Applying Quantum concepts to systems theory

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Abstract

System theory originated in the interaction between the observer and the observed system, which was evidenced by the quantum theory. The concept of quantum of action may be applied to flows between systems when it is considered useful. Then interaction flows are discrete, identity of systems is discontinuous and deeds of knowledge do account. The interplay between the instrument of measurement and the observed system may show their real and imaginary parts. Eventually, the quantum of action puts into evidence the factor which makes systems to exist, this factor grounds the intension factor to be distinguished of intentionality; this factor is exemplified in the political will which is founding a project. This may be used to define quality as the rapport between purpose and activity and then to define dynamism in a rigorous way.

Key-words: quantum, action, identity, dynamism, cohesion

Introduction

When one is observing a physical system with a corpuscle device, the system replies in a corpuscular way, when it is observed as a wave, it replies as a wave. This interaction between the protocol of experiment and the observed system puzzled many great minds and Niels Bohr created in 1927 the interpretation of Copenhagen. Soon philosophers developed this theme and the systems theory originated in this interaction: the object is not any more invariant in the process of measurement.
Quantum Mechanics (QM) –on broader scale quantum physics - is one of the more accurate theories, as it is accurate up to the seventh decimal. In our usual life and in usual systems, it is very seldom to get over a third decimal precision (0.1 %), so there is no need to use the quantum of action - an indivisible unit. However in some cases, an indivisible unit can be seen operating. It is the case with decisions, with political polls as François Dubois explains it, and in the deed of knowledge. One can know something or one does not, it is an elementary unit. Thus applying quantum concepts may be fruitful in some fields such as decision and knowledge.

1. Quantification

1.1 Conversing the concept of quantum of action

The fundamental unit at the basis of quantum physics is the quantum of action. Quantum means that it is an indivisible unit; it is like a pixel or a step, one can't make half a step, one may be able to make a smaller one, yet is a step. Thus the notion of quantum may apply to any cycle – unit in time - or

any form –unit in space.
This indivisible unit composes a grandeur called action. Action is an abstract grandeur in physics as it is not energy nor impulse but the product of an energy with time, describing the effect of energy during a period of time, or the effect of an impulse (mass and speed) along a distance; physical action has the dimension of an angular momentum = the inertia of some turning object. However the physical grandeur of an action is the abstraction of the usual meaning of action, to act on a object means to apply to this object some process making it change or not. One finds the same meaning of action in math: it is an external application on a set giving an image in the same set.

1.2 First move: making the flows discrete

Soon around 1927, physicists began to quantize the classical theory replacing classical variables with quantic operators: the observed "grandeurs" such as position, impulse, were replaced by probability of observing eigen values of these grandeurs, the probability playing more or less the role of a wave.
According the fractaquantic hypothesis [Dubois02], an indivisible unit may be perceived at any scale and quantic axioms presented in [Cohen77] may apply to systems. The first condition for this application is to have discrete flows of interactions. In systemic modeling, it is usually the case, though it may not be thought upon; flows of orders, products, invoices, are made of small "packets" i.e. they are discrete. However in influential systemic diagrams – showing positive and negative feedbacks – the fact that the changes are discrete is often forgotten or neglected.

1.3 Quantization of variables or observables

Another condition for a system quantic theory is that any grandeur is known by an interaction, because the very deed of measurement is an interaction and may alter the system.
Quantum mechanics describes a system as a vector in a space of states and the measurement of a grandeur puts the system in an eigenvector, the eigen value is then the observed value of the grandeur.
Operator System = value System
If the result of the operation on the system was another system - another state - then one could not define this transition Operator System = scalar AnotherSystem.
as there is no way to compare the new system with the other one. To say it otherwise, any knowledge on a system results from an interaction with it and thus assumes an action and some kind of invariance.

A classical - non quantic - theory can be described with operators and it is not a sufficient condition, however this condition is necessary.

2. Any action is counting

2.1 Variance under observation

In a classical theory the object does not vary under the observation. A car is red whether it is seen or not, a train going in a tunnel does exist though it can't be seen any more. The impact of the observation can be neglected in front of the massive object. It is not any more the case in quantum theory.

The observation is an action and indeed alters the observed system. Quantum paradigm means that our knowledge is composed of indivisible units - as pixels in a picture - and that we do not want to go inside a pixel, we want to know any action, any knowledge we get on the system as it may disturb it. To take into account what we do for acquiring knowledge on something is a very costly process. Usually the system is stable under our observation and usually we don't need to have such a strict observation of ourselves as knower.

2.2 Commuting observables

Any property of a system is known through an interaction, no property is given as such, without a deed of measurement. In Physics these possibly observed properties are called observables. Some properties or variables are independent, one may measure them without disturbing another property and there fore these observables are commuting.
Such is the case with position, in a frame Oxyz the measure along one axis does not disturb another one.
One may compose a complete grid of observation with independent variables, and get a set which describes completely a system. Such a set is called a Complete Set of Observable Grandeurs. Obviously it is an achievement to get a complete set of observable grandeurs, it would be nice to describe completely a biological cell, a company. In color description, red, blue and green are composing such a complete set; in quality management, dynamism, cohesion and adaptation compose too such a complete set.

2.3 Anticommuting observables

The characteristic equation of quantum mechanics is that some observables are not commuting they are said to anticommute. It is the case for the wave and corpuscle description, inducing a non-permutation between position and impulse. To summarize, position is describing a corpuscle while impulse describes the wavelength and direction of a wave. Thus two complementary views may work but they can't operate at the same time, a view is blurring and thus disturbing what has been achieved with the complementary view.
This can be perceived in many systems though such accuracy is seldom needed.
Management and production are complementary views: everyone knows that management requires actions which are slowing down the process of production, it is a general balance and not yet a quantic effect as no indivisible unit of action is taken into account. Yet at some times, the perception or not of a feature, the knowledge or not of a fact may bring about a decision or another. And a worker can't at the same time (in the same action) observe the result – along the management axis - and implement the process – along the production axis.

In colors, the additive frame Red, Blue, Green is complementary of the subtractive frame Cyan, Magenta, Yellow; one frame is used on screens and in theaters, the other one is used by printers, the first frame puts light in a dull background, the second frame describes the light reflected by a support.
In quality field, the frame Dynamism, Cohesion, Adaptation is complementary to the frame Openness, Optimization, Harmonization; the first frame applies to the political will, the second view applies to the qualities reflected in the

structure.
About social opinion, polls show that the position is complementary of publishing that poll, as the positions change as soon as a poll is published.

2.4 Identity is an action
Two complementary grandeurs anticommute and their result puts into evidence the identity of the system.
The characteristic equation of quantum mechanics is

Impulse Position – Position Impulse = iH Identity

H is the Planck's constant, appropriate to the quantum field, and the imaginary number i will be explained and developed in the following paragraph.
The above equation concerns operators and these operators do apply to systems. The equation means that if one measures the position of the system then its impulse, one makes the difference with the measurement of the impulse then the position, and that difference is equal to the system – its identity.
Identity requires an action; in quantum physics identity can't be given at the start, it has to be observed. That's one conclusion that this equation is offering to us.
It shows that identity is not continuous. It is obvious when considering a wave as this wave has a period, a picture has a definition where pixels appear.
General systems also require an action to have an identity. A company needs to assert itself and it is doing it through the many printing of its logo on the papers, in any connection with a customer. It is obvious with well-known companies, and it is also obvious at the creation of a company. Biological systems maintain their identity through immunity. According to Wilhelm Reich, a shape is a frozen movement and a cycle of this movement is drawing that shape.
Yet as many dots compose a seemingly continuous line, the various cycles of identity may be registered as a flow or a line of life.

3. Permutation between the instrument and the observed system

3.1 Contra variant and covariant

Systemic theory, more precisely systemic modeling, has been criticized as it is describing the present behavior but it does not put into light the forces of that behavior. Moreover, the model appears as a result without describing the interaction with the author of that model. Thus the systemic model has the advantage to describe a smooth and not static functioning, however there is no change in the structure, as the model is closed and fixed once for all. The observer or builder of the model remains out of it.
So it is most useful to observe the interaction Instrument-Observed system, as this interaction lies at the origin of Quantum Mechanics.
The difference between the instrument and of the object appears clearly when the instrument moves or is submitted to change: one is covariant in the change – it does vary conformably, the object is contra variant – it does vary in the reverse order of the change.
Let us begin by an example. Let us imagine a car moving in the night. When the car turns to the right, the headlights are turning to the right, while the

countryside – trees, road-signs - appear to turn to the left, in the opposite way, while everything in the car - and the view of the passenger - moves with the car and turns to the right in this example.
The object moves adversely to the reference frame: the measure instrument.
Etymologically, object comes from the Latin "ob-jectum" thrown to the front or against the throw.
In general rule, what is observed is contra variant, what is relative to the instrument –to the subject - is covariant

3.2 Measure Real and Imaginary parts

A measured object can be used to measure other objects or even the previous instrument. In this permutation of functions, the contra- variant becomes covariant and conversely. Quantum Mechanics formalism describes very precisely this permutation:

$$< \text{Instrument} \mid \text{Object} > = \overline{< \text{Object} \mid \text{Instrument}>}$$

The bar over the expression means the complex conjugate, the real part remains invariant, while the imaginary part takes the opposite sign. From this equality, one may infer

$$\text{Real part} = \tfrac{1}{2} (< \text{Instrument} \mid \text{Object} > + <\text{Object} \mid \text{Instrument} >)$$
$$\text{Imaginary part} = \tfrac{1}{2} (< \text{Instrument} \mid \text{Object} > - <\text{Object} \mid \text{Instrument} >)$$

This means that what is real is constant if one permutes the object and the instrument. In other words, reality does not depend on the point of view.
It is easy to understand in psychology: what is real is shared by both actors and what is not shared by both is imaginary. If I move toward a partner, and he (she) sees me moving toward him (her), this coming closer is real. If an approach is perceived as getting away, the interaction lies on imagination or fantasy.

QM is using for measurement a form which is linear on the right member and antilinear on the left member. The right member is contra variant, it represents the object, the left member is covariant and represent the instrument of measurement; antilinear means that a complex number gives its complex conjugate.
With the real numbers a, b, c, d

$$<(a +ib) \text{ Instrument} \mid (c+ id) \text{ Object} > = \overline{(a+ib)} (c+id) < \text{Instrument} \mid \text{Object} >$$
$$= (a –ib) (c+id) < \text{Instrument} \mid \text{Object} >$$

Now one may apply an operation on the object. This is very usual as any knowledge is acquired through an operation – it may be looking at it through a microscope or through glasses, or to put it on scales …
If one applies an operation on the object, it is equivalent to apply a conjugate operation on the instrument.

$$< \text{Instrument} \mid (\text{Operation} \mid \text{Object}) > = < (\text{Instrument} \mid \text{Operator*}) \mid \text{Object} >$$

The existence of these conjugate operations shows that it is a real interaction.

3.3 Simplified application on values

We shall now apply this form on the values themselves of the observables whereas QM uses this form on probabilities. Thus the examples here are outside of QM.

For example, if the object is moved toward the instrument of 2meters, it gives the same result than if the instrument is moved toward the object of 2meters; this is mere relativity.

Now if we divide the unit of measure by 2 – in the instrument - the object will have twice the previous value.

Let us assume a company and an audit and let us assume that a grid of qualitative observation is made by three axes: Dynamism, Cohesion, Adaptation [Chaumette06]

The audit evaluates the cohesion of the company to 50%, it is expected that taking one's own company for the unit of measure, the audit system appears as twice as cohesive as the company, therefore 2 units.

Let us assume now that the company is evaluated as 80% dynamism, while the company evaluates the dynamism of the auditors as 1.4 % - and not 5/4 the reverse of 4/5 – there is thus a discrepancy.

If the product of the both numbers X = 0.8 and Y = 1.4 is greater than 1, then the relative results of this mutual measurement are XY = 1.12

$x = X / \sqrt{XY} = 0.8 / \sqrt{1.12}$ $y = Y / \sqrt{XY} = 1.4 / \sqrt{1.12}$, we have $\sqrt{1.12} = 1.058$

The real part of this mutual measurement is cosine $\theta = 1/ \sqrt{XY}$ while the imaginary part is sinus θ. In this example, cosine $\theta = 0.945$ and sinus $\theta = 0.327$

The figures here are only given for completing the argument.

If the product of both numbers XY is lesser than 1, then the real part is equal to the square root of this product. Indeed if the product XY is equal to 1, then the imaginary part is null.

This is an easy example, it may help to understand the permutation of the instrument of measure with the object; here QM formalism has been used but not in the right way.

3.4 Correct application with probabilities

We used the form <Instrument │ Object > on values of observations, whereas QM is using the same formalism of measure on amplitudes of probability. It means that the formula gives not the value itself, but the probability of getting an expected value – an eigen value as it has been said above. The amplitude of probability is a complex number while the probability is the modulus of this amplitude.

If one want to apply QM formalism to an audit of a company, one has to take into account the probability that an auditor observes an event, the event has to take place at the right time and place when the auditor is there. So are appearing the probability of an event and the probability that the instrument – the auditor - is there; and this shows clearly how much do matter the interaction between both.

In most companies, the quantum paradigm is not necessary, for the searched for event leaves a trace in the data, and the data system makes the system stable, it does not change under observation. However, in biological systems or social systems, there may not be data to keep trace of what happened, and the observation may alter the evolving system.

4. In-tension (inner tension)

4.1 Creation and annihilation of particles

Quantum physics put in evidence that particles could be created and annihilated. This is a concrete consequence that identity is an action. A particle requires an action - a tiny cycle – to exist.
One may infer that a factor ensures the existence of an object and it has been called in-tension. One may imagine a fiber or a string within the object and this string is submitted to a tension. Thus was imagined the first string in the 1980's, the Dirac's string of electrons.

4.2 In-tension definition of Quality: purpose and activity

With the fractaquantum hypothesis [Dubois 02], the factor of existence and the inner tension does not exist only for atoms or indivisible units at the lowest level, the same concept applies to upper levels: to any form.
The intension is suggesting a new definition of quality: the rapport between purpose and activity [Chaumette 06].
Purpose is that why that system does exist, why it is created if it is an artifact. For example, a project does exist following the will of several partners, though the real purpose or deciding motive might not be clearly visible at the beginning.

Dynamism might be defined as the frequency of renewal of the existence, and it is obviously related to the tension which is founding the existence of this unit. In the atomic realm, the frequency of a particle is proportional to its energy through the formula

Energy = H Frequency

In other words, dynamism is the closeness of the link to the purpose.

To have a precise definition of dynamism is most useful at a time when phenomenology is talking about life. In its own way, it is exploring the openness of consciousness - analogous to the sensitivity of the instrument - and through the act of perception it touches upon the existence or life of things.
Taking again the example of a project, the dynamism of a project is the closeness of its purpose, the way that actions are related to the Why of this project. This purpose may be motivated by some values and a representation of values based on the chromatic circle has been proposed in [Chaumette06].
Dynamism might not be only a renewal or an impulse but it may also contain an "inner" direction, i.e. the selected values.

The indivisible unit of action is founding the existence, and one may visualize it as a pulsation in space-time, creating a form. A cycle is a unit in time, while a form is a unit in space. Dynamism is related to renewal, therefore to time, while cohesion is related to space. A heartbeat describes the frequency while a pixel describes the impact in space of the indivisible action.
One may thus define cohesion as the impact in space of the inner tension. In other words cohesion is the *rayon d'action* – outreach in English - of the founding factor, the field delimitated by the inner tension.

Cohesion is usually described as a strong connection between several parts of the whole, here cohesion has been described as the existence of the whole. The link between both aspects is indeed delicate though Blaise Pascal wrote "Je tiens pour impossible de connaître le tout sans connaître les parties et de connaître les parties sans connaître le tout" [I take for impossible to know the whole without knowing the parts and to know the parts without knowing the whole]. This quotation seems to say that both aspects -from the parts and from the whole -are complementary.

5. Perspectives

As we have seen the first perspective is to study cohesion i.e. the gathering of components into a whole.
A grid of qualitative observation has been described with 3 axes: dynamism, cohesion and adaptation. The last axis describes the link with the environment –the outer world, as phenomenologist would say - and it is the most known factor of systemic theory. Adaptation is based on interaction and an interaction is brought into existence through one factor, its intension. The question which remains is to sum up the many local interactions into one global interaction, hence to sum up the many factors which bring into existence this unit.

In order to apply quantum concepts to the theory of systems, we have seen that

- flows must be discrete
- any observation – deed of perception or measurement - has to be taken into account
- identity requires an action

Moreover, we have seen that the description of the modeler within the model is relevant. The probability to observe a phenomenon or a fact appears when the deed of perception is taken into account.
There exists a property in Quantum Mechanics which has not been used. Any particle is described with a spin, i.e. an intrinsic angular momentum. What could be the correspondence in a general system? An intrinsic angular momentum in a company could be a strategic direction, however this is an vague idea and it is has to be studied.
As has been said in the beginning, quantum paradigm appeared in physics when the accuracy was great – about the seventh decimal – our knowledge of systems is far lesser, however some indivisible units appear, specially when decisions or cycles do matter.

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