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The Invisible Reality of Quantum Mechanics
The Deterministic Perspective

A.V. Herrebrugh MScEE

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Abstract

The fundamental nature of quantum mechanics (QM) has been mathematically demonstrated in [17] to be *inconsistent* with it's *indeterministic* results. Indirect[1], commutative mathematics and integral transformations contradict probabilistic results with exact functions and demonstrates *determinism* in a quantum system - hence, this paper is written from a deterministic perspective (DP) in quantum mechanics.
Quanta cannot be observed in their original state and are literally invisible, while mathematical descriptions of physical phenomena are historically built for observables.
After a brief historic perspective, 'invisables' i.e. invisible entities of reality in mathematical treatment, are introduced. These entities can be handled by mathematics *in*directly i.e. are described in the transformed domain without variables violating the Heisenberg relation. The consequence is that direct (incl. if existing: hidden) variables theories of counterpart mathematics are *un*suitable for descriptions of the reality of individual invisables.
In nature, i.e. on micro and macro level, *causality* is fully 'entangled' with *information* in the meaning of ordered/coded energy. In contrast with the macro scale with many forms and types of memory functions, *without* a memory property of quanta, on the quantum scale, causality is the bearer of *information-symmetry*[2]: in a causal relation, the effect function includes all information of the cause function i.e. the last attained quantum states include all information of the causing states.
Furtheron in this DP paper: mathematical and philosophical consequences and influences in several paragraphs, regarding subjects such as 'free will' and expected 'threats to science', the Bell inequalities, Alice and Bob & entanglement, causality, information, retro-causality, spooky action, encryption and computing, teleportation, and in general interpretations rooted in indeterminacy in QM as well as associated topics on independence, fine tuning and interference – with the notion that this selection does not pretend completeness and calls for extensions from a deterministic perspective – in case *not* fitting as well - to test this DP proposal.
The last paragraph outlines the mathematical treatment of QM more extensively and may clarify references to the above mentioned topics of discussion in QM further.
The aim of the paper is clarification whether deterministic QM is viable i.e. whether any statefunction Ψ can be deterministic in the end; the paper is written with a minimum use of

1 Indirect in the meaning of frequency domain transformation, in general avoiding variables addressing individual quanta.
2 Emerges in literature as well as 'time reversibility invariance' i.e. associated with time reversal, not meant in this paper or [17]..

mathematics for accessibility and readability (for the mathematics see [17]).

Introduction

QM has been built on a complex orthogonal vector space of n dimensions i.e. the Hilbert space, in which states of a quantum system are represented by complex vectors. Together with the use of linear algebra and matrix mechanics, this has been the mathematical basis for the theory to date – c*ausality* appeared in discussions usually afterwards.
Physical reality in nature is the result of interactions leading to change, based upon energy transferred in the interactions[3], also when seemingly spontaneously happening on a scale one cannot observe at all, meaning that in nature, changes occur by causality on *all scales* i.e. in DP.

Cause and effect relations of interactions are in the roots of nature and therefore should be fundamentally incorporated by a mathematical causality description. In that case, a state-function Ψ(r, t) as the local evolving (discrete) function in spacetime for the quantum system, is the true *bearer* of the causality relations. In a system-theoretical model, the mathematical condition is that a(ny) spacetime causal relation can be described by integrable functions of the cause leading to the effect with commutative acting mathematical operators.
Causal relations in the state-function thus actually represent a key element in QM (nature) and knowledge about the relations and interactions creates further and deeper understanding of quantum behaviour (cognitive, epistemic).

Observation of objects by natural means is by a form of radiation i.e. photons (sight) and e.g. by man-made radar as well as tiny mass particles in electron microscopes, and an ‘observation’ or ‘measurement’ requires a tiny amount of energy of the object. This information-energy cannot be taken from quanta without changing their original state and state-function and is stated here as: ‘a *measurement of a quantum mechanical invisable yields an observable’*, indicating that an energy transformation takes place.
Eigenvalues are the vector space solution values of the state-function using matrix mechanics and linear algebra. As argued, without a collapse of a quantum state in an operation requiring information energy of the quanta, the values cannot be revealed by counterpart operators and therefore the resulting eigenvalues that are being revealed, are associated with transformations of invisables in *observable* states: i.e. due to the usual mathematical approach with variables addressing objects representing the *observed* state, the statefunction is *imposed* to use collapsed values instead of exact values.

1. Looking back

A key starting point in quantum mechanics was formulated e.g. by von Neumann on the mathematical treatment of quanta, and states that
‘*a measurement of a quantum mechanical observable yields an eigenvalue’* [3].
The ontological entities of reality or as Einstein [10] and Bell [9] named them the elements of reality and the (may-) be-ables, were initially all considered to be observables, and in principle could be measured/observed ánd mathematically described, and as such they were embedded in

3 Inter-reactive internal energy, and/or external energy

physics, or as A. Einstein formulated: ‘every element of the physical reality must have a counterpart in the [mathematics of][4] physical theory’.
This statement, explicitly taken up in the EPR paper [10], is valid, however not complete as it addresses quantum elements of reality with*out* the energy transfers and related operations in reality performed on them: a quantum transfers into an observable only by energy transforms. In fact, and with mathematics of observables only, *information* was not regarded to influence any objects *o*f study at all.

The state-function Ψ(r, t) is entirely determined by the manipulation of the quanta, be it in a slit-experiment, computational gate operation in a quantum computer or in a discrete change of energy level e.g. exitation in an atomic grid.
Moving on to linear algebra and the complex vector space matrix mechanics, obviously the solutions of the vector space mathematics are complex state vectors, which are considered as images of all states the state-function in spacetime can evolve into, and may include all space-vector superpositions possible – and this actually concluded the mathematics of matrix mechanics involved and yields eigenvalue results, which are as close as we can get *this* way to the exact solution. Superpositions of states (Dirac, [1]) also included partial states and mixed states and were facilitating probability interpretations of the theory.

Without knowledge even of determinism in the heart of QM, Einstein, Podolsky and Rosen [10] at the time actually had valid reasons to reject QM for not being a complete theory, and supported this conviction with the tools available*:* the definition of completeness of a theory, the mathematics of observables, and thought experiments. The queste started in 1935 and created a lengthy debate with tons of paper literature in interpretations and philosophy.
The meaning of the complex state-vector solutions in matrix mechanics of states of quanta was at the time *interpreted* by Born [4] and was generally accepted literally ‘*sine qua non*’ as a completing part of the mathematical solution - with lasting consequences for QM indeterminacy, being poured in concrete instead of being regarded as a human interpretation a posteriori, as Born himself might have realised, because it meant ‘a priori’ *negation of causality* on the quantum level of nature itself.

Even so, with a probability interpretation, quantum theory remained successful in applications, however since its conception not fully understood nor fully supported by the applied mathematics by yielding probabilities in a statistical result, and it remained unclear since then why this should be the case (e.g. R. Feynman [6], and many others).

2. Reality & Mathematics

In the DP of slit experiments, the final quantum states remain invisible after manipulation in the slit and do not change without cause i.e. are not in undefined state but remain invisible in an attained state, until detection of the quanta, when transformation into observables is manifest and e.g. in slit experiments, the ‘patterns’ are visible. This reveals behaviour of a class of entities that may be described only indirectly by mathematics. Operations c.q. operators directly applied to these invisables result in state changes i.e. partial or complete loss of the original state or property(ies) i.e. energy transformation, known as the Copenhagen ‘collapse’ of the states with related values in the ‘collapsed’ state-function.

4 Authors addition.

To move forward in mathematical treatment ánd to comply with an adapted EPR statement of the relation between reality and theory, a first step in this direction is to extend the entities of reality with an additional class next to the class of observables, e.g. the class of invisible entities of reality or beables, the '*invisables*' as opposed to observables. Invisables thus are defined as entities of reality that cannot be observed or measured without significant change of their energy or properties. The classes of entities are to be mutually exclusive, i.e. when an entity is part of one class, by definition it cannot be part of the other class.
As information is a coded or ordered form of energy[5], observables can be measured by neglecting the energy it takes to acquire the information of physical properties or state, i.e. can be 'observed' and described directly by counterpart mathematics. This is not the case for quanta, as the information energy is in the same order of magnitude of quantum energy and consequently, drawing information directly from quanta results in state changes. There is no way to overcome this problem and to *invent new mathematics* e.g. with hidden variables accounting for the changes of energy, as we are stuck immediately in case there is no knowledge about what *exactly* happens e.g. in energy transformations. In comparison, in the virtual reality of mathematics, transformations impose the requirements for *mathematical* functions[6] describing causality by integrability over the time of interaction and can provide descriptions with variables without violating the Heisenberg relation – this is the point where system-theory [13, 14] enters the stage.

The separation thus is proposed as the entities have different properties, i.e. satisfy different conditions in physical reality, and serves as well to separate invisables from observables in mathematical treatment, as by definition there is no intersection in the sets of classes.
A further distinction, is in internal and external energy of an invisable. The internal part are the *degrees of freedom*; the total energy becomes manifest in e.g. transformations. In line, physical operations on/with quanta are distinguished in an external and internal part as well, with related counterparts of internal and external operators acting on internal and external energy states of e.g. photons and electrons.

Invisables can have internal operators that affect their internal physical state; the energy required is provided by the local environment in an inter-(re-)active process with the invisable, and the total energy balance of the process is zero i.e. these processes contain phases of positive and negative (local) energy exchange (interaction) that do not require external energy.
These processes are in the core of a state function Ψ and *cannot be observed*, and require a thought experiment e.g.: invisables leave tracks, as their inter-reactive speed with the direct environment is limited by c, therefore requires time and causes delays e.g. by (rotational) polarization changes, and in case of momentum changes, their trajectories are adapted i.e. when the inter-reactive processes effectively are taking place, they are in general slowing down the *propagation of quantum energy* – this can be (has been) measured – i.e. the *signature* of the invisible activity of internal operators.

An example of the foregoing is the propagation of a photon in a glassfibre used for transmission, known for delivering internet superspeeds. As the (assumed otherwise ideal) fibre is no-where ideally straight, the polarization and momentum of the photon are forced to adapt inter-reactively in the glass grid (amorphous) atom structure within boundary conditions of e.g. core and cladding (to confine the photon in the core); and the delay caused by the interactions can be measured (and

5 With the *potential* to reduce uncertainty
6 Analogue or digital e.g. stepfunctions i.e. 'Stossvorgänge'.

treated in e.g. a dielectric constant); delay can be measured as well for (macro manifest) charge current values e.g. in copper based cables with dielectrics i.e. inter-reactive with construction (e.g. sheathing, shaping) materials.

Entities of reality are well known - both observables and invisables are ubiquitous around us – and given that the entire framework of mathematics used in physics by definition is built on observables by associating numbers (-series) represented by variables in algebraic equations in which all kinds of operators are active, one may conclude that mathematics were tailored to describe the reality of the *observable world* in abstractions.
Without a separation of invisables, and despite the assumed however questionable existence of ‘hidden’ variables, obviously persistent proposals have been made to somehow introduce the existence of hidden variables to explore quantum mechanics.

When external operators on invisables produce transformed energy values, this implies that the only way to observe or measure an invisable is by imposing such an operator whereby the invisable becomes visible; exactly this happens in detection e.g. our retina, at the cost of its original state: it transforms into an observable form of energy, from then on to be processed and possibly stored as: information.

One of the examples of transformation, ubiquitously around us nowadays, are the (man-made) photons of e,m-radiation in the frequency bands of 2.4 and 5 GHz used to connect our smartphones - and everything else - with a wifi network, showing once more that QM actually is only one step away from everyday life.
The photons interact in accordance with the Copenhagen ‘collapse’ of their state-functions with e.g. metallic antennas and electrical charge is manifest in electrical voltage and current in the antennas, i.e. the macro detectable energy transformations. In terms of physics, the momentum/energy of the photons transforms, the Heisenberg relation is violated and loses validity as the exact location and momentum of the photon at the antenna at this point are revealed. The photon disappears and a current of charged particles is manifest in the antenna.
This is a system-theoretical approach and it remains unclear what actually happens in the transformation of photon energy[7]; one cannot observe it and to date, we can only apply thought-experiments that fit with observable side-effects and boundary conditions as e.g. in high energy physics experiments.

3. Local Causality & Information

Looking back it is remarkable to observe that causality as a fundamental property of nature, never took a prominent part in the mathematical QM descriptions and has not been directly related to information, although causality has an extensive presence in the discussions in physics and philosophy.
Causality and the notion ‘in absence of a cause no changes’, is an axiom in nature i.e., as Gödel [Thesis, 1931] pointed out in his incompleteness theorems that in an axiomatic theory, the system mathematics cannot prove consistency in physics (i.e. mathematical descriptions of nature).

7 The thought experiment: The photon interacts with the atomic grid, transfers its energy fully and vanishes; the atoms deliver it instantaneously as kinetic energy to the electrons. The electrons can move relatively free in the metallic structure due to overlapping energy levels and cause a current of electrons i.e. each photon causes $h\nu = ½\, m_e v_e^2$. i.e. much in same sense as the fotoelectric effect, however below the threshold frequency. This then would be a mathematical description of photon energy transfer from the thought experiment. But what happens exactly in the atom in the energy transfer?

However it can be made plausible e.g. for quanta with mass: when e.g. considering energy levels in mK near 0 K, where hardly interaction is expected, e.g. electrons may pair and cause superconductivity in specific materials i.e. at the tiniest scale and lowest temperatures, causality plays an *extremely* important role in nature. And on the much larger scale and higher temperatures, one may appreciate what photons of the sun cause on earth.
The ‘arrow of time’ in reality cannot be reversed for any physical process and causality does not support an adaptation of a result of a causal relation by going back in time to alter or otherwise influence the cause in the past, as causality is related to interactive state *changes*, as a location on a time axis i.e. ‘*in time’*, and one experiences the macro *results* of these changes on a daily basis in e.g. in many forms of memory e.g. own memories and all ‘things’ around us that were created in the past. *A(ny)* described result in quantum theory therefore becomes manifest in the macro world as a part of an event i.e. as result of a change in a ‘state of reality’ becoming the memory of the past.

Knowledge starts with collecting information – e.g. from observations and memory functions holding information - and associating this with other available information of internal and external sources; the associations are part of a processing function that e.g. in humans may trigger new thoughts, ideas and other associations e.g. the ‘aha erlebnis or eureka moment’ to gain knowledge and insight.
When realizing that all the ‘states of reality’ of the past around us cannot enhance our knowledge about the cause of *changes* when *information* of the causes leading to the states of reality is not available – e.g. in our macro environment: stories, pictures, written information or messages in text and symbols, digitized information on (internet-) computers, smartphones, tablets, as well as knowledge residing in individuals etc. i.e. somehow stored in a *memory function* – then, without knowledge of the cause it would be impossible to increase or enhance knowledge and move forward e.g. in science or daily life for that matter.

Causality and availability of information in a memory function create a condition sine qua non to describe, gain insight and increase knowledge about nature: they are literally ‘entangled’ in order to understand nature.

A process of understanding does not change fundamentally when the subject of interest changes, here from the macro world to the micro quantum world: to gain knowledge one needs to access information and *associate* this with other information. In our brains these are natural processes and in principle are causality relations of information processing functions and storage i.e. memory functions[8].
In philosofical sense, information is everything with the potential to reduce uncertainty and in nature, information is to be carried by energy[16] - in a ordered or coded form - to be able to pass on or transmit the information, e.g. DNA[9], content on the internet or radio communication.
The notion of this strong relation between causality and information in nature is paramount as it provides the link of processing- and memory-functions with causality being present as well on a *quantum scale*.
An example is that ‘non-locality’ descriptions of e.g. *entangled* and again *separated* photons are to *include* information-energy: when the information (entanglement) is present (see §8), non-local causality is a fact and proven in experiments; when the information is not available, photons may or

8 And possibly as well ‘noise’ in the sense of random and random-biased associations.

9 Nature teaches that new forms in nature develop by causal relations on micro (quantum, molecule) scale, and may live (‘best adapted’).

may not have a common cause i.e. don't have a traceable 'link' anymore or never had.
In the deterministic perspective (DP), the additional requirement of *information availability* is present as the attained and without causality unaltered states[10] *only are known c.q. can be predicted* when the information of entanglement is still present and not lost. Treatment of causality is then inevitably fully 'entangled' with information-energy, meaning that absence of information e.g. by destruction of the *ordering or coding of* energy, actually *is the change*, *without* any physical changes anymore of the concerned quanta, as the information resided elsewhere and does not exist anymore, and the states of (once entangled) quanta are *unrelated* from that point on.
Vice versa, when a physical change occurs, e.g. assuming that one of the photons enters a black hole, the information of past entanglement is *not* destroyed and available i.e. one still can retrieve the original state after the object vanished – i.e. identical as in information (-functions) e.g. pictures, replica in the macro world regarding e.g. destroyed or eroded objects.
The foregoing means that *no interaction* i.e. *no spooky action* is required between the separated quanta, which is impossible anyway when e.g. one is captured by a black hole. A proposed action to signal the other quantum cannot even be initiated when captured, as nothing escapes a lurking black hole. In a generalized way of assuming signaling (thus as well assuming v > c), therefore excludes signaling of eavesdropping in encryptions with entangled pairs when a change occurs in one of the quanta.
If knowledge does not persist in a memory or the memory function is non-existing, the information on entanglement is lost and probability predictions of the states are down from 100% *with* information to 50% *without* information of entanglement (see §8) i.e. the absence of information changes our predictions, but not the results i.e. states of the quanta.
Obviously, when results are presented in *probabilities* (Born) as mathematical outcome, the foregoing reasoning stays the same, however the changes will *never* be detected in the already statistical 'result' without *exact* values, and interpretations become paramount.

In the description of causality on the smallest scale thus the intense relation in causality & information is present as well, however must differ in terms of memory-function because in contrast to fysicists or experimenters with (or access to) memory as creators of an entanglement, individual quanta do not have a memory property ánd one cannot observe what happens with the information! (see §2, §7).
The consequence is that the change and/or transformation in a causality description *inherently* must contain information of the cause in the result to transfer or pass on information *in nature* and i.e. in principle including a minimum amount of an *ordered form of energy* serving as the memory *function*[11] . This is where *information-symmetry*[12] on quantum scale enters the stage.
In manipulations of quanta, therefore the information memory is *embedded* in the result functions i.e. in the re-distribution or any *order creation in the energy* in timespace: the information.

A consequence is that the mathematical description of causality *mandatory is commutative* i.e. the information in the result is to be exact and good to reconstruct the cause (input and system in systems-theory), which does *not* relate to a time reversibility in physical processes but is an information-energy symmetry in causal relations of nature.

10 And after separation of the once entangled quanta
11 The phenomenon of information symmetry with quanta in causal relations is the *very basis* of information-transmission technology.
12 Bell: local commutativity → forward and backward in time → 't Hooft: time reversibility invariance → here: Information symmetry.

Indeed, it requires *information availability* in *memory functions* ánd *processing functions*[13] as argued at the tiniest scale in nature, and as well in daily life that together *may* reduce our ignorance – nature has given humans in principle both functions.

Because of the information symmetry in causality, one should be able to reconstruct information in the cause functions from the result functions throughout quantum operations/manipulations *for all macro observable results* as well.

When the causality relations are embedded in the description of a system (i.e. *any operation* with quanta) by commutative operators, consequently *non-commutative operators* in the treatment distroy a causality relation in information symmetry: mathematically there is *no way* to exactly reconstruct a cause (data-) function from a resulting correlation (data-) function i.e. the correlations are statistical functions showing statistical relations in probabilities that cannot reconstruct the exact mathematical functions, as data-points of input and output don't have an *un*ambiguous 1 to 1 relation. This means that correlations as part of causality descriptions, cannot yield the information carried in the cause functions by ambiguity and show ambiguous values (see §6).

The mathematical system-theoretical approach is built on causal functions that are the building (black-) boxes in the transformed domain where the boxes may be of biological, chemical, electrical, mechanical content or any mix of these, and are characterized by i/o relations: input & interaction(s) as cause and output (result) as effect.
A direct consequence is that operations c.q. counterpart operators that cannot comply with information symmetry thus are excluded *a priori* in causal system descriptions: in principle all mathematical operators that are not commutative, are corrupting causality by ambiguity and consequently all derived results c.q. interpretations and are not leading to exact results in QM.
It excludes e.g. use of cross (matrix) vector-products and cross correlations between functions or datasets of states i.e. a correlation operator cannot be used for descriptions of physical reality, although useful in statistical tests of outcomes of hypotheses. Even when hidden variables *would* exist and such theories *would* be valid[14], correlations used in the theory would destroy information-symmetry in the causality relations and show ambiguity.

4. Time & Retro-Causality

As adressed earlier, the arrow of time in reality cannot be reversed as in playing a recorded film backwards.
Reality is the spacetime environment where we are living in, and we can define and use a time axis for the location of a certain state of our universe in terms of events, fundamentally occurring as well at the smallest scale in causality.
Spacetime thus is a mathematical construction of 4 dimensions i.e. a model that one may use in mathematical descriptions [Minkowsky, 18]. In this mathematical concept, *time itself* is the axis of evolving *changes* in nature and may be defined in a reference frame of this entire evolving universe (i.e. nature, assumed to be a consistent – i.e. based on a consistent set of axioms – mathematically described system).

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13 Note the parallel with computers as information processing and memory equipment, hardware and software fully based on causality.

14 Hidden variables: a theory constructed for *local realism* assuming fundamental *in*determinism in QM. Is supposed to hold the information for measurement result and detector settings.

Each change of state in the evolving changes – starting at the tiniest scale – takes a new point i.e. a location on the time axis and throughout the universe, states of events may occupy the same point, as well in case events are unrelated in the universe. A clock is used to be able to measure in the coordinate, in the same sense as a measure in space coordinates, and is produced and adjusted in the local reference frame e.g. earth. This way the time axis i.e. ‘*time’* fits in a notion of a coordinated and 4-dimensional spacetime of locations on the coordinates to pinpoint results of causality in nature anywhere in the universe in spacetime.
Local reference frames i.e. in the universe static or moving with local events (planets, stars, black holes etc.) show local deformations in spacetime in accordance with Einsteins’ relativity theories. In observations, the local reference frame has to be defined as it has also to be included with the earth moving reference frame e.g. biasing the observations to be treated as separate (from the observed object) event.
Reality of a point in *spacetime* therewith are all locations that are not in the future, whereas the presence - on the time axis as a pivoting point of the light cones - is connecting past and future, sometimes referred to as local reality or local realism. The axis itself may be defined for the entire universe i.e. and *observation* of events treated as separated event, and is in principle independent of behaviour of a measuring device[15], calibrated in a local frame e.g. earth frame, with due to velocity and gravitational potentials observed *time* dilation and *space* deformations (curvature) in spacetime.

Although our notion of time is a dynamical one, one may see the reality pivoting point thus as a fixed point on an axis, by interpreting a collection of all events (in our universe) at the location of the presence, that become instantly the past. Each *point* in the local reference frame of *earth* spacetime obviously includes e.g. events we *were* not yet aware of (e.g. information of Hubble, James Webb observations) and as well events that we *are* not aware of and may be observed in the future, as well as events that we may never be aware of. It also means that only *local observations* as event are near the present[16], and most observations are not (yet) available and these observations *may* become part of the axis as observed events in the future.

Retro causality therefore is not making *any* sense by adressing influences on causes in a past, as e.g. all related information transfers (see §3) on (sub-)atomic scale, even including the *non-existing* i.e. not held in some memory function e.g. lost, destroyed, forgotten, erased etc. information[17] then would have to be included in decriptions in a local e.g. Hilbert space.
In nature i.e. in this universe there is only the future to influence, demonstrated as well by the enormous impact of human behaviour (and hopefully by climate activists’ demonstrations), and the reality of the past consists *only* of relics in the present i.e. the remainders of the reality states.

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15 As are space coordinates: there are no fundamental changes when measuring these in meters, inches, feet or yards and vice versa the measuring devices do not influence the coordinate system as defined and this includes measuring of time on the time axis. The evolving changes in nature are not in itself bound by a time related measuring device such as a clock. The behaviour of a measuring device i.e. clock is defined by the reference frame (RF) it is made for/in and does not influence other fundamentally evolving changes in the universe. So, the twin brother who became astronaut, left the earth and returned 20 years (earth time) later, discovers that he looks the *same age* as his twin brother, and he as well noticed that he got less presents celebrating his birthday e.g. only 15 times, just because he forgot to adjust his earth RF local clock. The same reason why gps satellites have local clocks (earth RF) that must be adjusted for a gps system to deliver correct results.

16 E.g. demonstrated by the time cones .

17 Implying that information (being energy), cannot be lost – false, but true for energy, not for the order or coding of energy. It occurs when a black hole absorbs information: the energy is not lost but re-arranged to fit properties of a black hole, and losing order or code.

5. The State-Function

The state-function, with both the vector-space and superposition, is the fundamental basis of quantum mechanics. This state-function is the mathematical counterpart of the QM causality relations in nature and describes the physical reality of quantum states occurrences in time.
It therefore may be regarded the function that defines the sets of the states in a vector space, representing the actual manipulation or operation occurring in a quantum system.
The state-function's values are represented by the values of the (complex) vectors, however when ignorant about the sets of vectors representing a manipulation exactly, obviously one cannot retrieve any exact information on behaviour (Δt) of a quantum system from a vector space. The key is in the state-function giving insight in evolvement of a quantum system.

If a state-function is a spacetime function supposed to hold information on variables e.g. location r and momentum p of invisables at the same time, the matrices representing both do not commute and yield a relation $rp – pr = i\hbar I_m$, i.e. a destruction of the causality relation because of the non-commutative matrix products.
This means that parts of the vector space don't (cannot) show the exact values when accessed for the actual *values* through *variables*: as no external operator is allowed for invisables, one cannot reveal the actual vectors of a state or derive these from equations with (hidden) variables with operators. Because of this, the acquired eigenvalues are values of collapsed states as the result of the operators in matrix mechanics & linear algebra, and are to be regarded as the limit of what we can attain in prediction of the result by this mathematical approach.

6. Bell's Inequalities

Invisables cannot be described directly by variables theories, and nature will show observables only, when using energy of invisables of transformations in i.e. collapsed values and prevents variables theories to describe the original quantum states in nature exactly.
We argue here that DP does not alter this equation, as one cannot access all required state values for variables on individual level at the same point in time.
What is clear, is that in a reality of collapsed values by use of variable theories, no exact values can be predicted as the variables cannot hold the exact information of individual quanta of both momentum ánd location - the violation of the Heisenberg relation.
Correlation indicates that values acquired from correlated data, are unrelated to e.g. the already probabilistic values (as result of manipulations in quantum systems), however these values are *all* typically *ambiguous* due to destructive non-commutative operators in the relations, and certainly not suitable for a reconstruction of the cause dataset from a resulting dataset.
In case a correlation e.g. between datasets of *results* of similar operations however, it is not excluded (possibly even plausible) that values may end up *closer* to a deterministic result i.e. obtained value(s) of a quantum system in a statistical comparison. With the ability to setup the experiments independently and with free will, it may increase accuracy of results by statistical treatment of many experiments' results i.e. identical with proceedings in high energy experiments.
When *all* 'loopholes'- if possible - have been closed in the experiments, measured values are to finally approach the deterministic values, with an accuracy depending on noise levels of measurement only.

7. Fine Tuning, Statistical Independence

The parameters in the slit-experiments may be adjusted by scientists fully exercising free will and to date a myriad of slit-experiments áll over the world performed in all different laboratories with physically different setups and components at all different times, are resulting in the same pattern types. This doesn't seem a conspiracy of fine tuners that may cheat us with all the independent results (not éven *with statistics* in the result functions).
The requirement is that experiments should be repeatable and when performed and setup with exactly the same parameters they should obviously demonstrate the same results as required in a verification process. Moreover, the exact differences can be predicted by knowledge of the experiment settings' differences in parameters e.g. from the model.
The found determinism however includes the invisables i.e. the state of invisibility of quanta *without* consequences of influencing free will and *with* statistical independence.

"*Determinism in QM is a threat to science"*- often is being argued that, extrapolating determinism would lead mathematically to a fully predictable view of our universe with philosophical *c*onsequences of e.g. free will and thus a serious threat to science. Turning this reasoning around would be 'proof' of the indeterminacy of QM (which sounds circular).
However in the quantum case, because of the information-energy sensitivity, quanta cannót be directly observed nór measured, and any *original state* of an individual quantum *remains completely hidden* from all and any type of observation(s), i.e. including our brains e.g. to initiate processes leading to influence or even control 'free will'; the observers thus remain completely unaware in concious and subconcious states, while they are fully able to excercise free will without *any constraints or external control*; the entire process may be performed even by (for the purpose control-able, strickly programmed) robotics; moreover, (changes and transforms of quanta) cannot be described in abstractions on the *individual* level of quanta with *any direct variable theory as well as* indirect system theory – therefore are fully shielding predictions on *individual* quantum behaviour from any variable theories.
A priori knowledge of evolvement of or a pre-determined universe is impossible with invisables: quantum behaviour can be subjected to thought-experiments, deduced from boundary conditions and side-effects in experiments, or reconstructed by the information in the causality relations *afterwards i.e.* 'a posteriori' from results e.g. to determine the past reality of the cause, and are in full contrast to 'threats to science', as the gained information serves *to increase knowledge and further understanding in science á*nd daily life, similar as in research in high energy experiments in e.g. large hadron colliders, observations in astro-physics and the reality of information transmission in the hardware base of the internet.

8. The Allocation of Probability

Deterministic results of the slit-experiments do not support probability / indeterminism as a fundamental property or result of quantum mechanics as the slit-experiment is a (full) quantum system in its own right.
States (i.e. the vectors) and linear combinations in quantum systems are deterministic, and probability then reflects the state of the observer only – being the translator into/from mathematics or creator of the experiment. Quanta are not required by assumption to be partly in different states of one property at the same time i.e. partially in two or more states (e.g. Dirac [1]) or mixed states, but evolve into different states in accordance with causality embedded the in time evolving state-

function Ψ(r, t), with properties that vary from (extremely) dynamic to (semi-) static in superpositioned states e.g. dynamic in speed and static in direction or vice versa i.e. quanta may be in more states however of *different* unrelated properties.
This is not different from the classical ideas about particles, *except* for the mathematical treatment of invisables.
It as well indicates that Schrödinger himself was right about what is a strange and awkward result of the theory due to indeterminism by ‘a posteriori’ human interpretation, and to *show* this awkwardness he presented his cat story. However in nature his cat certainly is not dead when alive and vice versa – many (if not all) of these type of ‘results’ just evaporate in the DP.

The superposition principle as a linear combination of states in e.g. the Hilbert space remains intact[18], however without intrinsic probability, does not require a specific quantum mechanical interpretation; the vector space handles only direction and value vector properties and 4 spacetime coordinates i.e. all real values. More properties can be added e.g. for fields (polarization) and complex numbers when required are allowed as well.
It is important to realize though that the internal energy manipulations cannot be observed - in the sense of providing information without state changes – therefore the result, when expressed in probabilities, has no bearing on the actual state of the quantum system, but reflects the state of the observer, who is lacking *exact* information and is ‘ignorant’. All mathematical results evolving from this point include human intervention and pass on probability to the observer. Meaning as well Born’s addition [4], which introduced very much room for interpretation, but *at the same time* proved to be quite *useful* in continuing with the successful theory, be it without *any exact* mathematical results.

9. Quantum Encryption & Computing

Because of the phenomenon of invisibility of quanta, it is obvious that when being observed, related changes of quanta may be relatively easy to detect in a scheme of encryption, by returning the detection values or measurement methods to the sender who then can compare them or deduce in case of measuring method, the value with the original sent values. A statistical measurement of many quanta then may provide the ‘eavesdropped’ or ‘clean’ information of the sent data. In a bright future this would create a safe encryption when quantum computers become available on the market. The reasoning is depending on observability of the quanta which can be detected due to (significant) state changes.
However, quanta may be copied, based on internal (re-active) energy exchange without altering their original state (see §10, §3) – entanglement and releasing photons is in research laboratories performed and in principle can be achieved.
Entanglement is a certain state of two quanta imposed by their environment, and seems to relate to the lowest internal energy state of two quanta in the environment energy level e.g. in the same sense as the Pauli principle in atoms - the phenomenon can be described by one state function. To produce the state in principle requires a tiny amount of energy, ideally the information energy and external energy to guide the photons in the environment for the manipulation. Therefore entanglement of quanta without affecting the original state of the sent quantum and with a tiny amount of external energy in principle is possible. In the DP the resulting state does not alter without a cause, and the for entanglement added and again separated quantum can be used for measurement: i.e. the data is detached in an inverted state and it would be quite simple to invert and read the information of the

18 Not all properties may be required of the Hilbert space.

originally sent quanta. The original quantum may be replaced even as photons in principle cannot be distinguished.
This process unfortunately renders the encryption fully transparent *ánd without any knowledge of eavesdropping* for the users of the ‘encrypted’ information exchange.
The use of entangled quanta is as well proposed using ‘spooky action’ when a change occurs with one of the quanta to signal eavesdropping. In case a physical change occurs e.g. one of the quanta meets a black hole, the proposed action to signal the other quantum cannot even be initiated when captured, as nothing escapes a black hole. Thus distroying and replacing the quantum in general does not reveal any eavesdropping.
Also, information of past entanglement is *not* destroyed and available i.e. one still can retrieve the (last) state when the object vanished and even replace it.
Without entering a detailed technical discussion, in a mainstream of development of quantum computers, therefore also quantum copy machines/computers will be developed that may be inserted e.g. in an optical data transmission line, as there is a market of criminal- governments and organized individuals, waiting around the corner as well.
Assume an UGP[19] scheme of encryption, with quantum computers waiting in our backyard, promising to crack the code in no-time because of the computer processing power they will bring in the future.
Obviously, with the smallest and fastest objects such as photons, this promises a potential of an extreme level of processing -speed and -power per unit of space that may be attained, but is as well heavily depending on the hardware processing to control hardware gates of qubits.
Computers to date usually work with only two bits of information a ‘0’ and ‘1’ that can be processed sequentially per clock cycle in time. As we have 2 bits, the information passed on per cycle is log 2 ~= 0,3[20] . When increasing the amount of levels (states) and combining these *all* in only *1* qubit, the information passed on will increase, however adding of additional levels is becoming less effective due to the logarithmic relation as it serves to increase the *accuracy* of information. Let’s assume instead of two, 16 levels may be used per qubit – meaning that the quantum qubit can be in any of the 16 states where each state represents different information. The information that can be transferred then is log 16 ~= 1.2 per cycle i.e. 4x more information than 2 levels. With 64 levels per qubit 6x, 256 levels 8x, 1024 levels 10x etcetera – which is not *really mind*-blowing.
It seems that a real ‘quantum leap’ of e.g. exponential growth in multi qubit processing, with photons and its related higher speed in parallel with multi-core processing, when realised with an increased density of circuits (with minimum dissipation) using photons and with increasing efficiency of the amount of qubits being processed per cycle, may be reality and depends entirely on the hardware basis of ‘gates’ to handle and control quanta in their ‘natural’ speed, limited by the environment.

10. Entanglement & Alice and Bob

One of the results we may use from the slit-experiments is that attained discrete states in quantum systems (i.e. without further - including ‘spontaneous’ - manipulation) may be be treated as ‘a priori’ fixed states and that probabilities introduced by the Born interpretation relate to the state of the observer.
The entanglement of invisables in par..., is an imposed state of two invisables, attaining opposite

19 Un-decryptable Good Privacy instead of ‘Pretty Good Privacy’ that has been cracked.

20 $^{2}\log 2 = 1$ bit actually, but we’re interested in ratio of improvement

state/property e.g. when their location is in the same energy environment and e.g. obeying a Pauli principle. Entanglement of two quanta can be described with one state function and is an effect on the internal energy state of the quanta e.g. spin, polarization or momentum in the environment facilitating entanglement.
The information on entanglement or the entangled state therefore is not intrinsically kept with the individual quanta but as a property of the entangled system with the creator or observer. When separating the quanta without affecting their state, the states of the quanta are fixed a priori, and without measurement unknown by an observer who is ignorant.

When photons are entangled, one is in state S(1), the other is in S(0). The states are attained in the manipulation of entanglement, then the quanta are separated.
In case of separated photons of the entangled pair without individual state changes, that are sent to Alice's and Bob's labs, the causality is embedded in the entanglement (and operation of separation, assumed without changes, ending physical entanglement) and in the DP are leading to two fixed contrasting states and the probabilities can thus be derived from *a priori states* by *a priori* information not influenced by Alice's or Bob's actions of e.g. measurement. As expected, the treatment becomes straightforward for each photon state they have – without observation or measurement, the state of the photons is fixed and does not alter as manipulation has ended, or whether 1 or 2 systems are considered,
so Alice (A) could have S(0) with P(A,0)=0.5 or S(1) with P(A,1)=0.5, and Bob (B) has the identical information.
The states in this example are mutually exclusive, so two combinations with each P=0.5 describe physical reality in terms of probabilities:
A <=> S(0) then B <=> S(1), or A <=> S(1) then B <=> S(0),
in which all observers A and B are ignorant, unaware of the actual combination, and we can use the relation to measure/observe the state of one quantum of the entangled pair and can exactly predict (with P=1 i.e. 100%) the other state even when separated lightyears, however *only* with *knowledge i.e. information of entanglement* (a priori condition for a predicting observer).[21]
Without information of entanglement, reality states are A <=> S(0) or S(1) and B <=> S(0) or S(1) and the prediction is P=0.5 i.e. 50%.
A predicting observer is to have information about the entanglement, as the information is to be a priori available to ensure P=1. This information is held by the observer and is not part of the energy of the quanta, which are in their own unaltered state being locally allowed by their environment, and obviously unaware of entanglement.
There are no changes when A knows the state and B is ignorant or vice versa, or both A & B know or are ignorant. There is no occurrence of '*spukhafte Fernwirkung*' as Einstein in his native language suspiciously addressed it, as the quanta are deterministic in their attained states i.e. not undefined in partial or mixed states.

11. Teleportation

Often, this phenomenon of 'teleportation' is associated with quantum mechanics as well as captain Kirk's *'beam me up, Scotty'*.
Teleportation is known from earlier experiments. The phenomenon is being ubiquitously deployed ever since development after first experimental attempts (Hertz 1887, Marconi 1894), and does not

21 One might use the outcomes statistically e.g. as reference in quantum computing without observing the other quantum.

demonstrate requirements of entangled states, shared or mixed states or other concepts found in QM publications.
Teleportation of pure energy-states is a state-of-the-art technique in coded energy technology e.g. in transmission of information, by a way of energy coding whereby the the original state of energy can be transformed without loss of the *original* information, *because* of the *causality relation on quantum level*.
In contrast with concepts in some QM papers on teleportation, the key is that the original information is not lost and may be retrieved fully (by saved data in case required in time), as should be the case from the QM state-function perspective, bearer of the local causality relations and the information; this indeed was the purpose of the radio-technology in the first place.

Unaware of QM and teleportation, the early radio transmission experiments were the first to exploit the energy transformation to transfer original information of *transducers* into em-energy (man-made phased photons) that could be transmitted over much greater distances. The transformation and information recovery became in a later stage known as modulation and de-modulation, and are nowadays deployed in analogue or digital form, with applications in wired, wireless radio and (optical) fiber transmission channels i.e. any- and everywhere located in the hardware base of the internet, including homes.
The amount of information per unit of time being ‘teleported’, requires a suitable channel e.g. with sufficient capacity for transmission of the required data (Nyquist, Shannon [16]); the *in*-sufficiency of capacity we sometimes may experience from a slow internet connection. The amount of data to beam cpt. Kirk, as well as the required channel with sufficient capacity to get him almost instantaneously to the right place – not even yet mentioning the amount of energy and <energy – information – energy> transformations which include matter, *without failures* to exactly reconstruct cpt. Kirk – all at the required *energy level of mass transfers* destructive for biological mass, render it impossible for bio-matter teleports to become part of reality.

12. Deterministic QM Mathematics

In more detail the mathematics used in [17] are briefly outlined. This proposed mathematical treatment of QM leads to a q.e.d.[22] of determinism in quantum mechanics. It has fundamental mathematical differences compared to the Schrödinger approach:

1. The Hamiltonian is modified, by substituting energy expressions with the quantum property momentum p[23] for both photons and mass-particle quanta
2. Causality in nature is embedded in the state-function Ψ by the counterpart convolution operator for local causal interactions
3. All operators mandatory are commutative in the entire system-theoretical approach due to information symmetry on quantum level
4. Quanta are mathematically treated as invisables instead of observables, excluding direct variable theory in descriptions, because of severe changes in momentum when information energy is required from quanta e.g. for observation, measurement or other operations
5. The application of system-theoretical mathematics based upon integral transformations, *replacing momentum p of quanta* to arrive at (k, r) frequency domain *energy-amplitude (intensity)* result functions of energy distributions

22 quod erat demonstrandum

23 Photons $h.\nu/c = E_{ph}/c = p \rightarrow E_{ph} = c.p$, for mass particles $p=m.v$ and $E_m=1/2\, v.p$ – constant c and v in the manipulation.

6. The result functions are exact and predictive i.e. demonstrating the fundamental deterministic character of quantum mechanics.

In the first step is proposed not to use energy directly in the model and avoid energy changes that should appear as vectors in the Hilbert space, not taking advantage of the properties of vector state descriptions in this space. The Hilbert space is required to be able to include all properties of the complex vectors to enable incorporating this with operators in the evolving mathematical treatment.

The substitution in the Hamiltonian facilitates linear functions of p and it as well incorporates the energy value for both photons as mass particle quanta in the description[24].
With the assumption of conservation of quantum energy in the manipulation, the energies in the distributions are linear functions of momentum p, in case of a constant speed c and v of the quanta without any external energy changes of quanta in the operation c.q. manipulation[25], in line with deterministic terms in a Hamiltonian of energy.
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Causality is introduced in the system i/o approach as a fundamental part of nature, with the counterpart convolution operator for a description of the causal time functions in interaction leading to the result function. The source and system then represent the cause, leading to the result i.e. the effect. Note that the actual mathematical interactive function is not required[26] for predictability. The pre-requisite is that on the interval of interaction, the condition for both functions is integrability over the interaction time to yield a result function.

Before taking step 3, we argue that information basically is ordered energy, which may be used to reduce the uncertainty of a property of an object, and that this energy is required for e.g. observation or measurement. The energy is in a coded or ordered (recognizable) form that has the potential to reduce the ignorance of the observer.
All the operators are required to support *information-energy symmetry* to allow partial or full re-constructions of the cause- from effect-functions after transformations, and therefore are to be mathematically commutative.

In further steps, the momentum function is being generalised in a Dirac pulse [8, 11, 14] of momentum in the system source. The source then can be considered ideal in terms of momentum. The energy spectrum density is renormalised to ‘1’ to avoid zero or infinite energy values in the equations with variable r.
The definition and derivation of the Dirac function and renormalising are both mandatory steps to be able to acquire mathematical information of the system-function of the operation, because the result of the convolution operator after transformation, transfers into the product operator in the transformed domain, and this result-function directly leads to the description of the system in the (k,r) domain i.e. energy re-distribution in spacetime [11, 12] which shows the distribution of the quanta after manipulation in the experiment.

An ideal input in momentum in system theory, by the convolution property thus reveals the system behaviour of the experiment or operation in terms of frequencies k in spatial locations r, with results

24 In [15], linear p-functions of the Hamiltonian in general were indicating the *deterministic* terms
25 For mass particles fully elastic mechanical interactions, for photons full reflections.
26 This would require knowledge and exact description of e.g. the energy transfers of photons.

in the distribution function in momentum p i.e. related to quanta energy in vacuum without external influences.
With the chosen Fourier transform, the distributions can be calculated for the quanta, as the frequencies k and the locations r are both *exact variables* i.e. (circle-)frequency k does not relate to (i.e. 'tag') properties of individual quanta which obey the Heisenberg relation i.e. no information is available on individual quanta. Therefore the distributions demonstrate the intensity or amplitude of the energy of E_{ph} or E_m at spatial locations r and thereby reveal the behaviour of the experiment as is visible in the detection plane, with *exact* mathematical functions i.e. spacetime energy location functions.

Postscript

Nature teaches that causality starts with energy transfers at the tiniest scale, preserving information and shaping our reality between the light cones where one experiences 'nearby' *physical events* and observes *events* by *information* reaching our location in spacetime.
Richard Feynman stated in 1964: '*I think I safely can say that nobody understands quantum mechanics'* – however, with determinism of invisables in quantum mechanics, leaving little room for interpretations and conclusions with roots in indeterminism, we may begin to see the light at the end of the tunnel – and I may as well conclude that A. Einstein was right after all in his notion that pieces of the puzzle seem to be missing in the successful theory.
I believe in scientific progress, and I'm favouring Schrödingers' point of view:
'*The task is not to see what has never been seen before, but to think what has never been thought before about what you see every day*' (in nature).

A.V. Herrebrugh 2022

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