\square = [\Theta] \Leftrightarrow (X \sqsubset \square \Leftrightarrow X \in \Theta)$$

The symbol \sqsubset means 'is part of'. It stands for a relation between concrete things and should not be mistaken with \in , which is a relation between elements and sets. The universe is a thing, the supreme or maximal thing, and not a set of things (sets are concepts).

The universe as a thing is studied by cosmology, the most extreme form of macro-physics.

We define the composition of a thing X as

$$\text{Comp}(X) = \{Y : Y \sqsubset X\}$$

O₇. All things are composed of **basic things** by means of superposition of juxtaposition.

$$X \in \Xi \subset \Theta$$

Basic things are elementary or primitive

$$X, Y \in \Xi \wedge (X \sqsubset Y) \rightarrow X = Y, \quad Y \in \Xi \rightarrow \neg \exists X (X \sqsubset Y)$$

O₈. All things have **properties** P . These properties can be **intrinsic** (if they only depend on the thing) or **relational** (if they depend on the thing and on other things).

e.g. *Charge*: intrinsic property. *Velocity* or *position*: extrinsic properties.

In the case of photons and massless bosons velocity is an intrinsic property.

Conceptually, we can represent a thing as an ordered pair formed by an individual and its properties.

$$X = \langle x, P(x) \rangle$$

Energy and existence

There is only one universal property shared by all material objects: ***energy***.

Energy is the potential to change. Only material things can change. Concepts do not change. Then, *to be material is to have energy, to be able to change.* Materiality is not related to mass. Massless things have energy, are material, and can change.

Material existence is identified with changeability. Conceptual existence, instead, is identified with being part of a conceptual system. We feign that conceptual objects have autonomous existence. But they don't. They are convenient fictions we invent to represent the world and to simplify our language.

A thing can be modelled representing its properties by functions defined over a domain M .

O₈D₁. A thing X can be modelled by a pair $X_m = \langle M, F \rangle$, where F is a collection of functions F_1, F_2, \dots, F_n over M and

$$F_i \stackrel{\wedge}{=} P_i \in P(x)$$

Then, $X_m \stackrel{\wedge}{=} X$

O₉. The **state** of a thing is the set of functions $\{F_i: M \rightarrow \mathfrak{R}, i=1,2,\dots,n\}$ such that $F_i \hat{=} P_i$

The set of accessible states of a thing X is the **lawful space state** of X: $S_L(X)$. The state of a thing is represented by a point in the n-dimensional space $S_L(X)$.

O₁₀. A **law statement** is a restriction upon the state function of a given class of things.

Since law statements are restrictions upon functions, they take the form of differential equations if the restriction are purely local or integro-differential equations otherwise. In some particular cases, when properties are represented by operators, law statements can be expressed by algebraic equations.

O₁₁. A **natural law** is a property shared by a class things that is represented by an empirically corroborated law statement. **Laws are objective patterns of repetition of events occurring to some class of things. Universal laws** (also called ‘principles’) apply to all things.

O₁₂. There are not lawless things, i.e. all things have properties restricted in regular ways. There are not magical things.

O₁₃. The **history $h(X)$** of a thing X is the part of $S_L(X)$ defined by

$$h(X) = \{ \langle t, F(t) \rangle : t \in M \}$$

where t is an element of some auxiliary set M , and F are the functions that represent the properties of X . The history is a $(n+1)$ -dimensional curve in the lawful state space.

O₁₄. Two things **interact** if each of them modifies the history of the other.

$$X \bowtie Y \leftrightarrow h(X . Y) \neq h(X) \cup h(Y)$$

where ‘.’ stands for composition: either juxtaposition or superposition

We can define that a thing X acts upon another thing Y if we previously introduce the **conditional history** of a thing

$h(X/Y)$: “history of Y in the presence of X ”

Then, $X \triangleright Y$: 'X acts on Y'

$$X \triangleright Y \stackrel{\text{def}}{=} h(Y/X) \neq h(Y)$$

O₁₅. An **event** e is a change of a thing X . It can be represented by an ordered pair of states.

$$e = \{s_1, s_2\} \in E_L(X) = S_L(X) \times S_L(X)$$

The space $E_L(X)$ is called **event space** of X

A **process** p is an ordered series of events: $p = \langle \{e_i, e_{i+1}, \dots, e_f\}, \prec \rangle$ where \prec is an ordering relation. If the events are continuous $p = e(t)$, with t a parameter.

The basic ontology sketched here is

1. Realistic
2. Objective
3. Materialistic
4. Deterministic

In what follows we shall show that it is also emergentist

Levels

Composition leads to a hierarchy of things. Reality seems to have **levels** of organisation.

A level is a collection of things that share certain properties and undergo changes according to some common laws that apply to all of them.

e.g. All chemical objects share some properties and obey to chemical laws, but do not have biological properties or are constrained by social laws

Higher levels have things with some properties belonging to lower level in addition to specific ones. E.g. I have mass, experience chemical reactions, and have biological functions. Conversely, an atom has not biological properties.

Levels

Reality (the collection of all real objects) seems to be composed by **5 major levels**: physical, chemical, biological, social, and technical. The objects of any level above the physical level are composed by entities belonging to lower levels. The individuals of higher levels have emerged along time from the association of individuals of lower levels.

There is no mental level. This is so because the ontology outlined here is materialist: the mind is a system of functions of an organism endowed with a plastic brain, as the digestion is a system of functions of the digestive organs. Mind is not an entity: is the result of several activities in highly evolved organisms.

Levels

The structure of the **level system** is:

where L is a set of levels and $<$ is an ordering relation (precedence).

$$\mathcal{L} = \langle L, < \rangle$$

For any level L_n , $L_n < L_{n+1}$ iff $\forall \sigma [\sigma \in L_{n+1} \rightarrow \text{Comp}(\sigma) \in L_n]$

Ordering of levels

Physical < chemical < biological < social < technical



increasing complexity

Systems

Within each level things compose to form more complex things. A composed thing is a **system**. Every existent is a system, except the basic entities if they exist.

A system is a composed thing characterised by its composition, environment, structure, and mechanism.

Systems

The **composition** of a system is the collection of its parts.

The **environment** of a system is the collection of things that interact with the system.

The **structure** of a system is the collection of relations (bonds or links) among its components, as well as with environmental objects. The former is the **endostructure** whereas the latter are the **exostructure**. The total structure is the union of the two.

The **mechanism** is the collection of all internal processes that occur in the system.

A **subsystem** is a system such that its composition and structure are part of another system.

The maximal system is the **universe**, i.e. the system of all systems.

Any system can be modelled by an ordered quadruple:

$$\mu(\sigma) = \langle C(\sigma), E(\sigma), S(\sigma), M(\sigma) \rangle$$

All these components of the system can be functions of time

The composition of a system at level L is $\text{Comp}_L(\sigma) = \text{Comp}(\sigma) \cap L$

Causality

Causality is a relation between events, i.e. a relation between changes of material things. It is not a relation between things.

$\mathfrak{C}(X)$: ‘an event in a thing X is caused by some other event $e_{X_i}^X$ ’,

$$\mathfrak{C}(X) \stackrel{def}{=} (\exists X)(\exists e_{X_i}^X) [e_{X_i}^X \in E_L(X)] \Leftrightarrow (\exists X_i)(X_i \triangleright X).$$

$C(X, Y)$: “an event in a thing X is caused by an event in a thing Y ”.

$$C(X, Y) \stackrel{def}{=} (\exists X)(\exists Y)(\exists e_Y^X) [e_Y^X \in E_L(X)] \Leftrightarrow Y \triangleright X.$$

In these definitions, the notation ‘ e_Y^X ’ indicates with the superscript the thing to whose event space belongs the event e , whereas the subscript denotes the thing that acted triggering the event. The implicit arguments of both \mathfrak{C} and C are events, not things. For simplicity in the notation we refer to the things that undergo the events.

Causation is a form of event generation. A crucial point is that a given event in the lawful event space $E_L(X)$ is caused by an action of a thing Y iff the event happens only conditionally to the action, *i.e.*, it would not be the case of e_Y^X without an action of Y upon X . Time does not appear in this definition, allowing backward causation and non-local causality.

An alternative and equivalent definition is this:

Two events e_1 and e_2 are causally related iff there is at least a process p (a series of events) such that e_2 is a component of p and e_1 is a component as well, and it is never the case that e_1 is not a component of p . Then I say that e_1 is a cause of e_2 . The event e_2 is an effect of e_1 . In symbols:

$$e_1 \triangleright e_2.$$

The process p involving e_2 can never occur without the existence of e_1 . The world is legal and determinate, but not strictly causal. There are events that are not causally related and processes that are not causally originated.

Chance and probability

In **epistemology** the word 'chance' designates the unpredictable character of some events in some theoretical framework. Chance, in this sense, equals ignorance.

The **ontological sense of chance** is that some events belongs to a random sequence. A random event has an objective stochastic **propensity** that can be quantified by a probability.

Propensity, in turn, is the property of a system to go from one state to another.

Causal: if the system is in a state A then will evolve to a state B

Propensity



Stochastic: if a system is in a state A then there is a probability P that will change to a state B

Stochastic propensity is deterministic if there are laws that determine the probabilities P univocally way.

Stochastic propensity is represented by the probability function $P: E \rightarrow [0, 1]$, which is defined by the following axioms:

A1. If F is a set and E_i is a subset of F , then all unions and intersections of E_i are in F . $E = \{E_i\}$.

A2. $P: E \rightarrow [0, 1]$.

A3. For any subset A of E , $0 \leq P(A) \leq 1$.

A4. If $(A \in E) \wedge (B \in E) \wedge (A \cap B) \neq 0 \rightarrow P(A \cup B) = P(A) + P(B)$

A5. $P(F) = 1$.

This is a version of the Kolmogorov's axioms

Probability is the quantitative measure of stochastic propensity, and hence a measure of a physical property. It is incorrect to assign probabilities to hypotheses, statements, or propositions. Probabilities can be assigned only to events.

Disposition is a parent ontological concept. A property of a thing is **actual** or **manifest** if the thing possesses it, and **potential** or **dispositional** if the property emerges under adequate conditions.

A thing X has the disposition D =def X has the actual property A and X interacts with another thing Y then as a consequence of such interaction X acquires the relational property R :

$$D_X \leftrightarrow AX \wedge \exists Y \exists R (Y \neq X \wedge X \bowtie Y \wedge RXY).$$

E.g. Longevity is a dispositional property of some individuals. Instead, life expectancy at birth is a statistical or collective property. In general, probability quantifies dispositional properties of individuals, whereas statistical parameters such as averages and variances are manifest properties of collections of individuals.

Space, time, and space-time

Substantivalism: space and time are things (Newton)

Relationalism: space and time do not have autonomous existence.
They are subsidiary to the existence of things (Leibniz).

According to the latter view time is a relational property of changing things and space a relational properties of interacting things.

Space-time: Space and time are different aspects of a larger entity (Minkowski, Einstein, Weyl).

The metric and other properties of space-time are determined by things. But also the motion of things is affected by the properties of space-time. So, the controversy continues.

Is space-time an entity that can exist without other objects? Or is it an emergent relational property of all existents? The problem is open.

Matter

An object is material iff its lawful space state has more than one point, i.e. if the object can change.

Materiality is co-extensive with changeability. The capability to change is called **energy**. Energy is the only universal property of all existents: it is the potential to generate change. Concepts and fictions do not change or interact.

Notice that mass is not a requirement for materiality: photons and other massless bosons have energy and can change. They are material. The same is true of fields.

What is matter?

Matter is the class of all material objects.

$$M = \{X : X \text{ is material}\}$$

Matter itself is not material since it is a concept, not a thing with energy.

Similarly, **reality** is not real: it is the set of all real things (i.e. existing independently of the mind). Since sets are concepts, reality is not real. It is a convenient fiction.

Mind

The mind is the set of cognitive functions of the brain and the organism that enables consciousness, perception, thinking, judgment, and memory, among others.

The set of mental events is a subset of the set of the events in the plastic neural systems of the human brain in interaction with other subsystems of the organism and the environment. Hence, **all mental processes are biological processes.**

If the mind is a set of functions of the organism, it is not a thing, but a concept abstracted from a class of activities of a given thing (the the organism and its brain).

“The power of the mind”: Nonsense.

Information

Information is a concept associated with the transmission of signals that codify some statements in some language.

Information is defined on the set of pairs signal-receiver, where a receiver is a system (biological or not) competent to decode the signal.

Not being a thing, information has no energy and has not independent existence.

Definition: If a signal (mark, sign, inscription, sound, etc.) is a sentence or represents a sentence, then **the information conveyed by the signal is the proposition designated by the sentence.**

If S and S' are sets of signals representing the sets of propositions P and P' respectively, then

- (i) the **information conveyed** by S is *larger than or equal to* the one conveyed by S' iff P' is a proper subset of P ;
- (ii) the **information gain** accompanying the substitution of S for S' equals $P - P' = P \cap P'$.

These propositions define what can be called **semantic concept of information.**

The information or message conveyed by a signal consists of the proposition or propositions the signal stands for. It follows

(a) that non-propositional signals convey no information,

(b) that the greater the content of a proposition the richer the information carried by the signal representing that proposition, and

(c) that the truer a proposition the more accurate the information carried by the signal representing that proposition.

Biological systems

We assume that an organism is a system such that

- (i) its *composition* includes proteins (both structural and functional, in particular enzymatic) as well as nucleic acids (which make for its reproducibility and the likeness of its offspring);
- (ii) its *environment* includes the precursors of all its components (and thus enables the system to self-assemble most if not all of its biomolecules);
- (iii) its *structure* includes the abilities to metabolize, to self-repair, and to reproduce.

Proposed problems:

1. Might there be non-biological organisms?
2. Can sophisticated robots and artificial systems be considered organisms?
3. Can computers think?
4. What is to be a person?

Social systems

A **society** is a system of interrelated individuals that display coordinated activities sharing an environment. This idea is formalised as follows: A society σ is representable as an ordered quadruple \langle Composition of σ , Environment of σ , Structure of σ , the Mechanisms of σ \rangle , where the structure of σ is the collection of relations (in particular connections) among components of σ . Included in the structure of any σ are the relations of work and of managing which are regarded as typical of human society in contrast to animal societies.

A human society has four sub-systems:
biological, political, economical, and cultural.

Proposed problems:

1. Can you identify social laws?
2. What is the minimal social system?
3. What is the difference between social laws and the laws of the legal system of a society?

Summing up: I propose an ontology based on **things**, changeable entities endowed with properties. Things combine with other things and form **systems**. Systems are grouped into **levels** according to their shared properties: physical, chemical, biological, social, and artificial. The systems that populate each level emerge from the previous level when new functions appear with increasing complexity. The changes of things are restricted by **natural laws**. There are no lawless changes. Some changes are **causal** (triggered by previous events) and others are **probabilistic** (stochastic but lawful). The common property of all things is **energy**, the capability to change. Objects endowed with energy are called **material**. Otherwise, they are **fictions**. **Information** is not a physical property or a thing. Information is the propositional content of encoded signals, and hence it is a concept.

Extra-slides

BOOLEAN ALGEBRA

A Boolean algebra is a six-tuple consisting of a set A , equipped with two binary operations \wedge (called “meet” or “and”), \vee (called “join” or “or”), a unary operation \neg (called “complement” or “not”) and two elements 0 and 1 (called “bottom” and “top”, or “least” and “greatest” element, also denoted by the symbols \perp and \top , respectively), such that for all elements a , b and c of A , the following axioms hold:

- $a \vee (b \vee c) = (a \vee b) \vee c$; $a \wedge (b \wedge c) = (a \wedge b) \wedge c$ — Associativity.
- $a \vee b = b \vee a$; $a \wedge b = b \wedge a$ — Commutativity.
- $a \vee (a \wedge b) = a$; $a \wedge (a \vee b) = a$ — Absorption.
- $a \vee 0 = a$; $a \wedge 1 = a$ — Identity.
- $a \vee (b \wedge c) = (a \vee b) \wedge (a \vee c)$; $a \wedge (b \vee c) = (a \wedge b) \vee (a \wedge c)$ — Distributivity.
- $a \vee \neg a = 1$; $a \wedge \neg a = 0$ — Complements.