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### RESEARCH ARTICLE

## HOW THE FORM AND MATTER EXPLANATION OF ST THOMAS AQUINAS ADDS BETTER INSIGHTS TO THE NG BOSON IN QUANTUM BRAIN DYNAMICS

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### Abstract

Form and Matter, two principles having their roots in ancient times as scholars past grappled with seeking to demystify the world's mystery around them. One tough issue relating to form and matter was - How can these two principles mediate a better understanding of the human person? In our contemporary society, there seems to be a lack of consideration of the two principles. Why? It is because they are considered obsolete in reference to scientific advancements of recent times. Nonetheless, we see these principles on display in many arenas of biological existence, such that they provide insightful depth to the consideration of biological life, whose understanding has been coloured by science and its experiments. The major consideration in this work will be the human person with respect to his power of cognition. We see with the dawn of Quantum Physics, that there are particular massless quanta that arise in the brain when symmetry is broken called the NG Bosons. These are the carriers of the information that are transmitted to the far-reaching ends of the brain, a principle referred to as long-range correlation. Does the Thomistic rendition of form and matter make better appreciated the insights of quantum physics on the brain under the auspices of quantum brain dynamics (QBD)? Thus, we start by clarifying some terms, then we delve into the Thomistic elaboration of form and matter. This will enable us to situate ourselves within the scope of the terminus of this work, namely to indicate that Aquinas' insights on form and matter are usefully valid for what pertains to QBD today.

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### Introduction:-

Quantum Field Theory was already on course to being a full-fledged scientific endeavour with the dawn of the electromagnetic field pioneered by the works of M. Faraday, A. Volta, and H. Christian at different times and using different experimental procedures. What was seen was that their electric forces were connected by means of a field and it was by means of this field that these forces could communicate with each other at long distances. This was ground-breaking, as it was to later inspire the likes of A. Einstein, who also noticed this "spooky action at a distance" occurring not only in electromagnetic forces, but also in the other fundamental forces, most especially the force of gravity. The knowledge of the quantum realm has enabled us to understand the reason for this "spooky

action at a distance". That is to say that these quantum particles that are entangled (from inception), even when they drift far away from each other, are yet able to affect each other in ways that defy their distance. These particles we already know are embedded in a field, which is their platform for operation. We are not able to make a comprehensive sense of what is happening in the quantum realm because awareness of this realm is on a coming in and going out of existence trend of the quantum particles. What should be considered from this introductory note is that even at infinitely long distances, particles that are entangled together evolve together through communication that is not conventional. More to this, it is known that these particles are able to do this because irrespective of the distance of separation, they are all embedded in a field. In this field there are information carriers that traverse the distance, thereby linking one particle to another.

Philosophical studies spanned the length and breadth of the scientific universe. The scientific world was born out of one of the major schools of thought that is as ancient as philosophy itself, namely, empiricism. It is more justifiable to situate philosophy as a compendium of the empirical and the rationalistic school of thought since both are not mutually exclusive in what pertains to knowledge, which is the desire of the philosophical inquiry. Thus, the scientific process is not and should not be alien to philosophy since philosophy targets the acquisition of knowledge, which science is all about. Aspects of philosophy that were thought to be speculatively elaborated have received clear-cut definitions all thanks to the scientific method. The shortcomings of the scientific method are nonetheless seen with regard to natural science. This shortcoming is based on the fact that in natural science, nature most times defies logic. It is in this that philosophy comes in to shed light on the scientific method, lending its experience and versatility to the scientific method for the sake of arriving at a solution to the conundrum posed by nature. One of such that has defied logic for so long pertains to form and matter as regards matter being made actual (given BEING) by the form. We want to show in this work, which will rather be a means to allowing further considerations to this, that as regards quantum brain dynamics (QBD, which uses the excerpts of quantum field theory QFT, to understand the operations of the brain), borrowing insights from the philosophical exposition of how form actualizes matter can provide meaningful insights to how ideas arise in the brain, and how they are executed. What we are proposing is that QBD, can be further understood by employing the philosophical exposition of the relationship between form and matter. The form and matter elaboration will be the one provided specifically by the insights of Thomas Aquinas.

### **Clarification of terms**

It is necessary to understand the technical terms that have been highlighted in this work. This is to ensure an ease of assimilation in what pertains to the goal of this research.

**Quantum Brain Dynamics:** Quantum Brain Dynamics (QBD) describes long-range ordered dynamics of the quantum system of electromagnetic field and water dipole field in the brain (Jibu and Yasue, 1997). QBD is Quantum Electrodynamics (QED) of the electric dipole field of dipolar solitons and water molecules with a symmetry property under the dipole rotation. The highly systematized functioning of the brain, according to QBD, is initiated by and in the spontaneous symmetry-breaking (SSB) phenomena. QBD, derives its mathematical formulation from quantum field theory or quantum field dynamics. Thus, we can, in extension, say that the brain can be analyzed and understood with excerpts gathered from quantum field theory or dynamics. We should also note that because the brain "is a mixed physical system of quantum dynamical system and classical dynamical system" (Jibu and Yasue, 1997), QBD is an intersection between the quantum and the classical mode. We can denote QBD to be the adaptation of the findings of Quantum Field Theory (en bref, we should note that quantum field theory provides postulations based off the mathematical formulations embedded in quantum mechanics to explain the fundamental reality of all that exists) to the brain, as an expected hypothesis, that can and will be used to "describe the mechanism of memory in the brain" (Nishiyama, 2019).

**NG Bosons (Nambu Goldstone Bosons):** these are quanta that arise in the brain at the spontaneous breaking of symmetry (SSB). According to the many-body theory, there is (are) long-range correlation in the brain, which occurs by means of a spontaneous breaking of symmetry, which immediately leads to the condensation of a quanta known as the Nambu-Goldstone Boson particles that are in its ground or vacuum state. The electric dipole rotational symmetry is the symmetry that is broken. (this is elaborated further in the course of this work, yet for our own purposes, it is necessary to state here that the water matrix and the biomolecules that enter the brain contain within them this quality of an electric dipole moment (Freeman and Vitiello, 2005)). The breaking of symmetry occurs due to the interaction of the system with its thermal bath; that is to say, this takes place in the brain because the latter is in constant interaction with the environment (its thermal bath). In SBS (spontaneous breaking of symmetry) theories, the Goldstone theorem predicts the existence of massless bosons, called Nambu-Goldstone (NG) particles. The

condensation density of the NG boson quanta determines the macroscopic field which is called order parameter, e.g. the magnetization in ferromagnets (Freeman and Vitiello, 2005).

From the aforementioned clarification, it is thus endorsed that the NG Bosons are an integral part of the QBD. QBD is the quantum elaboration of the dynamic processes of the brain, making use of QFT in its postulations.

### ST THOMAS AQUINAS ON FORM AND MATTER

According to Aquinas, form and matter are principles of nature (with the addition of privation<sup>1</sup>), and both are intrinsic to the substance. That is to say that both as principles and causes, form and matter are intrinsic to the substance. He notes: there are three principles of nature: matter, form and privation. One of these, form, is that by reason of which generation takes place; the other two are found on the part of that from which there is generation. Hence matter and privation are the same in subject...<sup>2</sup> (Aquinas, *Commentaria in octo libros Physicorum* (C.i.ol.P), I, 13)

As it was for Aristotle, for Aquinas, the form “is nature more than matter” (Aquinas, C.i.ol.P II, 2). This is because a “thing is said to be greater insofar as it is in the act rather than insofar as it is in potency” (Aquinas, C.i.ol.P II, 2). Between form and matter, there is a relationship of act to potency; and with respect to nature, form is natural in act, while matter is natural in potency (Aquinas, C.i.ol.P II, 2; *Physics* III, lectio II). He substantiates his claim thus:

If the form is the natural act and matter is natural potency, then it means that the form is prior to matter, in the order of nature (absolutely) and time. In his commentary to the *Metaphysics*, where he elaborates on this, he refers to the form as “specifying principle”, giving it priority over matter (Aquinas, *Commentary on the Metaphysics*, (C.ot.M) VII, 2). If the form stands as prior to matter, as the specifying principle, then it stands as prior even to the composite (Aquinas, (C.ot.M) VII, 2). Still commenting on Aristotle’s *metaphysics*, Aquinas is poised to reveal that as much as the form is a substance, the composite is a substance, matter is also a substance<sup>3</sup> (Aquinas, (C.ot.M) VII, 2). Thus, as important as the form is, so is the matter. But if matter is a substance and form is a substance, then can it be said that two substances make up one composite substance? To this objection, Aquinas gives clarity by stating clearly the relationship that exists between form and matter. Which is that the form is an immaterial substance, albeit a spiritual substance, and it exists with matter in an act-potency mode of relationship. The form of a corporeal being cannot and should not be likened to that of an incorporeal being (Aquinas, *De Substantiis Separatis*, VIII; (Aquinas, *De Anima*, II, I)).

The form of a material (corporeal) being is properly-suited to that substance, and the form of a purely intelligible being is suited to it (Aquinas, *SCG* II, 54, 7; 8; *De Substantiis Separatis*, VIII).<sup>4</sup> At this stage, our reference here is

<sup>1</sup> But privation is not so much considered because it is only a principle of nature and not cause, whereas form and matter are both principles and causes. Thus, Aquinas refers to it in his *Principles of Nature*, chapter II, as a per accidens principle, while the form and matter are per se principles. Aquinas, Thomas. *De principiis naturae*, II.

<sup>2</sup> Notice that here he uses the terms “subject and form” as principles per se, but in the *De principiis naturae*, he uses matter and form as per se principles. There is no discrepancy here because, according to Aquinas, matter cannot exist without a particular form. And as already noted, the composition of matter and form yields a subject. This does not negate in anyway the veritability of the form as the act which actualizes the potency inherent in matter. For example, the bronze statue that is to be made would have to come from the bronze itself, and the bronze as matter already contains a certain form that makes it bronze. Or the bed that is made from the wood is made from the wood that already has a form. Yet, in man, this natural occurrence is somewhat different. This is so because generation in man yields another man. Thus making firm the thought that the form of a natural thing is the nature.

<sup>3</sup> Even though the substantiality of form and the composite precedes matter, form and matter are first to knowledge than the composite. *C.ot.M*, VII, 2

<sup>4</sup> In purely intellectual substance, Angels, the form is equivalent to the substance. That is to say that the form is the substance (Aquinas, Thomas. *SCG* II, 54, 7). This is because the purely intellectual substance does not have any material, that is matter. The intellectual substance, thus, has the form as its subsisting substance. For the pure intellectual substance, since it is created, there is also an interplay, rather a composition of act and potentiality. In *SCG* II, 54, 8, Aquinas adds that in such intellectual substance, there is only one composition of act and potency, which is the composition of the substance and the being, that is form (which is the entirety of the substance) and esse. In the *De Substantiis Separatis*, he notes «It is clear therefore wherein the potency which is found in spiritual substances differs from the potency found in matter. For the potency of a spiritual substance is measured only according to its order to “to be”, whereas the potency of matter is measured according to its order both to a form and

being thinned down to the consideration of the human person alone. The form of the human person, his intelligible soul, exists with his body, matter. Aquinas first calls upon the definition of the term human person, then moves on to situate how dependent the soul is on the body, in the process of knowing, to indicate how necessarily both make up a composite immediately (Aquinas, ST I, 75, 4.).

The intellectual soul knows but knows not as the incorporeal intelligible substances know. The intellectual soul's operation is dependent on the body. However, this does not fully explain how both substances are immediately conjoined in the human person to make a composite.

It was earlier asserted that material substance is a natural potency to receive an act, while the formal substance is a natural potency to give an act. It was also earlier asserted that the form in a corporeal substance is fitted to that substance as that of the intelligible is to it. These two points provide the bricks with which the construction of a fitting description of the problem of the union between the soul and the body. For in the thought of Aquinas, "nothing acts except so far as it is in act; wherefore a thing acts by that whereby it is in act. Now, it is clear that the first thing by which the body lives is the soul" (Aquinas, Summa Theologica, I, 76, I). As the form of the body, the intellectual soul is a part of the human person and not the entirety. In the Summa Theologica, I, 76, 1, Aquinas dismisses two reasons why it would be claimed that the human person is the soul, reasons that include the soul as an accidental quality in man; this is debunked by the essence to which it is. The other reason is the soul as the totality of man. If so, why does its operation arise from a part of man? Aquinas thereby assents to the fact that the intellectual soul is a part of the human person (Aquinas, Summa Theologica, I, 76, I). To recapitulate, Matter "is that which is not as such a 'particular thing' but is in mere potency to become a 'particular thing'" (Aquinas, De Anima, II, I), and Form "is that by which a 'particular thing' actually exists" (Aquinas, De Anima, II, I). However, we have the composite (or the compound as Aquinas refers to it in the De Anima), which is "the 'particular thing itself'" (Aquinas, De Anima, II, I).

Between Matter and form, there is a relation between what is potential and what is actual. Matter, then, differs from form in that "it is potential being; form is the 'entelechy' or actuality that renders matter actual; and the compound is the resulting actual being" (Aquinas, De Anima, II, I). To this, Aquinas opines that

Since, then, there are three sorts of substance: the compound, matter, and form; and since the soul is neither the compound—the living body itself; nor its matter—the body as the subject that receives life; we have no choice but to say that the soul is a substance in the manner of a form that determines or characterizes a particular sort of body, i.e. a physical body potentially alive ((Aquinas, De Anima, II, I)).

This is where it gets a little bit interesting. Notice that in the quotation just offered, Aristotle does not say that the Form renders Matter (soul renders body) actually alive, but potentially alive. This is because actual existence relates to the compound (the composite), "For by a body actually alive is understood a living compound" (Aquinas, De Anima, II, I; De Principiis Naturae II). This brings us to the second order of act/potency composition that was earlier stated, that of subject and esse.

When the form informs the matter, it makes it potentially alive; this potency is in reference to another actuality that comes not from the form but from the esse. In substances composed of matter and form, there is a twofold composition of act and potentiality: the first, of the substance itself which is composed of matter and form; the second, of the substance thus composed, and being; and this composition also can be said to be of that which is and being, or of that which is and that by which a thing is (Aquinas, SCG, II, 54, 9).

The difficulty of how the soul and the body relate apparently was a disturbing issue for Aquinas, as much as it was for Aristotle, for he notes, "there had been much uncertainty about the way the soul and body are conjoined. Some had supposed a sort of medium..." (Aquinas, De Anima, II, I). A medium that connects one to another. This means that the conjunction of both is mediated. However, Aquinas responds that the form "is directly related to matter as the actuality of matter; once matter actually is, it is informed" (Aquinas, De Anima, II, I). Thus, the matter that actually is must have been informed. It would be worthwhile to recall that, in the human person, there is a two-order composition—form/matter (which gives rise to the subject potentially alive) and the subject and esse.

Proposition 1: How Does Form and Matter in Aquinas Relate to The NG Bosons?

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to "to be". If someone were to say that both potencies are matter, it is clear that he is using the word "matter" equivocally. » Aquinas, Thomas. *De Substantiis Separatis*, VIII.

If we were to loosely classify taxonomically the biogenesis of the human person, using the means of questions and answers, we would say:

What would physically comprise the human person? The human persons are made up of varied SYSTEMS, that coordinate the complex structure of person.

And What would physically comprise these SYSTEMS? Systems are made of ORGANS.

And What would physically comprise these ORGANS? Organs are made of CELLS.

And would physically What comprise these CELLS? Cells are made of ORGANELLES.

And What would physically comprise these ORGANELLES? Organelles are made of PROTEINS.

And What would physically comprise these PROTEINS? Proteins are made of AMINO ACIDS.

And What would physically comprise these AMINO ACIDS? Amino acids are made of ATOMS.

And What would physically comprise these ATOMS? Atoms are made of PROTON, NEUTRON AND ELECTRON.

And What would physically comprise these ELECTRONS? ... Electrons are made from ELECTRON FIELDS

What comprises these electron fields? ...

Based on what we presently have as scientific knowledge, the universe is made from fields, and these fields are not made from any smaller components. Calling to mind this loose taxonomy as regards the human person, it is noted that electron fields are the limit to which our knowledge of the physical constituents of the human body goes. Electron fields have a vacuum state (or ground state),<sup>5</sup> which is generated when symmetry is broken (Vitiello, 2001). The absence of symmetry implies that order has been generated in the system.

When order is restored, at the point of the lowest energy of the system, where no photon or mass-filled particles are to be found (that is, where only electromagnetic fluctuations are seen), massless quanta known as NG Bosons appear. This appearance is oft referred to as unwanted “because no one had seen any such bosons, and if they existed and had any reasonable strength of interaction, they ought to have been easy to see” (Kibble, 2014). At this very elementary stage in the field, in the absence of any particle, information still moves across the field (recall that it was earlier noted that the field at the ground state has a zero net energy but does not signify a collapse of dynamics, for fluctuations still occur). Such dynamism at the vacuum state is tied to the action of the NG Bosons. In Vitiello’s words,

when symmetry is broken, the invariance of the field equations implies the existence of quanta, the so-called Nambu-Goldstone (NG) quanta, which, propagating through the whole system volume, are the carrier of the ordering information, they are the long-range correlation modes: in the crystal, for example, the ordering information is the one specifying the lattice arrangement (2001).

Water would exhibit a dipole moment. It is also to be noted that in the human brain, water is the foundation of every process. Therefore, once symmetry is broken, the NG quanta that arise are those of the electrical water dipole rotational symmetry, referred to as the dipole wave quanta (dwq).

Proposition II: Can This Thomistic Elaboration of Form and Matter, meet with Contemporary Debate Pertaining to NG Bosons in QBD?

To answer this question, some points need to be laid out first. They include:

1. The Form is directly related to Matter as the actuality of Matter; once Matter actually is, it is informed.
2. When the Form informs the Matter, it makes it potentially alive.
3. Before the generation of the ground state, there is symmetry, which, once broken (generating the vacuum state), leads to an ordered state whose informational ordering is dictated by massless quanta known as the NG Bosons.
4. For the NG quanta to be able to span the full system volume and thus set up the ordered pattern, their mass has to be zero. (Vitiello, 2001). This means that the NG quanta does not carry energy, which is why the vacuum state is a state of minimal energy.

Could it be said that the state of symmetry is a state of full potentiality that is equivalent to the scholastic definition of prime matter? I propose yes. Can we say that the NG Bosons are the form responsible for the ordering of the system at the ground state when the symmetry is broken? Again, I propose yes. On the physical/biological level, the

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<sup>5</sup> Quantum vacuum is the lowest energy state of a quantum system. There are no quantum excitations in the quantum vacuum but despite the fact that no photons are present, there are still fluctuating electromagnetic fields. Yet the fields fluctuate about an expectation value of zero.

indicators seem to favour an all-positive answer. The spontaneity in the breaking of symmetry in the biological system, from whence order arises, is what defines the system. That is to say, that is where the observable dynamics are made noticeable. We have already noted that there can be form without matter, but no matter without form (except prime matter, which is actually an idealistic concept). The order, shape and manner in which the matter appears is tied to its conjunction with and to the form. That is to say that the form gives order to matter. To justify the “yes” answers given above, we need, first, to understand some terms, namely

1. Form and Matter (also privation, but this is a per accidens principle) are per se principles of generation in nature (Aquinas, *De Principiis Naturae*, II).
2. Form and Matter are also causes of generation in nature.
3. The term principle and causes can be used interchangeably, although according to Aquinas, in reference to Aristotle, there are three principles and four causes. Two of the three principles are also causes, and two of the causes are principles. It is in this sense that principles and causes are used interchangeably, which is when the reference is made to those principles that are causes, namely Form and Matter (Aquinas, *De Principiis Naturae*, III).
4. Form and Matter are intrinsic principles/causes (Aquinas, *De Principiis Naturae*, III).

As a principle and cause, the Form has the charge of ordering and inFORMATION, which it gives to Matter. Matter cannot be known without some particular form ascribed to it, as that which is open to knowledge arises from the composite of Matter with its component Form (Aquinas, *De Principiis Naturae*, II). The NG quanta determines the knowledge that is to be acquired from that which is generated; it determines the structure and the function of the observed dynamics. A fitting example is the phonons<sup>6</sup> of lattice crystals. The lattice-like structure of the molecular crystals is based on “weakly interacting waves of atomic (or ionic) vibrations...” (Katnelson, 2005). These weak interacting waves are so comprised because they are massless; they are bosons (they are massless bosons that carry ordering information to every corner of the structure, thereby giving the crystal a well-aligned structure. This is not to say that these phonons are noticeable when their structure is destroyed. What is noticed is the atoms that comprise the crystals. But when these atoms are arranged in order, the carriers of this ordered information are the phonons. Thus we can say that the phonons disappear once order is lost and appear when order is gained (Vitiello, 2001). These phonons hold the ordering information of the lattice crystals and are also the cause of the “inform-a-tion” given to the lattice crystal.

One point that is not to be neglected is that the observation of the dynamics inherent at quantum levels occur at regions that are “far away from the interaction region” (Vitiello, 2001; Freeman and Vitiello, 2007). The interaction region is where the dynamics operate, “given the in-fields and the in-states, the dynamics determine the out-fields and the out-states” (Vitiello, 2001). Observation thus begins as regards the quantum fields, long after an unobserved dynamic (the in-field and in-state) has generated the observed (the out-field and out-state) in places where and when “the interaction forces can be safely assumed not to operate (the asymptotic region)) (Vitiello, 2001).

To recap, in the case of crystals, the relative correlation quanta or “Goldstone bosons” are called “phonons”; in the case of ferromagnets they are called “magnoni”; in the case of living matter they are called “DWQ” (dipole wave how many “dipole waves”), etc... All these Goldstone bosons “exist” as long as they last and are related to the coherent states of the subject. Without crystalline state, there would be no more phonons, no magnets, no magnoni, and also, without life in a corpse, there would be no more DWQ - which then are physical manifestations of the metaphysical “form” of the living, of its “soul” as noted in the Thomistic ontology. It is clear that all this makes sense only in a dual ontology: form (information), as a relation of order, it is no less real and less measurable than matter (mass-energy).

## Conclusion

Before conclusively arriving at an open-ended scenario, thus leaving this research open for further analyses and research, it is necessary to make known some salient points, namely:

<sup>6</sup> Phonons are noticed in a lattice crystal when symmetry is broken. They are analogous to photons, having energy of  $\hbar\omega$  as quanta of excitation of the lattice vibration mode of angular frequency  $\omega$ . Since the momentum  $\hbar\mathbf{k}$  is exact, by the uncertainty principle, the position of phonons cannot be determined, and so, phonons are not localized particles. Nevertheless, just like the case with photons or electrons, a fairly localized wave packet can be constructed by combining modes of slightly different frequency and wavelength. Phonons cannot be determined because they exist as fields. According to Vitiello, «stable ordering requires long range correlation among constituents... and one needs fields» to describe such. (Vitiello, G. *My Double unveiled*, 17.)

1. The reference to quantum physics in relation to the Thomistic line of thought is not quantum mechanics but quantum field theory. The difference between quantum mechanics and quantum field theory can be simply construed as follows: the latter considers the wave-particle fundamentality of reality as embedded in a field. That is to say that before ever the wave-particle consideration, there is a field in which this wave-particle duality is embedded.
2. As pertaining to the field theory of quantum mechanics (that has been so rightly dubbed as quantum field theory), there is more robustness in understanding. That is to say that we can be sure that neither the wave nor the particle exists in a vacuum. There is a fundamentality that is more foundational to these physical realities of wave and particle. What we term as the quantum field. Science has come a long way since the conundrum of the wave-particle duality. We are not certain that when the particle moves, it moves in the manner of a wave. We further assert that the movement of this particle is within its field (for instance, electromagnetic particles will move as electromagnetic waves in an electromagnetic field). It ought to be noted that quantum mechanics has not been able to properly wade into the realm of the living (the animate) because its mathematical considerations are for open systems. However, quantum field theory considers open systems and the interaction between the system and its environment. In other words, QFT considers the two systems as one, whereas this flexibility is not seen in quantum mechanics. Since living organisms, with reference to the human brain, defy mathematical permutations and probabilities most of the time, QFT is best.
3. The quantum field has and is a form, one that is not albeit seen, but one that exists nonetheless. Quantum mechanics, in reference to the “cat in the box” thought experiment of Schrodinger is able to assert that these quantum particles do exist, but they are brought to the human macro consciousness (macro here involves every scale except the quantum, so it will include both macro and micro) when they are discovered at a certain point in space-time, what we refer to as the coming in and going out of existence of quantum particles.
4. Form and Matter are two realities that are always in existence, but only come to the human consciousness when they are determined at a particular point in space-time reality. Form is more foundational than matter; it is the field on which matter traverses, as the wave-particle (matter) traverses the quantum field (the form).
5. The actuality of form bringing matter to life is contained in the information that matter receives; that is why we assert that form “in-FORMS” matter. An example that might be considered quite mundane is the fact of a thought remaining in the realm of the non-physical except when brought to materialise in Matter, just like a carpenter making a chair from the form he had in his mind. The form of the chair that exists in space and time was there before it became materialized in matter. It was there as form (a thought, an idea).
6. QBD (Quantum Brain Dynamics) is still in its nascent stages; as such, it would require a lot of input from every academic aspect for it to mature fully. It would be speculative at this nascent stage to categorically assume that there is a quantum homologue for the brain. Instead, we are sure to affirm that the brain and its operations are all the action of waves that are being conducted to and fro, which shows itself in the eventual macroscopic (again, macroscopic involves everything except the quantum) attribution of the operation of the brain. In the aspect of the wave-particle duality theory, we are asserting that the field on which these wave-particles move is more fundamental and it is not seen; what is seen is the quantum particle that moves in and out of existence.
7. It is in the breaking of symmetry that the quantum particle is seen, that is, comes into existence. Before the breaking of symmetry, it can occupy any position available to it (it ought to be noted that its available positions are numerically countless; however, when symmetry is broken, one position is chosen).
8. With reference to the brain, we are speaking of quantum realities that birth the macroscopic order of operations that is seen in the brain. And we are alluding to the fact that the wave-particle communication that arises in the brain’s universe is embedded in a field- the DIPOLE WAVE QUANTA, which holds these particles together. This particle is the massless NG Bosons. Once symmetry is broken, and NG Bosons arise, an order is established that precipitates in the macroscopic operation that is witnessed in the brain.
9. What breaks this quantum symmetry? Information (that is triggered by what is biologically referred to as stimulus- be it internally generated as in a memory or externally orchestrated as coming from the universe outside that of the brain, for the brain is not a closed physical system, but is an open physical system, which is in communication with particles outside its universe). This wave-particle ordering arises many nanoseconds before the unconscious macroscopic manifestation and, indeed, many nanoseconds before the conscious awareness of such is observed. Where does this information arise? It is embedded in the Field. What does this information yield? Matter.

Conclusively, even though Thomas Aquinas was not experimentally detailed, nor was he clearly given to estimating what happens in the brain at a fundamentally quantum level, nonetheless his insights into and deepening of the form and matter conundrum gives meaningful clarity to the contemporary discourse on quantum physics and the human person. We do not ascribe in a tight-fitting fashion that form is related to the NG Bosons; that will be an unfounded assumption. Yet we allude to noting that that which the NG Bosons does when symmetry is broken can be likened to what form does to matter in the created order. More to this, we see how quantum physics becomes entangled in classical metaphysics. What NG Bosons does is to allow for the ease in the flow of energy (information) to the entirety of the system that now possesses the order.

We note that there are yet other areas to consider when we speak of QBD, especially as we try to make it more understandable to all. We are excited to note that further research in this field is ongoing, which is going to birth a better understanding of this phenomenon of the quantum universe of the brain.

## Appendix

Further elaborations about QBD (Quantum Brain Dynamics) as related to QFT (Quantum field theory) and not Quantum mechanics (Iwuh, 2023).

In its nature, QBD is dissipative; this owes a lot to the fact that it is carried out in complex systems that are open. According to Y. Bar-Yam,

A complex system is a system formed out of many components whose behaviour is emergent. That is, the behaviour of the system cannot be simply inferred from the behaviour of its components. The amount of information necessary to describe the behaviour of such a system is a measure of its complexity (Bar-Yam, 1997).

We can yet compute a complex system to be “an ensemble of many elements which are interacting in a disordered way resulting in robust organization and memory” (Ladyman, Lambert and Wiesner, 2011). Quantum systems are systems that interact with their environment; they are characterized by “these interactions and properties of the environment” (Semin and Petruccione, 2020). This implies that quantum systems are open systems. Open systems are to be contrasted with isolated and closed systems, for the open systems exchange energy and matter, while the closed ones exchange only energy, and in the isolated ones, there is no exchange (this is actually in an idealistic reality). With this said, when it comes to computing the total energy, the Hamiltonian, of the system, the open system, it becomes an arduous task; this is because the arena of experimentation is not controlled. This means that we might not really be able to determine the next flow or net exchange of the materials involved, which leaves us, at best, with a not-too-fair approximation of the total energy. Therefore, to overcome this challenge, the need to close the system arises. It should be recalled that the system being considered here is the dissipative open system. In trying to compute this, we

must include the details of the processes responsible for dissipation: thus, the total Hamiltonian must describe the system, the bath and the system-bath interaction. It turns out that the canonical commutation relations (CCR) are not preserved by time evolution due to damping terms. By including the bath, one “closes” the system in order to recover the canonical formalism, and one realizes that the role of fluctuating forces is, in fact, one of preserving the canonical structure of the CCR (Blasone, Jizba and Vitiello, 2011).

Yet, this might prove to be still arduous, as “the knowledge of the details of the processes inducing the dissipation may not always be achievable” (Blasone, Jizba and Vitiello, 2011); thus, what is done is that the degrees of freedom are doubled to attain to the requisite closure; eventually to do this, will imply that a mirror image of the system under consideration is created, which “behaves as a reservoir” (Blasone, Jizba and Vitiello, 2011).

QBD has been advanced by the findings of K. Pribram, K. Yasue, M. Jibu, G.G. Globus, etc., but such advancement came on the heels of a proposal arrived at by H. Umezawa, who saw it needful to apply the findings of Quantum Field Theory QFT, to the brain and all that pertains to it, especially consciousness. It can be stated that the emergence of QBD arises from the application of QFT to biological processes. This is because the brain is a biological organism that plays host to evolution in its functions and operations. Biological processes are mainly, at (their) base(s), biochemical, and at a deeper level, the laws of quantum physics still come into play. Currently, many “solid” physicists look at quantum physics with the eyes of “solid state physics”, and this is still the dominant thought. But the rule is simple: any equation which includes the Planck constant is a quantum physics equation. Looked at this way, photochemical reactions, electron transfer and ion interaction, getting a suntan, photosynthesis, the sense of sight and the breakdown of DNA under ultraviolet light are all unquestionably quantum physical reactions. But even if these equations and the Planck constant appear in school books, it is not emphasized that these are “photochemical quantum equations”. Most recently, with the

advancement of research on photosynthesis, on magnetic direction finding in animals (magnetoception<sup>7</sup>) and on the sense of smell, quantum biology has become an accepted subject (Tarlaci and Pregnotato, 2016).

We can denote QBD to be the adaptation of the findings of QFT to the brain as an expected hypothesis that can and will be used to “describe the mechanism of memory in the brain” (Nishiyama, 2019). For memory to be described, it means that consciousness must be contained, necessarily in that description. Again, we should add that QBD is quantum electrodynamics (QED) of the dipole field with symmetry under the dipole rotation (Jibu and Yasue, 2004).

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<sup>7</sup> Magnetoception or magnetoreception refers to the ability of living things to sense direction, height and their position by the use of a magnetic field. It was first shown in 1966 in a study of European Robins that on the evidence of behaviour certain animals use the Earth's magnetic field to move over long or short distances, (W. Wiltschko – F.W. Merkel, *Orientierung zugunruhiger Rotkehlchen im statischen Magnetfeld* in *Verh. dt. zool. Ges.* 59, 1966, 362–367).

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