



Uniwersytet
Kardynała Stefana Wyszyńskiego
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Towards a Contemporary Ontology

The New Dual Paradigm in Natural Sciences: Part II

Module 2 Class 2: Aquinas' metaphysical development

Course WI-FI-BASTI2

2014/15

Introduction

Introduction to the Class 2: “Aquinas’ metaphysical development of Aristotle’s ontology”

Course modules

Modules	Topic	Suggested Readings
SECTION ONE		
0.	<i>Introduction and Course Overview</i>	
1.	QFT: an evolutionary interpretation of nature from cosmology to neuroscience	Refs.: 1-5.
2.	QFT in fundamental physics and the Aristotelian-Thomistic ontology of nature	Refs.: 6 , chs. 5-6; 7-8.
SECTION TWO		
3.	Formal philosophy and formal ontology	Refs.: 9-11.
4.	The formal ontology of the conceptual natural realism (CNR)	Refs.: 12-15.
SECTION THREE		
5.	The formal ontology of the natural realism (NR)	Refs.: 16-18.
6.	The duality algebras/coalgebras in CT and the notion of Universal Coalgebra	Refs.: 19-24.
SECTION FOUR		
7.	“Modal logics are coalgebraic”: an application to NR and to the duality logical/ontological truth	Refs.: 24-28.
8.	<i>Conclusions</i>	

Main Contents of the Module 2

- In the second module we summarize the Aristotelian-Thomistic physical ontology of the four causes in order to suggest that it is the **descriptive (not yet formalized) ontology of QFT as a quantum thermal field theory**, and fundamental physics both in the relativistic realm (microphysics) and in many body physics (macrophysics).
- The contents of the **two classes** of our module are:
 - 1) The Aristotelian theory of the four causes
 - 2) Aquinas' metaphysical development of the Aristotelian ontology

Bibliography

Bibliography of the Module 2

Bibliography

- Main References:

1. G. BASTI, *Philosophy of Nature and of Science. Vol.I: The Foundations*, Rome 2002 (English translation for student use only), chs. 5-6 [[attached](#)].

- Other References:

- G. BASTI, «Intelligence and reference. Formal ontology of the natural computation». In: *Computing Nature*, G. DODIG-CRNKOVIC AND R. GIOVAGNOLI (Eds.), Springer-Verlag, Berlin Heidelberg, 2013, pp. 139-159 (Sapere, 7) [[attached](#)]
- G. BASTI, «The quantum field theory (QFT) dual paradigm in fundamental physics and the semantic information content and measure in cognitive sciences», in *Proceedings of AISB 2014 Convention. Symposium on: "Representation of Reality: Humans, Animals and Machine"*, London, April 1-4, 2014 <<http://doc.gold.ac.uk/aisb50/AISB50-S23/AISB50-S23-Basti-paper.pdf>> [accessed 24 May 2014] (in press) [[attached](#)]

Class 2

Aquinas' metaphysical development of Aristotle's ontology

The connection among Aristotle's four causes

- To understand properly the **ontological core** of Aquinas metaphysical foundation of Aristotle's ontology of the four causes, we have to start from Aquinas deep understanding of this doctrine, about the distinction and the connection of the four causes.
- This passage of *Quaestio De Pot.* 5,1 is particularly illuminating:
 - It needs to be noted that there is a certain order among the four causes, according to which a clear correspondence is established between material and formal cause, on the one hand, and efficient and final cause, on the other. Indeed, there is a correspondence between the efficient and final cause, because the efficient cause starts the 'becoming' and the final cause ends it. Equally, there is a correspondence between matter and form: indeed, the form gives being (*dat esse*) to matter and matter receives it. The efficient cause is the cause of the final cause in relation to being (*quantum ad esse*): indeed, by its action, **the efficient cause makes the end existing**. Conversely, the end is not the cause of the agent cause in terms of being, but only in terms **of the formality of the causal implication** [*ratio causalitatis*]. Indeed, the agent is cause inasmuch as it acts, but it acts [producing a certain effect] only thanks to the end. Therefore, the agent is made "efficient" [i.e., capable of *necessarily* producing a given effect] only by the final cause [square parentheses mine].

Causal implication as converse implication ($p \leftarrow q$)

- This passage is very important because it gives the **ontological foundation** in terms of acting and final causality, to the logical principle of **converse implication**, applied to the classical **modal problem** in intensional logic – specifically in alethic logic – of distinguishing between the **logical necessity** («it is impossible that a premise is true and the consequence is false» i.e., the so-called «(logical) strict implication» of C.I. Lewis, or **logical entailment**) and the **causal necessity** or **ontological entailment** that, following Aquinas, says: «it is impossible that an effect exists, without that its (efficient) cause exists», a statement that Aquinas asserts in another passage, *In Phys.*, II, 15, 5), we comment at length in the Module 4, because it is the logical core of the NR formal ontology.
 - This is indeed, the basis of the **ontological biconditional** (we denote as \Leftrightarrow), like when we say «Iff I take the bus at 8.00am, I arrive at school in time», It is, indeed, **invertible**, even though **non-tautological**, because the asserts posed here in a biconditional relation denote respectively a cause with its effect, as far as distinguished by the **logical biconditional** (\leftrightarrow) that is invertible because **tautological**: «iff a polygon has three sides, it is a triangle».
- In terms of the passage we are here commenting, given an acting cause in a non-deterministic, unpredictable process – namely, that is not governed by a law through which an **ordering relation** is given **a priori** as to the process – this cause becomes **efficient**, that is able to produce **necessarily** a given **effect** among the (infinitely) many outcomes it could produce, by an **a posteriori ordering**.
 - In terms of a coalgebraic modal semantics – the set-theoretic foundational theory of Kripke’s relational semantics –, as we see, the «reverse of the arrow» in the ontological bi-conditional is based on the powerful notion of **coinduction** as characteristic proof procedure of **coalgebras**, and **dual of induction** as proof procedure of **algebras**. In this way the duality **q-deformed algebra/coalgebra** that is the core of the QFT formalism, as we saw in the previous module, has its proper set-theoretic and hence computational foundation, based on the **Algebraic Universality** (the duality Universal Algebra/Universal Coalgebra (Rutten 2000)), and not on the **Turing Universality** like QM computational models of classical quantum computing.
 - For our present aims, this confirms at the deepest level of the formal philosophy analysis, that the Aristotelian-Thomistic natural philosophy is an optimal candidate for proposing itself as the **descriptive ontology** of QFT fundamental physics.

Participation of being and the notion of being as act I

- The previous text in which Aquinas explains the strict relationship between acting and final causality gives us two other suggestions for understanding the theory of the **being as act** and of **participation of being** as the core of Aquinas metaphysics:
 1. It gives a strong foundation of the superposition of **final and formal** causes in the Aristotelian ontology because it emphasizes the ontological role of the end state produced by an acting causality as a-posteriori **source of the causal formality (the necessitating link cause-effect)** of physical processes, as far as undetermined because of the potentiality of matter. Of course, this does not negate in principle the existence of mathematical laws of physical events, only emphasizes the **inductive character** of them, and their dynamical, causal foundation.
 2. At the same time, by emphasizing the role of the acting causality as to its effect as producing the **being of the effect** as end state of the process, so that the existence of the effect **makes necessary the existence of its efficient cause**. This implies the notion of **efficient cause of the being** in two senses:
 - The Aristotelian one of the **heavenly bodies** as eternal, efficient causes of the **being of the essences (natures)**, like as many compositions of **form and matter** of the perishable, contingent, **earthly bodies**. In the sense that the **relative stability** of species – both of non-living and living bodies – through the succession of perishable individuals – requires the ultra-stability of some other physical causes. This is the sense of the famous Aristotelian saying: *homo generat hominem et sol* («man and sun generate man»). Something similar to the role in quantum physics played by nuclear physics as to the stability of the different species of atoms, and molecules and of their compounds. It depends on the ultra-stability of the nuclear physics. In this sense, Weisskopf said that quantum physics transferred the physics of the heavenly bodies of ancient physics into the **core of matter**.

Participation of being and the notion of being as act II

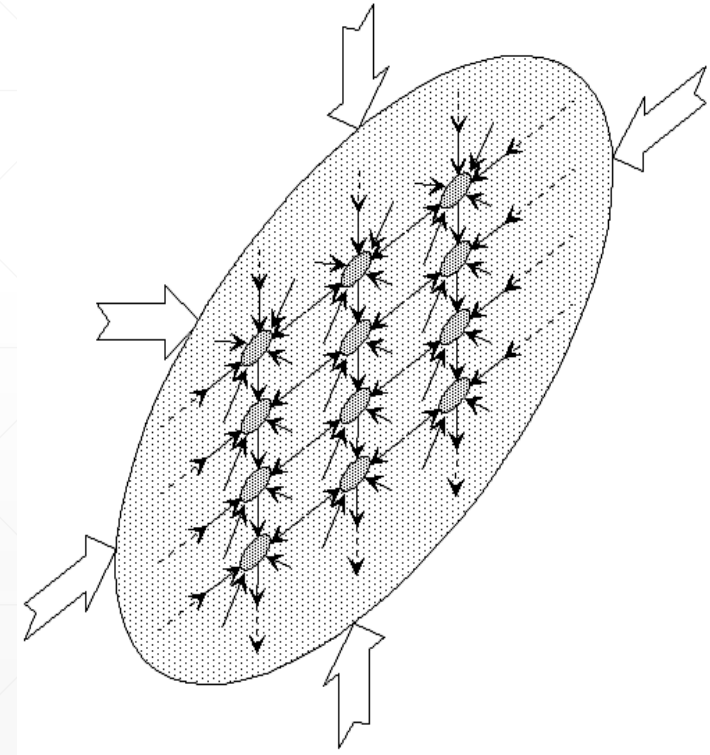
- Where Aristotle failed was in giving an **ultimate metaphysical, causal foundation** to another outstanding notion of his physical ontology: the notion of **individuals** as **primary substances** existing *in se* and *per se*, as distinguished:
 1. Against Plato, from the **secondary substances**, i.e., their essences or natures (natural kinds) that do not exist *in se* but *in pluribus*, in the many individuals sharing the same nature, because sharing the same causal complex concourse of acting and material causes;
 2. From their **accidents**, that is, events that happen to individuals, because of their proper causal concourse, but that do not exist *in se*, in themselves, like primary substances, but *in alio*, in other, precisely as properties and relations happening to individuals. From this distinction derives the other famous Aristotelian saying: «matter is the substrate of the forms, while a primary substance is the substrate of its accidents»
- Just because such an inconsistency, the Aristotelian ontology is generally interpreted within a **materialist metaphysics**, as historically happened in the Stoic or Epicurean traditions, or to the most famous of the Ancient Commentators Aristotle, Alexander of Aphrodisias (fl. 200 AD), or in the Modern Age, Spinoza. What is common to all of them, is to interpret individuals as **accidents of matter**, as explicitly Spinoza stated, making of it the only substance. In such a way, however, the richness of Aristotelian ontology get lost: before all the most original notions of matter as **potency**, and of individuals as **primary substances**.
- On the contrary all this richness can be preserved if we give Aristotelian ontology its ultimate consistency by supposing a **primary universal cause** of the whole being (the being of essence and the being of existence).

Participation of being and the notion of being as act III

- Compared to Aristotle, Aquinas introduced a new way of interpreting a fundamental metaphysical distinction:
 - One thing is the **existence**, common to all entities (*common being* or *esse ipsum*, «the being that is the same for all beings»), in Parmenides' sense that “every being exists”.
 - Another thing is the **modality of existing** or the **being of essence** (*entitas*, «entity»), which is specific to different kinds of entities and possibly to individuals.
 - The **act of being** includes causally both the being of existence and the being of essence of all beings. As «act», it is an effect of a metaphysical «agent cause», just as the form is «act», because it is effect of physical «agent» causes acting on the potency of matter determining the essences of the different beings, and hence their different modalities of existing (e.g., as a natural being, as a fictitious being, as a logical being, as a living being, etc.).
 - From this the Aquinas theory of the **double metaphysical composition** of act and potency of all the physical beings from which their existence derives:
 - In substances composed of matter and form, there is a **double composition** of act and potency. The first is the composition of the (secondary) substance itself, as made of matter and form; the second is made of the **already composed substance** (the essence as **potency**) and **being** (= being-as-act, *N.o.A.*) (Aquinas, *S. c. Gent.*, II, 54, 1295).

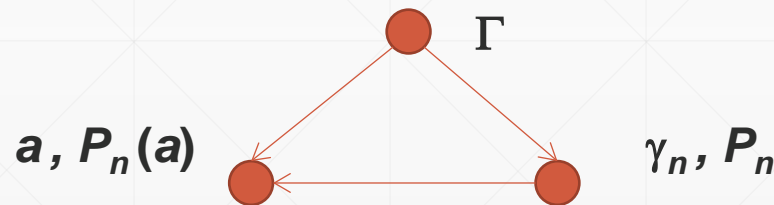
Participation of being and the notion of being as act IV

- To sum up the existence of all physical beings depends on a **double composition act/potency**:
 - 1) Matter and Form → Essence
 - 2) Essence and Being → Existence
- In this way each thing, as existing, participates in the act of being «according to the measure» of its essence determining the modality of existing of a given thing.
- Of course, because also matter exists, it exists as pure potency, because its nature consists in non having any actualized form, any actual ordering, having any of them in «**passive potency**».
- On the contrary, the efficient cause of all being is necessarily **Pure Act** without any potency, having in its «**active power**» all forms, so that, when interpreted as God Creator, as Aquinas himself does, He is very different from the Neo-Platonic God with the “exemplar” causality of His ideas.
- Aquinas God is the Ultimate Source of everything, but **which, when and how** the forms will be actualized in matter depend on the concurrence of physical causes. → Compatibility of **creation** and **evolution** (without their respective “-isms”).



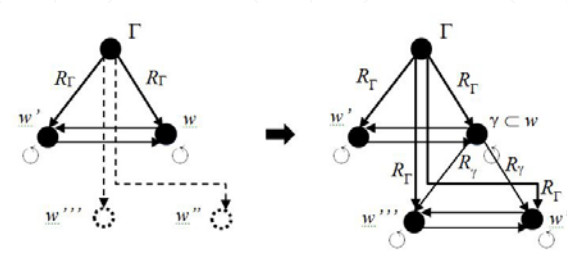
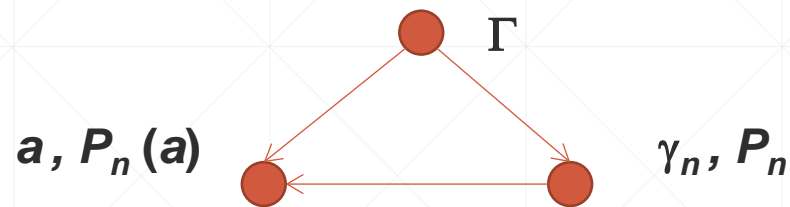
The coalgebraic modal logic of participation of being

- The **double composition, metaphysical and physical**, act-potency (being-as-act (*esse ut actus*)/essence & form-as-act/matter) on which the concrete existence (actually-being (*actu esse*)) of each individual (a) in the universe(s) $W_i (i \geq 1)$ depends, is the result of a **double acting causality**: **1)** from the metaphysical **First Cause** or **Pure Act** or **Subsistent Being**, Γ , (i.e., the participation of being at each individual); **2)** from a concourse of **secondary causes** γ_n (causal foundation of the essence of each individual) also this, however, «causally included» in the acting causality from Γ .
- All this can be formalized by the following **directed graph with one source Γ** . This graph is the same (**homomorphism**) for all individuals or primary substances (a, b, c, \dots), whichever be the number n of the **secondary causes**, and hence whichever be the specific predicate P_n characterizing the essence of the individual w (**homomorphism without isomorphism: bisimilarity** → **coalgebra defined on De Giorgi-Aczel non well-founded sets**)
 - In such a coalgebraic (modal) logic, indeed, there is a non-transitivity of the inclusions (\rightarrow), i.e. ($\neg((x \rightarrow y) \wedge (y \rightarrow z)) \rightarrow (x \rightarrow z)$), because the non well-foundation of the sets implies no well-ordering among them. Therefore, the inclusions can follow the **Euclidean rule** ($((x \rightarrow y) \wedge (x \rightarrow z)) \rightarrow (y \rightarrow z)$) like in our case, and hence the relational semantics can be a **first order complete semantics** (=coalgebraic completeness of Kripke's semantics):



Two main consequences: the metaphysical consequence I

- Because the **participation scheme** founding the individuals (a) as **primary substances** can be **nested** as many times n as we need in each universe W , and because the Euclidean relation, can be naturally integrated with a seriality relation R ($\forall u, v (uRv \rightarrow vRv)$), at each level n of the nesting procedure, an **equivalence class of sets by bisimilarity** (that is, a non-extensional, or **intensional equivalence**, because irrespective of the cardinality of the sets involved (non well-founded sets, because allowing infinite inclusions, are non well-ordered: proofs in them are by **coinduction** not by induction like in algebra), can be extended from individuals, a , to **natural kinds (genera-species) w** , as far as naturally “generated” by a concourse of secondary causes γ , and as far as **potentially including** an indefinite number of individuals. Effectively, a **total (top-down) ordering** of the equivalence classes can be founded, so to justify the index n of the relative P).



- In this way, such a metaphysics satisfies what is required by an **evolutionary ontology of the universe** and by a **theology compatible with it**. This can be easily understood when we recall that :
 - The **seriality condition** corresponds, in physics, to the **energy conservation principle**; in metaphysics, to the **uniqueness of the act of participation of being**, and in theology, to **the uniqueness of the act of creation for all material beings** (a coinductive proof in coalgebra is, indeed, always **upper bounded**, just as an inductive proof in algebra is always lower bounded). This is true, even though the second alternative supposes a **free decision of God**, and hence the Biblical faith in His Personal Nature.
 - The flowing of time** within each possible universe (i.e., within each possible nested causal procedure of natural kind generation) is a function of n , just as the complexity of the predicate P_n , **specifically** characterizing each individual, requires. It hence it reflects the evolutionary history of the universe generating it, and, finally, it explains why a given species of individuals appears only at a given age of the universe evolution.
 - The act of creation is **irrespective of time** because time is only **within (each) universe** and hence compatible both with **the co-eternity with God** of the, universe and with **the sempiternity** (infinite in time only as to the future) of the universe as required by Christian faith (Lateran IV Council). Namely, where the universe has an **absolute beginning**, even though “outside time” (St. Augustine, St. Thomas Aquinas).

Two main consequences: the metaphysical consequence II

- Three **illuminating** texts of Aquinas metaphysics of creation, now **formally illuminated** by a formal ontology supposing a coalgebraic modal logic.
 1. What is created comes to existence without any becoming or change, because every becoming and every change presuppose that something existed beforehand. Accordingly, when creating, God produces things without any change. [...] If we eliminate the 'becoming' from an action, the relation alone will remain in place. [...] Therefore *creation in the creature is simply a certain relation to the creator, as the principle of its being* (*S. Th.*, I, 45, 3c).
 2. Indeed, it is clear that the world leads to the knowledge of the creating divine power, both in the case it has not always existed, and in the case it has: everything that has not always existed was clearly caused, although this cannot be immediately understood when applied to what has always been (*S. Th.*, 46, 1ad 7).
 3. We have to say that the fact that the world has not always existed is something that cannot be proven in demonstrative form[...]. Therefore the idea that the world had an origin is a matter of faith, but it cannot either be demonstrated or known [through reason]. It is important to consider and think about this, so that someone, seeking to demonstrate what is an object of faith, does not ground such an aspiration in motivations that cannot demonstrate anything, thus opening the way to the mockery by those who do not believe, who could then think that we believe certain things not by faith, but in light of such false motivations (*S. Th.*, I, 46, 2).

Two main consequences: the ontological consequence I

- The separation between existence of **individuals** and the **formal causality** by separating **essence** and **being** as depending on two distinct, even though concurrent, **efficient causalities** (i.e., Aquinas doctrine of the **real (causal non logical) distinction between being and essence**) is able to give a metaphysical foundation to another distinctive component of Aristotelian hylomorphism from the Democritean atomism.
- I.e., **the virtual existence of parts within a composed primary substance, i.e., within a new individual.**
- At the same time it gives also a ontological foundation to another distinctive character of QFT: its dynamic interpretation of **particle-wave duality**, according to which the particle-like behavior is meaningless when **a new phase coherence domain of the respective fields** emerges (see Module 1).

Two main consequences: the ontological consequence II

- In the philosophical essay *De Mixtione Elementorum*, Aquinas explains such **formal unity** (i.e., a **phase coherence domain**) of compounds by emphasizing what characterizes this unity is that:
 - 1) all composing elements **instantaneously modify** their characteristic quantitative properties (i.e. their **quantum numbers**) in accordance with their belonging to the totality;
 - 2) in view of this, the elements within the compound are characterized by a “weak objectivity”, i.e., they **virtually** exist in compounds as non-local parts, i.e. as force fields exhibiting a phase coherence, so that only the whole is **local**, and hence it is a new individual.
- Aristotle in this regard used the analogy of the drop of water: the whole drop is together in one only position of the space, and hence as an **individual**, because the moving droplets can be everywhere inside it (in QFT terms – even though such an example is more kinematical than dynamical – , they are no longer particles but quanta of the respective force fields).
- The similarities with the phenomenology of the quantum states, considered in the light of QFT, are again impressive: think, for instance, at (1) as quantum **entanglement**, and at (2) as quantum **non-locality** as far as interpreted non in the (absurd) terms of instantaneous particle interactions and/or as statistical properties (eigenvalues) of the Schrödinger Ψ in QM, but in terms of phase coherence correlated, characterizing values of their respective force fields.
- Of course, the ontology of Aquinas theory of compounds is not understandable if you interpret the **virtuality** of the parts inside the whole as virtuality of their **forms**, as generally the modern interpreters of Thomas do. If are their forms that become virtual, it means that they are no longer **distinguishable**. But if this was true – Thomas observed –, it would mean that we can **never more** extract them from the compound, and this is not true (think at ions in a water molecule in a simple electrolysis experiment). It is their existence – i.e. their modality of existing – that became virtual, not their form.
- Now, if our metaphysics is not able to distinguish **really**, i.e. causally and hence dynamically, between **being** and **essence**, between **how** they exist and **what** they are, the problem cannot be metaphysically and physically solved, as it happens since more than eight centuries!

Two main consequences: the ontological consequence III

- Conversely, by a sort of «bisimilarity» relationship between QFT and Aquinas ontology of compound substances, the most intriguing phenomenon of a new substance generation, i.e., the simultaneous change (correlation) among all the characteristic magnitudes of the parts, has a very elegant explanation in QFT. There is no interaction among particles, simply **a phase coherence of force fields**. Becoming «virtual» means becoming «quanta of the relative field».
- Indeed in the relativistic realm (special relativity) of QFT, the **phase velocity** propagation in a phase coherence domain of a field, i.e., $v_p = E/p$ (where P is the phase, v_p is its velocity, E is the energy of the field and p is the momentum), we are faced with no sending of material signals at a superluminal velocity ($v > c$) in **quantum entanglement** phenomena. That is, always $v \ll c$, as special relativity requires, against a false divulgation of this phenomenon (teleportation).
- Now, if $E = mc^2$, $p = mv$, and γ is the Lorenz constant, the value of v_p is given by this simple dimensional equation:

$$v_p = \frac{E}{p} = \frac{\gamma mc^2}{\gamma mv} = \frac{c^2}{v}$$

- When we recall that the characteristic lengths in quantum atomic physics are of the order of **10^{-8} cm**, it is evident that phase propagation velocity is practically **instantaneous**. No mystery in quantum entanglement in a non-atomistic physical ontology!