

## On the Joint Probability of Correlated Physical Occurrences

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*Correlation meaning interaction for physical occurrences, the joint probability formalizes this interaction and conceptualizes a stochastic causality. Bayesian reversibility then expresses action-reaction symmetry for spacelike, and cause-effect symmetry for timelike, separations. Information-negentropy equivalence (that is, reversibility of the twin-faced information concept) extends Mehlberg's "lawlike reversibility" and vindicates Wigner's claim that psychokinesis is reciprocal to gain in knowledge. A covariant axiomatization of probabilities as expressing physical interaction, and displaying the spacetime propagation of information, is proposed. Its correspondence (but essential difference) with the quantum calculation recipe is evidenced. The unfolding paradigm of a twin-faced reality-and-representation universe is stressed, and Pauli's hints in this direction are mentioned.*

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### 1. INTRODUCTION

I will argue that physics places specific constraints upon the concept of *correlated probabilities* unheeded by the existing axiomatic schemes, so that *an ad hoc conceptualization-and-formalization of physical probabilities* is needed. If probability is assumed inherent to physics (not just a makeshift compensating imperfect knowledge) its reaxiomatization implies scrutiny of fundamentals.

*In physics correlation means interaction or a causal link; so, the joint probability of two physical occurrences, or events, expresses their interaction. This implies identifying the concepts of joint probability and of causality, whence in Jaynes<sup>(1)</sup> wording, a blending of ontology and epistemology— which he rejects.*

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*My contention consists of that blending, stated as existence of a reciprocal binding between reality and representation, and expressed by the information-negentropy equivalence. Remember that Aristotle's and Shannon's<sup>(2)</sup> information concept is twin-faced, knowledge as the obverse, organization as the reverse of one same medal.*

*Then, a chance occurrence is not just an accident but evidences a two-way interaction between observer and observed. As an elementary-level phenomenon (not brushed under the carpet) psychokinesis must exist as reciprocal to gain in knowledge. Wigner<sup>(3)</sup> draws this same conclusion from his own symmetry arguments. Mehlberg's<sup>(4)</sup> lawlike reversibility and factlike irreversibility must then be restated thus: easy and normal forward, the negentropy-cognizance transition is hard or paranormal backward.*

*Drawn from first principles with numerous verified consequences, this conclusion seems inescapable: to deny it would unduly legalize factlike irreversibility. And to ignore it is overlooking what is truly meant by "choosing initial conditions."*

*The cognizance-organization blending extends of course far beyond the practice of physics; more than one philosopher has discussed it. Hoyle's<sup>(5)</sup> "intelligent universe" and Jung's "collective unconscious" have relevance here.*

*In quantum mechanics Jaynes<sup>(1)</sup> objects to the consciousness-induced wave collapse theory its implication that "the universe is run by psychokinesis" (insofar as quantum mechanics is basic). My contention is that by itself the probability and information theory entails this very conclusion. But a comment is needed.*

*In the normal use of quantum mechanics consciousness is assumed neutral when collapsing the state vector, which conforms to factlike irreversibility. However, the lawlike cognizance-organization symmetry implies that consciousness can bias the outcome when collapsing the state vector.*

*Random-event generators based on electronic noise do test this psychokinetic effect as small, but reproducible. Jahn<sup>(6)</sup> has lectured on it at international conferences, and Stapp<sup>(7)</sup> has recently expressed his views on the matter a propos the quantum measurement process.*

*Taking the joint probability of two physical occurrences as the expression of their interaction entails technical consequences. First, the Lorentz and CPT invariance required in any basic conceptualization and formalization of physical occurrences is required in that of the calculus of physical probabilities. Then, this calculus must evidence the covariant propagation of information throughout spacetime.*

*Covariance goes with intersubjectivity; the physics community resembles less a card players party than one of mushroom gatherers. All observers of a physical occurrence are in agreement, their guesses being addressed to Nature, not to their colleagues.*

So, contrasting the Bayesian approach emphasizing subjectivity, or relativity of information, *the physical approach to probability must evidence covariance and intersubjectivity.*

## 2. INVERSION OF THE JOINT PROBABILITY, LORENTZ AND CPT INVARIANCES

Bayes' principle states that: *The joint probability of two correlated occurrences A and C equals the conditional probability of A if C times the prior probability of C, or inversely: the conditional probability of C if A times the prior probability of A. It is A and C symmetric; and is not symmetry implied by definition of the word joint?*

Spacetime geometry, however, where *joint probability* means *interaction*, does not let things go that simply: to her the A-C symmetry means *action-reaction symmetry* for spacelike separated events, *cause-effect symmetry* for timelike separated ones.

*The latter implies retrocausation at the elementary level.* Had Loschmidt argued (as Van der Waals<sup>(8)</sup> did later) via the Bayesian reversal, his objection to Boltzmann would have been more radical. Retrocausation, which is routinely displayed in the quantal delayed choice experiments,<sup>(9, 10)</sup> can be concisely expressed<sup>(11)</sup> in terms of CPT invariance of the quantal transition amplitude.

Reversal of the joint probability of timelike distant events disposes of the hasty wording that "tendency towards disorder is a consequence of the laws of chance." What is evidenced in the wide class of disorder-generating phenomena is *equality* (or near equality) *of the final priors*, that is, *retarded causation*. However, evidencing the opposite tendency, and formalizable via equality of the initial priors, the class of phenomena including voluntary action and biological development blatantly displays<sup>(12)</sup> advanced causality, that is, *finality*.

So, in quantum mechanics, CPT symmetry adds spice to the inversion of Bayes' formula. *Experimental evidence of the C & P and the CP & T violations exemplifies that inversion of a joint probability has a meaning deeper than merely grammatical.*

*Such allegiance of logic to spacetime geometry displays a binding between ontology and epistemology.*

## 3. COVARIANT AXIOMATIZATION OF INTERSUBJECTIVE PROBABILITY

In contrast to the Bayesian approach connecting conditional probabilities *relative* to two observers playing some sort of poker game, or to

alternative views taken on a problem when the possibility of tampering with the final priors is discarded, what we need<sup>(1,3)</sup> is *one formula expressing covariantly the intersubjective joint number of chances of two correlated events of either spacelike or timelike separation. Both priors must be displayed symmetrically.*

By definition, the joint number of chances  $|A) \cdot (C|$  of two correlated events A and C is smaller than the product of their prior probabilities  $|A) \equiv (A|$  and  $(C| \equiv |C)$ . Thus, there exists a number which I term *reversible conditional probability of A if C or of C if A*

$$0 \leq (A|C) := (C|A) \leq 1 \quad (1)$$

such that

$$|A) \cdot (C| := |A)(A|C)(C| \quad (2)$$

Normalization is possible according to

$$\sum |A) = \sum (C| = 1, \quad \sum_A (A|C) = \sum_C (A|C) = 1 \quad (3)$$

so the word *probability* is justified. But the joint number of chances  $|A) \cdot (C|$  cannot be normalized to unity.

The composition law

$$(A|C) = \sum (A|B)(B|C) \quad (4)$$

is added.

The Lorentz and PT invariances are naturally accepted by this scheme, the latter encoded in the symmetry (1). Even CPT invariance has meaning if internal symmetries of the particles are ignored: had Loschmidt likened his molecules to rotating ogival bullets where right and left, fore and aft, make sense, he would have ended with a CPT invariance.

This scheme is none else than that of the transition probabilities of statistical mechanics, where  $(A|C)$  denotes the *intrinsic collision or transition probability*,  $|A)$  and  $(C|$  the (initial or final) *occupation probabilities*,  $|A) \cdot (C|$  the *dressed collision or transition number of chances* (loosely speaking, “probability”).

Prediction or retrodiction of a collision are pictured in spacetime by a  $\wedge$  or a  $\vee$  shaped ABC zigzag; transition from an  $|A)$  to a  $(C|$  state via a collision, using a  $<$  or  $C$  shaped ABC zigzag, can be computed either

predictively or retrodictively; in Mehlberg's<sup>(4)</sup> wording "blind prediction" equates all (C)'s, and "blind retrodictions" all (A)'s.

Formally speaking, *blind prediction* amounts to *preselection* and *blind retrodiction* to *postselection*; thus, the twin-faced *information* concept again reclaims our attention.

#### 4. EXISTENTIALISM AND UNIVERSAL CONSTANTS: RECIPROCITY OF COGNIZANCE AND ORGANIZATION

A universal constant is a keystone bridging two phenomenologies. Thus, the constants  $c$  and  $k \ln 2$  respectively express Einstein's spacetime and Boltzmann's information–negentropy equivalences.

*Whenever, as expressed in practical units, a universal constant is very large or small, the implication is that the phenomenology at stake extends well beyond the familiar landscape; acknowledging the finiteness of such a constant is like opening to sailing a new ocean.*

Unknown to Galileo and fully understood long after its discovery, the finiteness of  $c$  reveals that, reciprocal to the conversion of time into space by relative motion there is a conversion of space into time: this was (and still is) hidden to our awareness by the disproportion between our inward and outward perceptions of time.

As for information theory, it unveils a truth hidden since the inceptions of both probability theory and statistical mechanics. In Gabor's words quoted by Brillouin<sup>(14)</sup> "one cannot get anything for nothing, not even an observation"—which must be paid in negentropy. Reciprocally (*a momentous discovery!*) *a representation can be converted into a situation*, which is Maxwell's demon "miracle"; Brillouin has definitely *not* exorcised the demon by handing him a negentropy source!

*Converting a concept into a situation is psychokinesis, an elementary level phenomenon explicitly postulated by the symmetries of the equations.* Descartes<sup>(15)</sup> forecasted it as operating in voluntary action; Eccles<sup>(16)</sup> claims he has proved it in neurophysiology. In a twin-faced reality-and-representation universe à la Hoyle<sup>(5)</sup> psychokinesis may well be what controls biological ontogenesis and phylogenesis.

Lawlike reversibility is evidenced by the finiteness, factlike irreversibility by the smallness of Boltzmann's constant. As one thermal entropy unit (say a clausius) yields some  $10^{16}$  bits (say boltzmanns) both the negentropy cost of information and the very possibility of psychokinesis were ignored until quite recently. Now cybernetics asks consciousness-the-spectator to pay a very cheap ticket, and grants to consciousness-the-actor exorbitant wages.

## 5. QUANTUM TRANSITION AMPLITUDES; SPACE-TIME NONSEPARABILITY

One more reason supporting our scheme is its *manifest correspondence* with Dirac's *transition amplitudes* scheme.

Corresponding to the *reversible conditional, intrinsic collision probability* (1), there is the *Hermitian reversible conditional or transition amplitude*

$$\langle A|C\rangle = \langle C|A\rangle^* \quad (5)$$

Then, together with the *prior, or occupation, amplitudes*  $\langle A|$  and  $|C\rangle$  and the *dressed transition amplitude*

$$|A\rangle \cdot \langle C| := |A\rangle \langle A|C\rangle \langle C| \quad (6)$$

the *composition law*

$$\langle A|C\rangle = \sum \langle A|B\rangle \langle B|C\rangle \quad (7)$$

build up the Dirac amplitudes scheme.

Its built-in Lorentz invariance has been evidenced by Feynman. Its Lüders or CPT invariance is encoded in the Hermitian symmetry: respectively,  $\langle A|C\rangle \rightleftharpoons \langle C|A\rangle$  and  $\langle A|C\rangle \rightleftharpoons \langle A|C\rangle^*$  symbolize the PT-and the particle-antiparticle exchanges.

Concatenations of ABC zigzags build up Feynman graphs, which can be used either predictively or retrodictively.

Finally, the *recipe for the transition probability*

$$P(A|C) = |\langle A|C\rangle|^2 \quad (8)$$

erases respectively the final or the initial phase relations in prediction or in retrodiction. Using a Wheeler<sup>(9)</sup> metaphor we can say that this recipe draws per force the "smoky dragon" down from the complex plane unto the real axis. Alexander, it is said, having cut the Gordian knot, could conquer Asia up to the Indus, where he met "gymnosophists" likening reality to an illusion.

Anyhow, *spacetime nonseparability consists of the presence at each Feynman vertex of a Wheeler dragon*, that is, a *superposition of "virtual states."* In a  $\langle$  or  $C$  shaped ABC zigzag the dragon forbids that any "real hidden state" exists between preparation and measurement. In a  $\wedge$  shaped zigzag it blurs retrodiction telling from which source came any detected particle. And in a  $\vee$  shaped zigzag, "EPR nonseparability" means non-existence in the source of the later measured correlated states. This implies

retrocausation *by definition*—tested as such by Aspect.<sup>(10)</sup> But the story does not end there.

Faster than light telegraphing is *normally* impossible via an EPR correlation because telegrams are sent via retarded waves; it is *paranormally* allowed,<sup>(17)</sup> however, via psychokinesis taking a relay in the past, at B [by its very essence psychokinesis is retropsychokinesis]. A simple setup could use a laser and a semitransparent mirror; for the physicist this may be a more attractive test of psychokinesis than those performed so far.<sup>(6, 7)</sup>

In a recent book Penrose<sup>(18)</sup> endorses the retrocausation rendering of EPR correlations, finding it, however, “not crazy enough.” The needed (and testable) extra-craziness is, I believe, cognizance–psychokinesis reciprocity.

To conclude, for both *use* and *interpretation* of quantum mechanics *the Lorentz and CPT-invariant time-extended transition amplitude is a far more sesame-like opener than the state vector*. CPT noninvariance of the state-vector-collapse concept is indeed a capital sentence worded: *undue legalization of factlike irreversibility*.

## 6. THE UNFOLDING PARADIGM

By a “synchronicity” à la Jung, the belatedly published *Writings on Physics and Philosophy* of Pauli, edited by Enz and von Meyen,<sup>(19)</sup> are just out. Interspersed with comments on the state of the art up to the time of Pauli’s death, they contain acute remarks pointing towards the conclusion I intended to draw.

In *Albert Einstein and the Development of Physics* Pauli quotes Einstein sarcastically saying, “Physics is after all the description of reality, or should I say that physics is the description of what one imagines?” and adds: “This question shows Einstein’s concern that the objective character of physics might be lost through a theory [like] quantum mechanics in that the difference between reality and dream might become blurred.”

In *Phenomenon and Physical Reality*, after a similar remark Pauli conjectures that “the observer in present-day physics is still too completely detached [as he was classically] and that [in the future] physics will depart from [this].” This, as it seems, remains to be done, because Pauli continues: “The results of single observations, not predetermined by laws [can be] checked by many observers [but] not influenced by [them], [as occurring] in the last resort in classical measuring apparatus. In this sense they present themselves as objective reality governed by the laws of probability. Subjective or psychical properties of the observer do not enter physical descriptions of nature. The transformation of state implied by any measurement does not appear as wholeness of subject and object.”

In his paper on *The Idea of Complementary* Pauli writes: "What knowledge is gained and what is *irrevocably lost* [my italics] is left to the experimenter's *choice* [my italics] between mutually exclusive arrangements." Herein resides an ambiguity: *macroscopicity* of the measuring device has often been blamed for *irreversibility*, but what is truly at stake is *shortsightedness: neither seeing nor seizing the needle in the haystack.*

*What makes the loss "irrevocable" is detachment of the observer.*

What blocked Pauli's way forward was that the new concept of (twin faced) *information* escaped his attention: *it is the keystone binding subjectivity with objectivity, and loosening the strangulation by irreversibility.*

Referring in *Science and Western Thought* to Schopenhauer's "direct influences of the will," Pauli sees no philosophical reasons sufficient to dispose of them, and adds: "should the positive results of ESP prove true this would lead to developments unforeseeable."

Pauli should have known better—*via the "Pauli effect."* Fierz, quoted by Enz, writes: "Even quite practical physicists were convinced that strange effects emanated from Pauli... His mere presence in a laboratory produced all sorts of mishaps. His friend Stern never let him enter his laboratory. This is not a legend, I knew Pauli and Stern both very well! Pauli himself thoroughly believed in his effect. He sensed the mischief already before as a disagreeable tension..."

*Concluding:* An implication of the present essay is that physics has fully played its part in this investigation, where further clarification should come from neurophysiology and psychology.

Let Shakespeare spell the conclusion: There is more in Heaven and Earth than in (today's) natural philosophy.

*The twin-faced information concept does bind together epistemology and ontology, reality and representation.*

Reciprocity of *knowledge* and *psychokinesis*, "correctly" dressed as *pre- and post-selection*, is formalized as CPT symmetry.

Smallness of  $k$ , largeness of  $c$ , no more hide this truth.

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