Quantum Hocus Pocus

http://tph.tuwien.ac.at/∼svozil/publ/2017-Svozil-FQMT-pres.pdf

Karl Svozil

ITP/Vienna University of Technology, Austria
& CS/University of Auckland, NZ
svozil@tuwien.ac.at

Background picture: Hilma af Klint (1862-1944, Stockholm), Urkaos, nr 16, 1906-1907 Ur: Serie WU/ROSEN. Grupp 1 (c) Stiftelsen Hilma af Klints Verk

Växjö, Sweden, EU, June 13th, 2017

I shall not talk about this:

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A variant of the Kochen-Specker theorem localising value indefiniteness

Alastair A. Abbott,[1,2,a)] Cristian S. Calude,[1,b)] and Karl Svozil[1,3,c)]
[1]*Department of Computer Science, University of Auckland, Private Bag 92019, Auckland, New Zealand*
[2]*Centre Cavaillès, École Normale Supérieure, 29 rue d'Ulm, 75005 Paris, France*
[3]*Institute for Theoretical Physics, Vienna University of Technology, Wiedner Hauptstrasse 8-10/136, 1040 Vienna, Austria*

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The Kochen-Specker theorem proves the inability to assign, simultaneously, noncontextual definite values to all (of a finite set of) quantum mechanical observables in a consistent manner. If one assumes that any definite values behave noncontextually, one can nonetheless only conclude that *some* observables (in this set) are value indefinite. In this paper, we prove a variant of the Kochen-Specker theorem showing that, under the same assumption of noncontextuality, if a single one-dimensional projection observable is assigned the definite value 1, then no one-dimensional projection observable that is incompatible (i.e., non-commuting) with this one can be assigned consistently a definite value. Unlike standard proofs of the Kochen-Specker theorem, in order to localise and show the extent of value indefiniteness, this result requires a constructive method of reduction between Kochen-Specker sets. If a system is prepared in a pure state $|\psi\rangle$, then it is reasonable to assume that any value assignment (i.e., hidden variable model) for this system assigns the value 1 to the observable projecting onto the one-dimensional linear subspace

A little bit about this:

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Quantum hocus-pocus

Karl Svozil*

Institute for Theoretical Physics, Vienna University of Technology, Wiedner Hauptstraße 8-10/136, 1040 Vienna, Austria, and Department of Computer Science, University of Auckland, Private Bag 92019, Auckland 1142, New Zealand

ABSTRACT: The claims made in a manifesto resulting in the European quantum technologies flagship initiative in quantum technology and similar enterprises are taken as a starting point to critically review some potential quantum resources, such as coherent superposition and entanglement, and their dormant usefulness for parallelism and communication. Claims of absolute, irreducible (non-epistemic) randomness are argued to be metaphysical. Cryptanalytic man-in-the-middle attacks on quantum cryptography are well known to be feasible but hardly mentioned. If all of this is taken into account, a more sober perspective on quantum capacities emerges, but it may be ethically more justified than the 'hype and magic' that drives many current initiatives.

KEY WORDS: Quantum computation · Quantum information

. . . and this:

Delivering on a quantum promise

With the European Commission investing €1bn over 10 years in quantum technologies, **Karl Svozil** warns against overselling many of the initiative's longer-term goals

Unlike modern-day politicians, scientists have great authority regarding the pursuit of truth. As a consequence, many members of the public – as well as political bodies and institutions – tend to uncritically take science as a matter of fact. Yet there are some occasions where the benefits and risks of science need to be communicated carefully. A striking example is nuclear energy and the bold claims made by some that nuclear-fission technology is "safe beyond doubt". One only has to look at the nuclear power plants at Three Mile Island, Chernobyl and Fukushima to know that such claims can prove spurious.

In a similar fashion, I believe that the alleged applications of quantum physics are,

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Quantum questions Are the applications of quantum physics as viable as we are led to believe?

Should "fairy tales" be marketed to the public and politicians?

the age of the universe". I am at a loss to imagine what that could be, given the

It cannot originate from elements such a lossless beam splitters because these ar merely "permuting" the quantum state. I measurements were the source of random ness, then any such randomness would b tied to the notorious quantum-measuremen problem – how or whether wave-functio collapse occurs. Moreover, because c "incompleteness theorems", any statement regarding the indeterminism, let alone ran domness, of empirical bit sequences ar unprovable. Thus regardless of what we ma be inclined to believe, and whatever author itative certificates are issued, such claim remain metaphysical and conjectural.

Security considerations

Finally, contrary to publicized claims, quan tum cryptography is insecure and can b successfully cryptanalysed through man in-the-middle attacks. As a consequence to be safe, such quantum-cryptographi protocols require both an uncompromise classical as well as quantum communica tion channel. With these provisos, one ma ask: what exactly is the advantage and wha is the "added security"? Is quantum cryp tography presenting itself as the solution t

QM measurement conundrum

Setting the stage by a practical example: A (lossless) beam splitter is represented by a (perfectly) unitary – that is, one-to-one, norm preserving – and thus deterministic and reversible evolution of the state.

In general, von Neumann (1932), Schrödinger (cat papers, 1935), London and Bauer (1939), Everett (1957), Wigner (1961) pointed out that a *nesting argument* yields a uniform unitary – that is, one-to-one, norm preserving – state evolution, leaving no room for irreversibility (many-to-one) and indeterminism (one-to-many state evolution).

Cf. quantum erasure (Scully & Drühl, 1982, Greenberger & YaSin 1989, Ma *et al*, 2013)

So is the solution "against 'measurement' (Bell, 1990)?" That is, are measurements merely fapp and means relative to the resources invested?

Where exactly does quantum randomness reside?

With such epistemic "measurements" there goes the irreducible randomness.

Similar situation as for the 2nd law of thermodynamics, which appears to be means dependent (Maxwell, 1878, Myrvold, 2011).

One “revolutionary” (according to Schrödinger) resolution

In his 1908 inauguration address as Rektor of the University of Vienna, Franz Serafin Exner stated, “*. . . in the region of the small, in time as in space, the physical laws are probably invalid . . . we have to perceive all so-called exact laws as probabilistic which are not valid with absolute certainty; but the more individual processes are involved the higher the certainty. All physical laws can be traced back to random processes on the molecular level, and from them the result follows according to the laws of probability theory. . .*”

German original: “*. . . im kleinen, der Zeit wie dem Raume nach, gelten die physikalischen Gesetze voraussichtlich nicht . . . So mšsen wir also alle sogenannten exakten Gesetze nur als Durchschnittsgesetze auffassen die nicht mit absoluter Sicherheit gelten, wohl aber mit um so größerer Wahrscheinlichkeit aus je mehr Einzelvorgängen sie sich ergeben. Alle physikalischen Gesetze gehen zurück auf molekulare Vorgänge zufälliger Natur und aus ihnen folgt das Resultat nach den Gesetzen der Wahrscheinlichkeitsrechnung. . .*”

Exner was explicitly mentioned in Schrödinger's 1922 inaugural lecture in Zurich, and also later

"Long before modern quantum mechanics made their quantitative statements with respect to the degree of inaccuracy, it was possible, although it was not necessary, to doubt the justification of determinism from a far more general point of view. In fact, such doubts were raised in 1918 by Franz Exner, nine years before Heisenberg set up his relation of indeterminacy. Little attention was paid to them, however, and if support was given to them, as by the author in his inaugural dissertation at Zurich, they met with considerable shakings of heads."

What if the Schrödinger equation is inaccurate for very few particles or scales, just as Schweidler's 1905 suggestion deviations from Rutherford's decay law (1902) for small sample seizes?

Another promising resolution: Schrödinger on individuation, entanglement and qm object-observer relation

Schrödinger again (cat papers, 1935) wrt entanglement and individuality: *"The whole is in a definite state, the parts taken individually are not."*

German original: *"Das Ganze ist in einem bestimmten Zustand, die Teile für sich genommen nicht."*

Suppose through measurement the object & observer (measurement apparatus) interact and become entangled. Then none of them appers to be in a definite state *individually* any longer, even if both of them were in a definite individual state before the measurement. The initial information got re-encoded into relational properties. This was already discussed by von Neumann (1932), Schrödinger (cat papers, 1935) & London and Bauer (1939), among others.

Breathing in & and out of individuality & entanglement

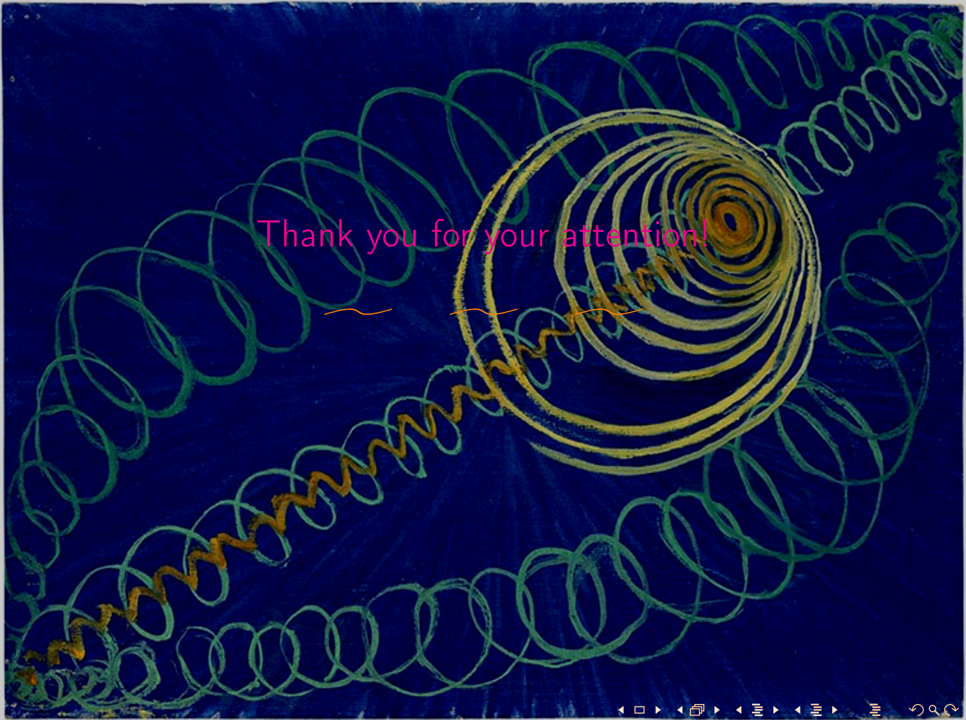
Toy example involving the Cartesian standard basis $\big(|\mathbf{e}_1\rangle, |\mathbf{e}_2\rangle, |\mathbf{e}_3\rangle, |\mathbf{e}_4\rangle\big)$ (for individuation) and the Bell basis $\big(|\Psi^-\rangle, |\Psi^+\rangle, |\Phi^-\rangle, |\Phi^+\rangle\big)$ (for entanglement). Then,

$$
\begin{aligned}
\mathbf{U} &= |\Psi^-\rangle\langle \mathbf{e}_1| + |\Psi^+\rangle\langle \mathbf{e}_2| + |\Phi^-\rangle\langle \mathbf{e}_3| + |\Phi^+\rangle\langle \mathbf{e}_4| = \\
&= \big(|\Psi^-\rangle, |\Psi^+\rangle, |\Phi^-\rangle, |\Phi^+\rangle\big) = \frac{1}{\sqrt{2}}\begin{pmatrix} 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ -1 & 1 & 0 & 0 \\ 0 & 0 & -1 & 1 \end{pmatrix}. \\
\mathbf{V} &= |\mathbf{e}_2\rangle\langle \Psi^-| + |\mathbf{e}_3\rangle\langle \Psi^+| + |\mathbf{e}_4\rangle\langle \Phi^-| + |\mathbf{e}_1\rangle\langle \Phi^+| = \\
&= \begin{pmatrix} \langle \Phi^+| \\ \langle \Psi^-| \\ \langle \Psi^+| \\ \langle \Phi^-| \end{pmatrix} = \frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & -1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{pmatrix}.
\end{aligned}
$$

$$
|\mathbf{e}_1\rangle \overset{\mathbf{U}}{\mapsto} |\Psi^-\rangle \overset{\mathbf{V}}{\mapsto} |\mathbf{e}_2\rangle \overset{\mathbf{U}}{\mapsto} |\Psi^+\rangle \overset{\mathbf{V}}{\mapsto} |\mathbf{e}_3\rangle \overset{\mathbf{U}}{\mapsto} |\Phi^-\rangle \overset{\mathbf{V}}{\mapsto} |\mathbf{e}_4\rangle \overset{\mathbf{U}}{\mapsto} |\Phi^+\rangle \overset{\mathbf{V}}{\mapsto} |\mathbf{e}_1\rangle.
$$

Planck, The seventeenth Guthrie Lecture, delivered on June 17, 1932

> "... the law of causality is neither right nor wrong, it can be neither generally proved nor generally disproved. It is rather a heuristic principle, a sign-post (and to my mind the most valuable sign-post we possess) to guide us in the motley confusion of events and to show us the direction in which scientific research must advance in order to attain fruitful results. As the law of causality immediately seizes the awakening soul of the child and causes him indefatigably to ask "Why?" so it accompanies the investigator through his whole life and incessantly sets him new problems. For science does not mean contemplative rest in possession of sure knowledge, it means untiring work and steadily advancing development."



Thank you for your attention!