The Intelligent Bit

Introduction.
In identifying the fundamental quality change \(0,1\) Claude Shannon brought a quantum leap in data handling. Now we've hit noise limits implied by his capacity theorem; overcoming noise in one channel needs power, spilling over as noise into another. Supercomputer power input is also at sustainability limits. The thirst for speed and storage is insatiable but practicalities of quantum computing and multiple entanglement means we may have years to wait. A new approach suggests far greater capacity exists in areas not yet fully searched. A quantum leap in a new direction seems possible using new degrees of freedom, 'changes' and information capacity hidden in two higher order 'spaces'. These spaces are; infinite hierarchical subsets of Sample Space an essential gamblers aid, and the 'Excluded Middle' between 0,1 inaccessible to binary systems but irrepressible in logic. The hidden power found allows an intelligent qubit or IQbit, from nature (it), but telling us far more of nature than the bit. As 'spooky' instant signalling is the Holy Grail of information theory the Einstein-Podolski-Rosen (EPR) paradox case is used as the sternest of tests for the IQbit.

A bit has a state 1 or 0 or wave peak or trough; up/down. Quantum qubits can have superposed states of freedom; \(ket\ 0, ket\ 1\) corresponding to two polarization axis of the spin 1 photon. Electron polarisation (angular momentum AM) differs from spin but in a ' photon' the two are considered as the same. It's been assumed that simple 0,1 spin states are all a photon has to offer. But what if they have more to give? Wheeler identified our questions as yes/no, which can only get yes / no answers. Moore's law of annual power doubling now applies to qubits. A D-Wave' 512 qubit chip reduces a half hour task to half a second. Quantum computing is already exploring unexpected optical phenomena, particularly orbital angular momentum (OAM). It was 1948 when man found cardinalised values 0,1 as the most a wave could offer, yet the wavefunction \(\Psi\) is more complex, including OAM. We need major processor upgrades. Could quanta give more information than we ask them? And what is \(\Psi\)?

The Excluded Middle.
Binary based mathematics relies on the Law of the Excluded Middle between assigned symbols 0,1, A,B, or yes/no for waves. Fibre optic cable signal degradation comes from the blurring of sharp cornered steps, so encroaching onto that excluded wave 'trough'. Nature is commonly assigned symbols such as 'numbers' to allow computation. Yet in this vast excluded middle ground lies most of nature and a dichotomy with logic. Gödel's n-valued (1932) and Fuzzy logic, Laplacian/Bayesian inverse distributions and the uncertain probability amplitude distribution (PAD) of quantum mechanics (QM) populate the space between cardinals 0,1. In information theory brings new views, such as Haykin and Kasko (2001), proposing 'Probability' as a sub-theory of fuzzy logic, deriving Bayes Theorem via 'fuzzy subsets'.

Russel's Predicate Logic and calculus tried to derive mathematics direct from logic but ended with paradox. No logical or mathematical system claims to have overcome paradox. Infinities and irrational and transcendental numbers (i.e. \(\pi\) outnumber rational numbers! A fresh view
suggests that the most foundational logical proposition; $A = A$, or Aristotle = Aristotle is false. Essential to mathematics and metaphysics $A = A$ is proposed as not applicable to natural physical entities and interactions. Aristotle is a Proper Noun, the definition of which is a unique entity. There can't then be more than one Aristotle, so $A = A$ can only be true metaphysically. Studying physical entities afresh it becomes apparent, if surprising, that for sizes at observable scales no two physical entities are identical. Even cases of numerous similar entities where set quantifiers such as heap, or field are essential no two may be identical. It is then proposed that no two galaxies, planets, trees, people, snowflakes or grains of sand will be found absolutely identical when observed at above molecular level.

Common Nouns are then in the same class as Proper Nouns, and in a different class to metaphysical concepts including mathematics, algebraic symbols and derivatives. If there is a non-zero probability amplitude for all possibilities in nature it may then be that in an infinite universe Cox and Forshaw are correct; everything that can happen will happen. QM's non-zero statistical amplitude distribution is similarly non-zero but can't offer any hint about underlying mechanisms or meaning. Max Born also had no physical explanation for squaring the wavefunction (Born Rule) to give the PAD. So what precisely is now proposed? Firstly we argue that that differentiation and definition of the separate rules applicable to the two identified classes is needed. The domain labels already exist; Physical and Metaphysical. Paul Dirac also identified;

“the limitation in the extent to which mathematical theory applies to a description of the physical universe.” and “…if it is only to a part...this part ought certainly to be sharply distinguished from the remainder. But...there does not seem to be any natural place in which to draw the line.”

(P Dirac 1939)

This natural place now emerges. Mathematics freed of paradox needs only refinement and layering in sub-sets to approximate nature with increasing precision. The further discrete hierarchical sample space dimensions are addressed below. On the reality side, a need for new laws of nature arises with domains constrained to physical entities and interactions. Probability amplitudes between propositions can vary infinitely in nature with curvature profiles, reducing to the middle. It is then suggested that a new “Law of the Reducing Middle” describing Bayesian distributions replaces the Law of the excluded Middle, long disputed by Brouwer and others. But the new law only applies only to relationships in the natural universe. Probabilistic descriptions of infinite n-outcome subsets relate the domains. The proposed law, covering outcomes of real interactions formalises the proposition;

**a) In an infinite universe all probabilities are non-zero.**

The concurrent denotation of similar to; $A \sim A$ better describes real entities. Socrates held a similar view that there is no absolute equality in nature. The rule's domain limits may be characterised as temporal and a classical scales provisionally between galaxy and molecular levels, proposing;

**b) No two entities are absolutely identical at any instant.**

Time itself is a special case. The concept time is a human invention to describe change, often confused with the physical evidence of emissions from 'clocks'. Physical artefacts propagate as sequences (giving Minkowski's events) obeying the laws of physics so liable to evolution due to spread and requantizations, en-route or at 'detection’. Apparent changes observed are changes to physical entities and relationships NOT to any entity called 'Time'. Dirac's Line
then more clearly divides Proper Time (unchanged) from apparent co-ordinate time \( \xi \) from signals originally emitted in any other frame. Defining 'detection' as the real interaction of the photon sequence with an electron allows this simple axiom, tested below. Propositions a) and b) are axiomised in discussing psi (\( \Psi \)) and Born's rule.

So what's just happened? Has the universe been split into two!? No. The new propositions only untangle the discordant elements of each half. Those other two halves, the Classical and Quantum universes, can then cohabit more consistently. In particular John von Neumann's proposition for a more consistent application of QM's uncertainty principle, to all interactions, is supported. Better conceptual understanding of the real 'reducing middle' to consider nature in full will enable mathematics to follow sound conceptualization. As Wheeler said: "Never make a calculation until you know the answer". Most differences may be trivial, but some are fundamental and fatal to comprehension. Quantum logic and 'time stepping' maths may help mathematical precision in describing uncertainties in nature. But a higher order space with mathematical implication also exists, found by pre-Galilean mathematician Geralamo Cardano.

**Cardano's Sample Space.**

Studied by students of probabilism but still mysterious and hidden, Sample Space is the home of chance and invisible 'probability mass'. New degrees of freedom are hidden both by binary cardinalisation and by intuitive assumptions. Often described as the set of all possible outcomes sample space is also an infinite scale hierarchy of many higher order spaces or subsets in which variables must be separately enumerated. Difficult to visualize, sample space needs explanations and examples to reveal it's full power. The initially counter-intuitive lessons to be learnt are difficult to generalize and easy to forget.

Cardano, also a doctor, objected to gruesome medical practice but did well at gambling. He defined sample space in a book "On Kinds of Games" as containing enumeration of a full circuit of possible outcomes. Correct odds can not be calculated from derivations such as correlations of 1, 0, or number combinations. Galileo later explained in 'Sopra Le Scoperte dei Dadi', how 3 dice had the same side combinations totalling; 9, 10, 11, and 12, yet the odds were unequal.

The "Parade" agony aunt Ask Marilyn won an argument with leading mathematicians in the 1990 Monty Hall case using sample space: A prize lies behind 1 door of 3. One is choosen. One other is then opened to reveal no prize. Two doors remain. The question is "Are the odds of winning improved by changing choice?" Clearly choosing now has 50:50 odds. Mathematics said No, Marilyn said Yes. Long argument ensued. But Marilyn was using the IQbit, hidden from maths in in sample space. She was proved correct. The invisible inequality of a 2:1 probability mass lies with the two doors not first selected, and remains there. Only removing the original choice removes the mass. Only one 'new' choice then remains, with 50:50 odds. For Galileo's 3 dice; number correlations can't give the full circuit of possible throws, utilising each of the 18 faces. 216 different cases then exist. Only counting those shows the hidden true odds (bet on 10 not 9).

Probability Theory uses sample space, but it seems it's full domain and power are not yet fully understood. Independent parametrization and mathematics must also be hierarchically layered as subsets in 3D+T space, then access limitations between layers identified. The description above uses the words inequality and correlation for good reason. When deriving his famous theorem and inequalities John Bell used the normal assumptions about sample space, so the
additional mechanisms and freedoms were not accessible. The IQbit was obscured beneath the simplified photon parameters 1,0. Such hidden higher order factors must then be parametrized. In excluding hidden variable theories Bell didn't rule out large scale variables such as action at a distance and $c < \lambda$. The new distribution within 0 and 1 is Local and Universal, deterministic and probabilistic, so agreeing with Bells;

“...nobody knows just where the boundary between the classical and the quantum domain is situated. (...) More plausible to me is that we will find that there is no boundary. (Ψ)...would prove to be a provisional or incomplete description of the quantum-mechanical part. It is this possibility, of a homogeneous account of the world, which is for me the chief motivation of the study of the so-called "hidden variable" possibility.”

J.S Bell 1987

Toroid & Helical Wavefunctions.
Collapse of $\Psi$ may also be seen as creation of $\Psi^1$ on interaction. To avoid anomaly and paradox convention in optics and astronomy uses change to physical quantity wavelength $\lambda/\lambda$ for Doppler shifts. Frequency ($f$) is a numerical derivative so only metaphysical. Assumptions that $f$ is physical lead to paradox. A value can only be assigned to $f$ after the process of detection, channelling (via a wire or optical nerve) to a processor and computing against time using some datum for signal 'speed' (speed itself is only a derivative of length $\lambda$ and time). Only then can any measurements be produced.

Using $\lambda$ also clarifies that the datum we must always use for assigning a speed $^M$ to calculate $f$ is the observers rest frame, i.e; the rest frame of the channel to the processor. Traditionally the previous 'approach medium' rest frame has been assumed by some processors as applicable. In that case paradoxes are created for observers moving through that medium. No observer in motion through a background has direct access to relative approach speed or $\lambda$. If a relative 'observer speed' is obtainable then relative 'far field' approach speed and $\lambda$ can be derived. When at rest in the medium light 'speed' is Locally Real propagation speed $c$. It then becomes clear that only the difficulty of envisaging relative speed in a diffuse medium (previously considered a 'perfect vacuum') creates theoretical problems. Defining detection as real first interaction allows resolution consistent with the postulates of Special Relativity.

A 'detection' may then exist at all particle interactions, at a lens or not, but 'measurements' are the later output of a processor. The IQbit may help with processor upgrades. Assigning the propagation frame datum relevant for 'speed' is critical because $\Psi$ needs a background frame parameter. Instantly on interaction with the first peak of a wave changes occur to wavelength $\lambda$ and $\Psi$. The old frame then cannot be used for computing the new frequency $f$. Using the observer frame means Proper Time may be properly used (the rate of a clock at rest in that frame) to compute $f$.

Detection is then defined as the physical interaction 'collapsing' $\Psi$ which state changed instantly. $\Psi$ can be both a 'potential' and a real entity. The optics convention is Huygens Construction of infinitely many wavelets expanding and interacting, so any point just has a potential. Squaring to 3D spherelots is more precise. Coherent forward scattering (CFS) in plasma narrows scattering angles (plasma beams can be self focussing). Yet a photon on interaction/re-emission is particle-like. Two starting assumptions of Wheeler's 'delayed choice' case would then be wrong: Photon particles scatter, and statistics can't access the same data as comparison of each entangled pair, explaining the apparent paradox.
Collapse then creates a new $\Psi$ in the new medium. Potential may then be seen as the players of a team heading to one point to interact as an entity, representing multiple Huygens spherelets. The anomalous spread function of Schrödinger’s non-linear (NLS) time-dependent wave-packet is consistent with gradual spread from particle to waves. Expanding Schrödinger sphere surfaces also contain local angular momentum combining 360° ‘transverse’ and ‘longitudinal’ states. The toroid and implicit helical path over time is as found in recent optical research, of waves, particles or surface plasmons. The helix as a wave squared to a 3D distribution of energy offers a hint of grounds for squaring the wavefunction to find the PAD. The helix/torus/helix formed by particles and time appears to epitomise duality and the multiple IQbit vectors. Figure 1 shows the 2D/3D relationship between waves and rotating or orbiting particles.

A wave, giving the binary 0,1, is the simple 2D form of a (3D+Time) helix. The first new freedom of the (red) sine wave is then the (green) cosine wave. But many more degrees of freedom may exist in a 4D wavefunction. The simple dipole shown translating on its axis in time describes the powerful double helix. But the popular toroidal (donut) or multi toroid model of a particle contains further inherent helices. The tubular body of the ring is itself counter-wound with two more continuous helices. Nuclear tokamaks, the basis of atomic fusion, use this same electromagnetic (EM) toroid dynamic. Because lines have no thickness curvatures can vary infinitely with ellipticity. Elliptical polarisation is common along with gyro-electromagnetic optical Interstellar Faraday Rotation (IFR). Interaction angle $\theta$ critically relates to detector EM field orientation so a datum exists for recovering information from these additional freedoms. A datum is essential in the EPR case. Malus Law states that for plane polarised light; Intensity $(I) \propto \cos^2 \theta$. Energy distribution is then directly proportional to the square of the cosine of the angle between polariser/particle axes and detector field. Malus Law applies at emitters and detectors. When two toroids meet, the settings change the orientation of detector field particles. The setting $\theta$ then dictates relative ellipticity and, using the detector datum where in the circumference the toroids meet and interact. The energy distribution is then asymmetric on interaction. The other entangled particle behaves precisely conversely. The relative positions of the ‘charge peaks’ around the 360° body sets the additional parameter value, so also each local cosine curve of intensity distribution (see Figs 2 - 4).

Uncertainty issues remain. The D-Wave addresses these by using binaries to represent the smaller probability peak positions, so again using statistics and taking time. Uncertainty can be diminishing via many subsets but never vanishes. Free space is faster than solid optics but spread and stochastic gradual decoherence effects slowly degrade signal quality. Multi tube optical waveguides are now more common. The optical helix has also shown it’s power as a waveguide. Wang et al. (2012) and Rechsman et al. (2013) have shown that orbital AM and arrays of helical ‘waveguides’ act as topological insulators allowing the new freedoms to be exploited. Whether from single particle spin, sphere surfaces or carrier beams, the ‘change’ implicit in orbital motions power the IQbit. Harmonic resonance, tomography and ‘steering’ effects are closely related but short range with a limit <c. The EPR case of similar opposite hand split spin pairs is at long distance. Spin orbit and propagation on the toroid axis in time gives the helix, which is now also axiomised.
Axioms
1. Particles as non-point charges orbit, propagate, and interact on detection all on an axis.
2. Hidden higher order variables exist between integers 0,1, requiring enumeration.
3. Real physical entities and interactions (not derivatives) produce real physical effects.
4. Law of the Reducing Middle; In an infinite universe all probabilities are non-zero.
5. As John Bell's belief "there is no boundary" to classical and quantum domains.

The Einstein Podolski Rosen (EPR) Paradox
The EPR case correlates spin 0,1 found by two distant detectors at various relative field angle \( \theta \) settings. The correlations predicted by QM appear classically impossible without spooky action at a distance or superluminal signalling. John Bell's famous Theorem and Inequalities showed mathematically that no classical Locally Real theory of hidden variables could reproduce QM's prediction of an uncertain cosine probability amplitude distribution (PAD) curve. Despite experimental difficulties the predictions are so far verified, but as with Born's Rule no mechanism is offered. The findings predicted at each detector may be simplified to green and red lights. At 0° difference in \( \theta \) anti-correlation is perfect, at 180° correlation is perfect. 90° = 50%. But then at relative 60° difference in \( \theta \); correlation = 75% and 120° = 25%. These intervening results produce QM's cosine distribution curve.

Figure 2 shows a full 360° circuit. The curve is proposed to also represent the inverse Bayesian or Gödel many-valued 'reducing middle' between the certainties of 0°, 180° and 360°. But the curve may be viewed as the 2D form of the part of a helical orbit between wave peaks, which is the cosine waveform curve of figure 1. A real rotational interaction mechanism is identified producing the same curve, dynamically represented here; http://www.youtube.com/watch?v=vnZmZzOhBkM

To conceptualise consider the left side of figure 2. Below the curve = Green, above = Red. Only the question 'red, or green?' is asked. The curve represents the proportion of answers over a large sample at various relative settings of \( \theta \). But we now ask a question of the more intelligent IQbit, and for EACH interaction; How Much? We introduce an enumeration of differing values of intensity of red and green in each case. As relative detector setting is changed the peak charge point separation changes as Malus Law giving interaction \( \Delta \theta \). Because charge density reduces non linearly, around the orbit so does the relative density, and so will the findings. The physical 'cause' of this inequality of correlations is then moved from some metaphysical statistical 'space' between \( A \) and \( B \) to the real physical interactions at each detector.
Because the entangled particles are *handed* they act conversely with respect to relative field $\theta$. Local variables then exist of a different *type* than assumed. The variable is a continuous *orbit* of values. When asked how much? the answers are a range of values between 0 and 1. At 90° the answer is not: “don’t know” but “equal 0,1.” To answer this question each particle pair must be accurately identified. Simply statistically correlating the large sets of results currently produced denies access to the data and cosine curves of density distribution at each detector.

Figure 3 represents a 'face on' view of the interaction density distributions, reproducing the predictions of QM with a quasi-causal mechanism. The *scale* of uncertainty is then reduced.

![Figure 3: Relative energy density on detections gives the cosine curve locally at EACH detector via relative field orientation parameter. Intensity change is NON-linear.](image)

Both the EPR case and Bell assumed single pairs. True single photon emission (SPE) remains problematic but technically possible\(^{xxi}\) in a waveguide. Aspect experiment sources\(^{xix}\) typically emitted $\sim 5 \times 10^7$ photons/sec, selecting <40/sec, but even time varying analysis can't guarantee real pair matching. So called *single photon detection* is also still problematic\(^{xxi}\). A search reveals no findings correlating individual pair returns. No argument raising valid objection to this thesis is found and no EPR 'loophole' is needed.

John von Neumann postulated the same solution proposed here in 1932; that as the system and the meter physically interact *both* must act as quantum mechanical systems, so each meter should “*equally obey the uncertainty principle*”. Pascual Jordan agreed, that; “Observations not only disturb what is to be measured, they produce it.” The IQbit's *reality* based solution allows coherent application of QM principles with a largely deterministic mechanism but including uncertainty at each detector.
Figure 4 shows the angle change, ellipticity and non-linear density distributions obtained from a THz laser experiment as Malus Law.

Conclusions

An intelligent IQbit with new helical/toroidal freedoms is found hidden in a Sample Space of hierarchical subsets, and an Included Middle between binary 0 and 1, including $\Psi^2$. More than just yes/no questions are asked. The answers show the IQbit comes from reality (it), but unity of Probabilism and Local Reality is found from the IQbit. Quantum distributions are causally derived to a higher order, yet uncertainty never vanishes. Paul Dirac's proposed 'natural line' between the metaphysical and the physical universes emerges. A new "Law of the Reducing Middle" is proposed with a domain strictly limited to nature, founded on the uncertain; $A \sim A$. Mathematics, is untangled from paradox and retains $A = A$.

The IQbit's resolving power is shown to be held in the new 'changes' of multiple orbital angular momenta, and is tested against the EPR paradox. All the predictions of QM are shown as reproduced at each detector interaction. Superluminal signalling and action at a distance are then falsified. Loopholes are not invoked and stochastic effects are secondary. The EPR case specified a single pair, but a starting assumption that statistics can precisely reflect the evolution of real physical interactions is shown as wrongly used and false. The quantum eraser 'particle' case uses the same assumption and 'conserved photons' so produces paradox. But Bell's prediction of 'no boundary' between quantum and classical regimes is verified. An experiment using single pairs will verify the proposition. The IQbit passes the test and offers new insight into the nature that produced it.
Malus' Law and 'Single Photons'.

Malus' Law. Measured intensity $\Phi = \Phi_0 (\cos \theta_{A-P})^2$ where $\Phi_0$ is the measured intensity without the analyzer and $\theta_{A-P}$ is the difference between the second polarizer (analyzer) and the first polarizer. The intensity of light passed through two polarizers depend on the square of the cosine of the angle between the two polarization axes.

The Law is well known and considered in the EPR case but without the full package and explanation of the IQbit, including propagation on the handed particle axis, interaction condition at the detectors, and single photon correlations.

“Common misunderstanding of the term single photon” (University of Nuremberg 2008) “Many elementary texts on quantum physics are using the following example as a demonstration of single photons (see figure 1): A light source, for example a laser, is strongly attenuated by a filter. A detector sensitive to single photons is registering events. Such a setup is then extended with a double slit, an interferometer, etc. for showing interference of single photon “particles”. However, such an interpretation in terms of basic (nonrelativistic) quantum physics is not valid.”

http://www.holmarc.com/malus_law.html

The statistical 'beam' method can still not access individual photon pair comparison data. A time delay between single emissions is required.

Aspect (1983, p 265-7) states that his source of signals was not “rotationally invariant”, and that this led to slight variations in the estimated values of one of the transmission co-efficients as the first polariser was rotated when using two polarisers to calibrate the second one. This anomalous observation is consistent with our thesis, stemming from density/amplitude variations at both polariser and detectors. Aspect noted that he made 'adjustments' to match quantum theory predictions. In 1980, at the time of the experiments no classical theory was available satisfactorily explaining all his results, so such adjustment was considered reasonable. The variations however turn out to be important hints as to the mechanism.

Quantization of light in any form, including a spherically expanding function, is considered to carry absolute angular momentum h, energy ($h^*f$) and momentum ($[h^*c]^*$frequency). The Photon 'wave equation' is used to study the propagation of photons in a medium.

The photon 'wave function' is: “still not fully accepted among the scientific community, as it doesn’t have all the properties of the wave function of particles with mass in quantum mechanics. This arises mainly because of nonlocalizable nature of the photon and the consequent difficulty in defining the position operator for photon. This means photon wave function cannot exist in position eigenstate.”


Maxwell's equations are the classical description, (if lacking the near/far field transition mechanism). The disputed (2nd) quantization of the fields gives the relativistic quantum description and 4D space-time symmetry of 'single particle motion'. (see Carl Von Weizsäcker ref.). Photon 'ladder operators' are a sequence of creation/annihilations re-quantized at interactions, which may be looked upon as working alongside and countering the spread function. (Plasma n=1 minimises decoherence of photon psi). Such infinite sequences may be expressed by Lie algebras, including cyclically closed chains, analogues to string theory. A new approach to the interaction of photon and the medium is interactions given by a term proportional to the current density induced in the media due the presence of the photon.

Photon Quantum Computer findings; March 2013. “Scientists at Yale University have found a new way to manipulate microwave signals that could aid the long-term effort to develop a quantum computer,... The advance involves photons, the smallest units of microwave signals, which can serve as a quantum computer’s memory, like the RAM of a regular computer.; Report; http://scitechdaily.com/using-photons-for-quantum-computer-memory/ See also Images; https://en.wikipedia.org/wiki/Polarizer


'Chaotic' Free Space Communication

Chaos is considered by the IQbit as just highly complex and unpredictable evolution of very large but organised systems, with causal rules. So 'deterministic' but not pre-determined. It has been found that chaotic signals could overcome physical constraints and lead to superior performance of wireless communication. Information transmitted by a chaotic signal in a wireless communication system is not modified by the wireless channel as it is for non-chaotic signals.


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