EN_52: We can build quantum machines with conventional electronics

Computing through relations without knowing the value until measurement

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Additional project documents: Q-V construction and comparison sheets · Translators and compilers for V · Presentation to the community · Complete resource index · Relations, measurement and Bell.

Premises of the comparison and the proof

$D_{PROTOCOLO}$ — Protocol and scope of the operational comparison.

The hypothesis of this work is that there exists a physical machine V, buildable with conventional electronics, operationally equivalent to a quantum machine Q in the computational model considered. The comparison will be governed from the outset by the following premises.

1. Strict symmetry of the criterion. Q and V must be subject to the same operational protocol and the same restrictions. V will not be required to meet a criterion that does not also hold for Q, nor will V be granted information or a resource that is not allowed for Q. This rule applies reciprocally to both machines.

2. Explicit correspondence of conditions. Each comparison will define the corresponding preparations, inputs, transformations, measurement settings and readout times. The physical implementations may differ: what must match is the operational protocol being compared. The environmental and operating conditions of each implementation will be declared, without requiring identical components.

3. Equal access to information. If the protocol does not observe the internal values of Q during computation, it will not require observing those of V either. Observed outcomes will not be attributed to measurements not performed in either machine. The conditions of communication, control, synchronization and choice of measurements will be made explicit for both. This access restriction does not presuppose the nature of the physical state of either machine, nor does it by itself prove their equivalence.

4. Distinction between prediction and outcome. P represents the predicted probability of obtaining an output; q and v represent the values recorded when measuring Q and V, respectively. For a binary readout at t = to:

$$q = M_Q(t_0) \in \{0,1\}, \qquad v = M_V(t_0) \in \{0,1\}.$$

Common notation from the outset. We adopt ξ (xi) to indicate that the outcome of a binary readout has not yet been observed. It is a convention of this document, applied with identical meaning to Q and V, not a universal symbol of quantum mechanics. We write $K(A) = \xi$ to express our knowledge of the outcome associated with A, not an assignment of the physical value $A = \xi$. In the expressions $K(Q(t))$ and $K(V(t))$ we refer to the outcome of the readout specified by the protocol, not to complete knowledge of the machine's state.

When that readout is performed at $t = t_0$, $b \in \{0, 1\}$ is recorded. Arrows starting from ξ are diagrams of observation and knowledge, not equations of evolution of the physical state. We reserve ψ for the state description when the model uses it; knowing that state does not amount to knowing the outcome of a run before measurement. Sharing ξ does not presuppose that Q and V have the same dynamics or distribution. The pairs of predictions shown in the comparisons identify the two quantities whose equality must be checked; they do not assert their equality.

Formula notation conventions. To make the expressions readable by the PUBLICAR compiler, col(a,b) denotes the column vector with components a and b; mat((a,b),(c,d)) denotes the matrix whose rows are (a,b) and (c,d). If the entries are blocks, this is the corresponding block matrix, with compatible dimensions declared in each model. norm(z) is the Euclidean norm, or the Hermitian norm of the complex vector. ket(psi) denotes the same state vector as Dirac notation; e_0 and e_1 are the readout basis vectors, and e_j is the vector of that basis with index j in a larger register. These conventions do not change the operations or their physical implementations.

In P(a,c_{\mathrm{protocolo}}), P(a,b,x,y) and analogous expressions, the last arguments are the protocol conditions: these functions represent conditional probabilities, not joint probabilities with the controls. The same convention applies to F for frequencies. Uniforme(0,1) denotes the reference uniform distribution with preparation support 0 less than or equal to r and r less than 1; it adds no point mass at the endpoints. phys(Q) and phys(V) identify the physical implementations, not their outputs. Chains of relations are written as successive maps; when T_j is specified, the recurrence R_j = T_j(R_{j-1}) retains each step. For bits A and B in the domain {0,1}, the NOT gate is written B = 1 - A. This expresses its truth table, not a negation of propositions. The post label identifies the state after a measurement, not a power. c_protocolo is the protocol configuration, distinct from a matrix C or a binary port C. The readout diagrams show the transition from the unobserved outcome to the outcome b belonging to {0,1}; the arrow is not an evolution of xi as though it were a physical value.

The symbol ξ does not constitute a third stored value or determine probabilities: these are derived from the preparation and the operations. Once an output has been recorded, that run has a known outcome; probabilities describe predictions and expected frequencies in repetitions of the protocol. Their general domain is [0,1], including the cases of certainty and impossibility.

5. Full exposition of each equivalence. For each operation, its definition in Q, its proposed implementation in V, the correspondence between them and the justification of their results will be presented. The assumed premises, derived mathematical identities, physical readout rules and available experimental results will be distinguished. The prediction and measurement rules used for Q and V must be made explicit; the equality sought will not be introduced as a premise.

6. Common observable criterion. For a protocol C with corresponding outputs a, equivalence requires:

$$P_V(a, c_{\text{protocolo}}) = P_Q(a, c_{\text{protocolo}}).$$

Experimental comparisons will use common statistical criteria, a declared number of repetitions and justified tolerances. Agreement on an isolated outcome or a marginal distribution does not by itself establish equality of all correlations or all protocols.

7. Scope and composition. The reference Q model and the permitted protocols will be specified. Establishing full equivalence in that model will require justifying the elementary operations, their composition, the permitted measurements and extension to multiple units. A partial equivalence will be identified as such. Equivalence of outcomes and any resource advantage will be assessed separately.

Symmetry of conditions is the starting point of the proof; full operational equivalence V = Q is the hypothesis to be established through the development.

Abstract

$D_{HIPOTESISV}$ — Hypothesis of physical equivalence proposed for investigation, not an established theorem or a premise that can be taken as proven.

This work starts from a very simple question: is it essential to build a machine with specifically quantum components to obtain the computational behavior we seek in a quantum machine?

The hypothesis I develop here is that it is not necessarily so.

I propose a machine, which I will call **V**, buildable using conventional electronics, whose fundamental principle consists in deliberately forgoing knowledge of internal values during the computation process.

The machine does not store ξ.

$$\xi\text{:resultado binario no observado}.$$

The values continue to belong to the logical domain:

$$\{0, 1\}.$$

As long as we do not measure, we do not know which one we have. However, not knowing the values does not mean not knowing the **relations between them**.

We can know, construct and transform relations between unknown values. We can propagate those relations, introduce delays, phases, excitations, inhibitions and compositions without performing an intermediate measurement.

Only when we impose a measurement at:

$$t = t_0$$

do we necessarily obtain:

$$b \in \{0, 1\}.$$

The proposal consists in subjecting a quantum machine Q and a conventional machine V to exactly the same operational conditions and studying whether there is any observable operation of Q that V cannot replicate.

V does not aim to mathematically simulate Q.

$$\text{V replica Q; no simula Q.}$$

What is presented is a working hypothesis and an invitation to study it, discuss it, extend it, refute it or build it.

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1. The origin of the idea

$P_{INVERSION}$ — An inverter establishes a relation between input and output without requiring their prior readout.

In a conventional computer we want to know and control the logical states. But we can physically build a conventional circuit and **forgo knowing the value traveling through that circuit**.

A transistor does not need an observer to know the value on which it acts. Neither does a NOT gate.

If $K(A) = \xi$, we can physically construct:

$$B = (1 - A)$$

without measuring A beforehand. Then:

$$K(A) = \xi, \qquad K(B) = \xi,$$

but we know:

$$A \neq B\ .$$

or:

$$A \oplus B = 1\ .$$

We can be unaware of the values and know the relations.

2. What ξ means

$D_{DESCONOCIDO}$ — Epistemological notation and binary domain.

We will write $K(A) = \xi$ when the value of A is unknown.

$$\xi \text{ no es un valor}\ .$$

We are not defining $\{0, 1, \xi\}$. The logical domain remains:

$$\{0, 1\}\ .$$

ξ is not a third logical state, a stored value, an electronic signal, a superposition that we must implement or a hidden variable. It is our notation for:

valor desconocido.

We can write $K(A) = \xi$ to make explicit that we are talking about our knowledge. The machine does not store ξ.

3. Measurement

$D_{LECTURA}$ — Outcome recorded at the time of observation.

Deps: D_DESCONOCIDO

When observing A at $t = t_0$ we perform $M(A, t_0)$ and:

$$M(A, t_0) \in \{0, 1\}.$$

Never $M(A, t_0) = \xi$. Therefore:

$$\xi \mapsto b \in \{0, 1\}$$

expresses that beforehand we do not know the value and afterward we know the outcome.

4. Collapse understood as measurement

Until $t = t_0$ we do not know the outcome. At $t = t_0$ we measure and obtain $b \in \{0, 1\}$.

For this work, the experimental consequence is sufficient:

antes de medir: resultado desconocido;

después de medir: resultado conocido.

5. Two machines: Q and V

We will use Q for the quantum machine and V for the VED machine.

> **We will not require from V information that we do not require from Q, nor attribute to V a value that we do not observe in Q.**

Before measurement:

$$K(Q(t)) = \xi, \qquad K(V(t)) = \xi.$$

Upon measurement:

$$M_Q(t_0) \in \{0, 1\}, \qquad M_V(t_0) \in \{0, 1\}.$$

Thus:

$$Q{:}\xi \mapsto b \in \{0, 1\}$$

$$V{:}\xi \mapsto b \in \{0,1\}$$

6. Computing without measuring internal values

The proposal does not consist in hiding from the user a variable known internally. During computation we do not use measurement of internal values as a necessary condition for continuing.

If:

$$K(A) = \xi, \qquad B = (1 - A), \qquad C = B, \qquad D = (1 - C),$$

we can keep the individual values unknown and know the entire relational structure. **Computational information lies in the relations.**

7. Computing relations

$D_{RELACIONES}$ — Transformations of relations without intermediate observation.

Deps: D_PROTOCOLO, D_DESCONOCIDO

Let us represent the relations by R. We can apply transformations:

$$R_j = T_j(R_{j-1}), \qquad j \in \{1, \ldots, n\}\,.$$

While:

$$K(V_1) = \xi, K(V_2) = \xi, \ldots, K(V_n) = \xi\,.$$

The principle is:

transformar relaciones sin medir los valores relacionados.

8. A physical operation does not need to know its input

For an inverter:

$$B = (1 - A)\,.$$

It does not need to perform $M(A)$ first. Therefore:

$$\xi \mapsto \xi$$

does not mean that nothing has happened: we know exactly the relation $B = (1 - A)$, even though A and B are unknown.

9. The time function $f(t)$

D_{TIEMPO} — Physical evolution and readout time.

Deps: D_LECTURA, D_RELACIONES

We introduce a physical evolution $f(t)$. It can describe the evolution of the machine while:

$$K(V(t)) = \xi$$

and $R(t)$ evolves.

Measurement selects $t = t_0$:

$$M(V(t_0)) \in \{0, 1\}.$$

The binary outcome comes from having restricted this first V to the logical mode comparable to a qubit, not from $f(t)$ being binary.

10. The biological neuron as inspiration

A possible future V may be more like a biological neuron: multiple excitatory and inhibitory signals, pulses, temporal trains, delays and feedback.

A V unit could incorporate:

$$\text{excitación}, \quad \text{inhibición}, \quad \text{retardo}, \quad \text{fase}, \quad \text{realimentación}.$$

This work first establishes the principle, not the complete construction.

11. Phase ϕ

Phase must be treated symmetrically:

$$Q' = \Phi_\phi(Q), \qquad V' = \Phi_\phi(V).$$

Here Phi_phi denotes the phase phi operation of each model; it is not presupposed that their physical implementations are the same. The control phi is retained explicitly, even when the state has not been observed.

Symmetric execution and readout rule. In this protocol, neither Q nor V is required to determine, measure or expose its internal phase before measurement at $t = t_0$. V is not assigned a prior readout that Q is not required to perform. Applying a phase transformation does not require a prior phase readout. An operation parameter explicitly supplied as input is distinct from an unknown internal value. Operations run without intermediate readouts; the latch jointly records internal and external states at $t = t_0$. The Q reference is consulted only after V has finished.

We can know:

$$X^{'} = T_{\phi}(X)$$

without knowing X or $X^{'}$:

$$K(X) = \xi, \qquad K(X^{'}) = \xi\,.$$

Therefore:

conocer la transformación ≠ conocer el valor transformado .

11.1. Amplitudes: independent definitions and comparison criterion

$D_{AMPLITUDES}$ — Q amplitudes and normalization of V signals.

Deps: D_PROTOCOLO, D_LECTURA

For Q we write the pure state of one unit in the readout basis:

$$\text{ket}\,(\psi_{Q}(t)) = \alpha_{Q}(t)e_{0} + \beta_{Q}(t)e_{1}\,, \qquad |\,\alpha_{Q}\,|^{2} + |\,\beta_{Q}\,|^{2} = 1\,.$$

For the candidate signal implementation of V, let s0(t) and s1(t) be the complex envelopes of two coherent channels, described through real amplitude and phase components. They do not represent bits already read. If the total power p_norm = |s0|² + |s1|² is positive, we define:

$$\alpha_{V} = \frac{s_{0}}{\sqrt{p_{\text{norm}}}}, \qquad \beta_{V} = \frac{s_{1}}{\sqrt{p_{\text{norm}}}}\,.$$

Normalization gives |αV|² + |βV|² = 1. These are normalized signal amplitudes; calling them probability amplitudes additionally requires a readout rule connecting their squared moduli to the frequencies of binary outputs. That connection is developed in section 12.2. It does not follow solely from lack of knowledge of internal values.

The symbol ξ is reserved for knowledge of unread outputs. Amplitude expressions mathematically describe this signal model; they are not an instruction to read, estimate or calculate a run's internal values before $t = t_{0}$. Knowing a transformation law is not the same as observing the signals on which it acts. A complex amplitude is not identified with a binary outcome or a real probability.

The comparison objective in this signal model is:

$$\text{col}\,(\alpha_{V}(t), \beta_{V}(t)) = e^{i\gamma(t)}\ \text{col}\,(\alpha_{Q}(t), \beta_{Q}(t)),$$

with γ a global phase common to both channels. This correspondence is a sufficient criterion for the operations and measurements of the model, not a requirement that every V architecture have those same internal states. The hypothesis is not introduced as a result: it is checked through the evolution equations and initial conditions.

11.2. Time evolution of Q and a candidate V implementation

For an ideal closed Q, we define GQ = HQ/ħ. Its evolution is:

$A_{EVOLUCIONQ}$ — Law of the ideal closed Q model, cited as a reference.

Deps: D_AMPLITUDES

$$i\frac{dz_Q}{dt} = G_Q(t)z_Q(t), \qquad G_Q^\dagger = G_Q\ .$$

The unitary evolution generated by the Hamiltonian is described in IBM Quantum Learning: Utility II.

For V we propose a continuous signal block with the following real specification. We write GV = A + iB, with A real symmetric and B real antisymmetric, and s = u + iv. The components must satisfy:

$D_{CIRCUITOV}$ — Specified law for the candidate signal block; its physical implementation remains to be validated.

Deps: D_AMPLITUDES

$$\frac{d}{dt}\ \mathrm{col}\ (u,v) =\ \mathrm{mat}\ ((B,A),(-A,B))\ \mathrm{col}\ (u,v)\ .$$

This equation prescribes integrations and linear couplings between signal components. A candidate circuit will have to implement its coefficients through specified and calibrated elements and connections. It is not asserted that an inverter, an AND gate or an arbitrary ALU automatically satisfies this law. It is a proposed dynamic design, not an experimental characterization of the author's original circuit.

Multiplying and grouping its real and imaginary components yields:

$$\dot{s} = (B - iA)s =\ -iG_V\, s\ .$$

The block's real matrix is antisymmetric. Consequently:

P_{NORMAV} — Conservation of the norm under the ideal law D_CIRCUITOV.

Deps: D_CIRCUITOV

$$\frac{d}{dt}(s^\dagger s) = is^\dagger G_V^\dagger s - is^\dagger G_V\, s = 0\ .$$

Therefore, N is constant in this ideal model and signal normalization does not add a nonlinear evolution:

$$i\dot{z}_V\ = G_V\, z_V\ .$$

Both laws have been set out: one is that of the reference Q model; the other is obtained from the real couplings prescribed for V. Their developments are not declared in advance to be different.

$T_{AMPLITUDECOND}$ — Conditional equivalence of the ideal evolutions.

Deps: D_AMPLITUDES, A_EVOLUCIONQ, D_CIRCUITOV, P_NORMAV

Equality of generators means equality of the functions GV and GQ throughout the evolution interval considered, not just at one instant. They are assumed to be continuous over that interval, so that the linear problem with the declared initial preparation has a unique solution.

$$(G_V\ = G_Q \wedge z_V(t_i) = z_Q(t_i)) \Longrightarrow z_V(t) = z_Q(t)\ .$$

Proof under the declared assumptions: if the preparation and calibration correspond with GV(t) = GQ(t), the difference e = zV − zQ satisfies i ė = GQ e and e(0) = 0. By uniqueness of the solution of the linear equation, for continuous or piecewise regular coefficients, e(t) = 0. If GV = GQ + g(t)I, with g real, only the global phase exp(−i∫g dt) appears, without changing the probabilities of the isolated register.

Conditional evolution result. Under those laws, preparation and calibration, the amplitudes evolve identically until readout, up to a global phase. Verifying the coefficients of a real circuit is an experimental obligation; assuming their equality does not replace it.

11.3. Explicit solution for two coupled channels

$P_{SOLUCION}$ — Solution of the two-channel laws with constant coefficients.

Deps: A_EVOLUCIONQ, D_CIRCUITOV

For constant coefficients, we consider separately in each model a matrix of the form:

$$G_X = \text{mat}\left((\omega_{0X}, \kappa_X e^{-i\chi_X}), (\kappa_X e^{i\chi_X}, \omega_{1X})\right), \qquad X \in \{Q, V\}.$$

We define ΩX = (ω0X + ω1X)/2, ΔX = (ω0X − ω1X)/2 and gX = √(ΔX² + κX²). For τ = t − ti, cX = cos(gXτ) and hX = sin(gXτ)/gX, with hX = τ if gX = 0, we obtain:

$$P_{SOLUCION}: \quad \alpha_X(t) = e^{-i\Omega_X \tau}\left[(c_X - i\Delta_X h_X)\alpha_X(t_i) - i\kappa_X e^{-i\chi_X} h_X \beta_X(t_i)\right], \qquad \beta_X(t) = e^{-i\Omega_X \tau}\left[- i\kappa_X e^{i\chi_X} h_X\right.$$

The derivation uses (GX − ΩXI)² = gX² I and the exponential series. It has not used an intermediate measurement. The expressions allow parameters of both machines to be compared without imposing equality on their outputs: when the initial conditions, Δ, κ and χ correspond, the development matches up to the global phase due to Ω. If the parameters do not correspond, both responses are calculated before concluding whether there is an observable difference for the chosen protocol.

As checks of this solution:

- If κ = 0, the channels retain their moduli and accumulate phases exp(−iω0τ) and exp(−iω1τ); the relative phase changes by −(ω1 − ω0)τ in both models.
- If Δ = 0 and the input is (1,0), the normalized intensities are cos²(κτ) and sin²(κτ) in both models.
- If Ω = Δ = χ = 0 and κτ = π/2, the block implements −iX: it swaps the amplitudes up to a global phase.
- If Ω = χ = 0, Δ = κ = g/√2 and gτ = π/2, the block implements −iH. Two blocks of that type produce −I, equivalent to the identity for readouts of the isolated register.

These checks verify phase evolution, transfer between channels and composition. The agreement does not arise from attributing a dynamic law to lack of knowledge, but from solving the specified laws.

11.4. Measurement, mixtures and imperfections: scope of the development

In Q, the readout rule in the reference basis assigns $|\alpha Q|^2$ and $|\beta Q|^2$. In V, that assignment is justified only if the proposed physical readout implements the probabilities $|\alpha V|^2$ and $|\beta V|^2$; its conditional proof is set out in section 12.2. Identical amplitude evolution does not allow verification of readout and update to be omitted.

For statistically mixed preparations, amplitudes are not averaged as though all runs were coherent. The density states $\rho X = E[zX\ zX^{\dagger}]$, operations and observable distributions are compared. This avoids confusing lack of knowledge of the preparation with coherent phase.

Losses, unforeseen delays, noise and coefficient errors will be declared in both implementations. An ideal Q is not compared with an imperfect V to attribute the difference to their principles, nor are V's imperfections omitted when comparing real devices. Equality of the ideal equations is a conditional mathematical result; equality of devices requires physical characterization and common tolerances. Comparing a V architecture different from this signal model requires its own evolution laws.

As an additional check of the formulas, the four real equations of V have been directly integrated and compared with the complex solution in 103 cases of constant evolution. The maximum numerical error was approximately 8.49×10^{-12}; the norm conservation error was approximately 7.32×10^{-14}. The X, H and H-H blocks and a sequence of eight control segments were also checked. These are numerical checks of the model, not data from a physical device or proof of the readout hypotheses of section 12.2.

12. Two paths and relative phase

$P_{INTERFERENCIA}$ — Sum and difference identities for coherent phases.

Deps: D_AMPLITUDES

If:

$$\phi_B - \phi_A = \phi,$$

we can combine:

$$R_C \propto e^{i\phi_A} + e^{i\phi_B},$$

$$R_D \propto e^{i\phi_A} - e^{i\phi_B}.$$

With $\phi_B = \phi_A + \phi$:

$$R_C \propto e^{i\phi_A}(1 + e^{i\phi}),$$

$$R_D \propto e^{i\phi_A}(1 - e^{i\phi}).$$

And:

$$P_{INTERFERENCIA}: \quad |1 + e^{i\phi}|^2 = 4\cos\left(\frac{\phi}{2}\right)^2, \qquad |1 - e^{i\phi}|^2 = 4\sin\left(\frac{\phi}{2}\right)^2.$$

This does not determine in advance which output we will observe. Before measurement:

$$K(C) = \xi, \qquad K(D) = \xi\,.$$

12.1. First explicit Q-V comparison protocol

$D_{PROTOCOLOFASE}$ — Preparation and operations of the phase comparison.

Deps: D_PROTOCOLO, D_AMPLITUDES, P_INTERFERENCIA

We fix a protocol Cφ: reference preparation, splitting into two paths of equal amplitude, application of a relative phase φ, recombination and binary readout at t = to. No intermediate readout of the paths will be performed in either machine.

Preparation is a specified operation, not an obligation to continuously observe the internal state. The time to is fixed relative to the start of each run by a common timing rule.

Development of the protocol in Q

In the ideal one-qubit model, we represent splitting and recombination by H and the phase change by Uφ:

$$H = \frac{1}{\sqrt{2}}\,\mathrm{mat}\,((1,1),(1,-1)), \qquad U_\phi = \mathrm{mat}\,((1,0),(0,e^{i\phi}))\,.$$

For the reference preparation |0⟩, the state before readout is:

$$HU_\phi He_0 = \frac{1+e^{i\phi}}{2}e_0 + \frac{1-e^{i\phi}}{2}e_1\,.$$

The measurement rule of the Q model assigns to each output the squared modulus of its amplitude. Therefore:

$$P_Q(q=0, C_\phi) = \cos(\phi/2)^2, \qquad P_Q(q=1, C_\phi) = \sin(\phi/2)^2\,.$$

This rule and the role of phase in operations are described in IBM Quantum Learning: Quantum information. The derivation above applies those rules to the protocol defined here.

Corresponding development in V

To make the proportional expressions in this section precise, we consider two coherent signals of equal amplitude and an ideal recombination with calibrated gains. The common amplitude and phase factor is removed by normalization. The normalized output signals are:

$$c_V(\phi) = \frac{1+e^{i\phi}}{2}, \qquad d_V(\phi) = \frac{1-e^{i\phi}}{2}\,.$$

These numbers describe amplitudes and phases of physical signals, not two binary values read simultaneously or a stored ξ. Their specific electronic implementation must specify how the signals are produced and combined. Mathematical notation does not replace that implementation.

We obtain the identity:

$$I_C = |c_V|^2 = \cos(\phi/2)^2, \qquad I_D = |d_V|^2 = \sin(\phi/2)^2, \qquad I_C + I_D = 1\,.$$

Thus, under the declared signal conditions, the normalized intensities of V match the probabilities predicted by Q. Calculating these quantities does not require observing internal values during the run; likewise, calculating the amplitudes of Q does not require measuring them.

Readout rule and scope of the equivalence

In Q, a rule connecting amplitudes to probabilities of binary outputs has been made explicit. To complete the comparison, the corresponding physical rule of V must be made explicit and justified as to whether it satisfies:

$$P_V(v=0, C_\phi) = I_C, \qquad P_V(v=1, C_\phi) = I_D\ .$$

This requirement is symmetric: both descriptions need a connection between their physical evolution and the recorded outcomes. It does not require V to share Q's physical mechanism, or its interior to be measured beforehand. Nor does it allow intensity and probability to be identified automatically.

If V's readout satisfies these equalities, equivalence of output distributions is established for this ideal protocol:

$$P_V(v=a, C_\phi) = P_Q(q=a, C_\phi), \qquad a \in \{0,1\}\ .$$

What is established here is the algebraic agreement of normalized intensities with the reference probabilities and the precise condition for converting it into readout equivalence. It is not presented as an experimental measurement or as proof of equivalence for all protocols.

Reference results for the comparison

Relative phase φ	P_Q(0)	P_Q(1)	Outcome required of V's readout
0	1	0	Output 0 with certainty in the ideal model
π/2	1/2	1/2	Both outputs with the same probability
π	0	1	Output 1 with certainty in the ideal model
3π/2	1/2	1/2	Both outputs with the same probability

The general proof of this protocol covers all values of φ; these four cases are checkpoints, not a substitute for it. In real devices, the imperfections of both machines will be declared and the frequencies compared with common statistical uncertainties. Exact equality between frequencies of independent finite samples will not be required.

12.2. A candidate electronic readout and its conditional proof

$D_{COMPARADOR}$ — Candidate threshold and time-reference circuit.

Deps: D_LECTURA, D_PROTOCOLOFASE

To move from intensities toward a binary output, we present a candidate construction. It is a proposed extension of the V model, not the description of a prototype already built or an experimental result. Nor does it presuppose that this mechanism is the only possible one.

This comparator is a specific proposal, not an additional rule of the author's V machine. Its conditions apply only to this construction and its conditional proof. The equations below describe the comparator's internal operation; they do not require the observer to know or measure the phase, signals or threshold beforehand. In particular, they do not replace the latch trigger at $t = t_0$ with an early readout or an answer obtained from Q.

Signals feeding the readout

Let cV and dV be the complex signals of the previous section. Their description can be given through four real components:

$$c_V = x_C + iy_C, \qquad d_V = x_D + iy_D .$$

We define the physical quantities that the readout block must produce:

$$J_C = x_C^2 + y_C^2, \qquad J_D = x_D^2 + y_D^2, \qquad w = \frac{J_C}{J_C + J_D} .$$

The construction requires J_C + J_D > 0. If both signals are zero, the run is invalid and must be recorded as such, without assigning it an arbitrary probability. In the ideal protocol of section 12.1:

$$w = \cos(\phi / 2)^2 .$$

The candidate circuit transforms signals through physical operations of squaring, addition and normalization. It does not need an observer to know the numerical values during computation. This internal signal transformation is not identified with external observation of the output. Its effects and possible disturbances must be included in the physical implementation.

Time reference and comparator

We introduce a periodic reference with initial phase η, and describe its normalized position at the readout time by:

$$r(t_0) = \text{ frac } (\frac{\omega t_0 + \eta}{2\pi}), \qquad 0 \le r(t_0) < 1 .$$

Here frac takes the fractional part and ω is the angular frequency of the reference. A ramp signal can represent that phase position. The comparator, followed by a register triggered at t0, delivers:

$$(r(t_0) < w \Longrightarrow v = 0), \qquad (r(t_0) \ge w \Longrightarrow v = 1) .$$

This is a readout mechanism defined through signals and a threshold; it does not introduce ξ as a state of the circuit. The outcome may be determined by the physical conditions of each run even though it is not known to the observer before readout.

Preparation condition that must be justified

$D_{CONDICIONREFERENCIA}$ — Condition of uniformity and independence of the reference; not an assertion that it has been physically verified.

Deps: D_COMPARADOR

The proof requires the phase η to be uniformly distributed over [0,2π) across preparations, independently of φ and the protocol controls. The time to is fixed according to the common rule and is not chosen after consulting η. These conditions imply:

$$r(t_0) \mid C_\phi \sim \text{Uniforme}\,(0,1)\,.$$

Not knowing η does not prove that its distribution is uniform. The distribution and its independence must be justified through the preparation mechanism and tested experimentally. The construction does not require a particular interpretation of probability: a distribution over unknown preparations is sufficient for the following derivation.

The reference and its preparation are declared physical resources of V. They do not provide information about Q's output. Their admissibility must be checked against the restrictions of the common protocol. If it prohibits that resource, this candidate construction does not satisfy its premises.

Derivation of readout probabilities

$P_{LECTURAUNIFORME}$ — Comparator probabilities under D_CONDICIONREFERENCIA.

Deps: D_COMPARADOR, D_CONDICIONREFERENCIA

Under the above conditions, w is fixed by the protocol and:

$$P_V(v=0, C_\phi) = P(r(t_0) < w \mid C_\phi) = \int_0^w dr = w\,.$$

By complementarity:

$$P_V(v=1, C_\phi) = 1 - w\,.$$

Substituting the calculated value of w:

$$P_V(v=0, C_\phi) = \cos(\phi/2)^2\,, \qquad P_V(v=1, C_\phi) = \sin(\phi/2)^2\,.$$

Conditional proposition. If V implements the signal transformation of section 12.1, produces the indicated threshold w and satisfies the preparation and readout conditions of this section, it reproduces the distribution of Q's final readout for all values of φ in this ideal protocol.

The proof also covers the endpoints: for w = 0 the comparator always delivers 1; for w = 1 it always delivers 0, since r belongs to [0,1). There is no need to read or select an individual outcome beforehand.

What has been established and what remains to be built

Element	Result of this development	Physical validation pending
Two-path transformation	Algebraic identity of amplitudes and intensities	Circuit and amplitude and phase calibration
Threshold w	Normalization defined for nonzero signals	Signal operations and threshold precision
Time reference	Uniformity of r if the conditions on η are met	Preparation, independence and stability
Binary readout	Distribution derived through the ideal comparator	Recording at t_0, response times and errors

This construction implements an output distribution through a candidate physical mechanism. It does not by itself prove a complete quantum architecture, a resource advantage or an equivalence of successive measurements. After each readout, the subsequent evolution and preparation of V must be specified and compared with those of Q. Equivalence of multiple units also requires joint distributions; it is not obtained automatically from this equivalence of a single readout.

12.3. Successive measurements: construction and equivalence of one ideal unit

$D_{ACTUALIZACION}$ — Transformation and feedback of the one-unit model.

Deps: D_CIRCUITOV, D_COMPARADOR, P_LECTURAUNIFORME

The preceding readout must be completed with a transformation following the outcome. Keeping the previous signals unchanged does not, in general, reproduce successive measurements of Q. We propose the following ideal feedback mechanism, whose physical operation must be validated.

Signal state and operations between measurements

We describe a V unit through two normalized complex signals:

$$z = \mathrm{col}\,(\alpha, \beta), \qquad |\alpha|^2 + |\beta|^2 = 1\,.$$

This is a mathematical description of signals; it does not assume that the binary output has been observed. The corresponding Q state is:

$$\mathrm{ket}\,(\psi) = \alpha e_0 + \beta e_1\,.$$

For each unitary operation U permitted by the protocol, V's transformation block must implement $z' = Uz$. A specification in real signals is obtained by writing $U = A + iB$, with A and B real matrices:

$$\mathrm{col}\,(\mathrm{Re}\,z',\ \mathrm{Im}\,z') = \mathrm{mat}\,((A, -B), (B, A))\ \mathrm{col}\,(\mathrm{Re}\,z,\ \mathrm{Im}\,z)\,.$$

The real matrix is orthogonal if U is unitary. It defines the gains and linear combinations that an ideal analog block acting on four real components would require. This calculation specifies the transformation; it does not yet establish a circuit built with sufficient precision.

Readout and feedback in the reference basis

At each measurement time tk, the threshold w = |α|² is physically calculated through the readout block. The comparator delivers 0 when rk < w and 1 otherwise. After the output is recorded, feedback prepares the signals corresponding to the outcome:

$$(v = 0 \Longrightarrow z_{\text{post}} = e_0), \qquad (v = 1 \Longrightarrow z_{\text{post}} = e_1), \qquad e_0 = \text{col}\,(1, 0), \quad e_1 = \text{col}\,(0, 1).$$

The register selects the channel to retain and reinitializes the pair of signals with reference amplitude. For an isolated unit this matches, up to a global phase with no observable effect, the post-measurement state of an ideal projective measurement of Q in that basis.

If the protocol permits only a final readout at t0, this feedback is not activated during computation. If it permits multiple measurements, both machines are read at the same times t1, ..., tm. No additional measurements are introduced in V to obtain information unavailable in Q.

Measurement in a basis chosen by the protocol

Let b0 and b1 be the orthonormal vectors of the chosen basis, and let B = (b0 b1) be the unitary matrix whose columns are those vectors. V's measurement operation is defined through three steps:

1. Transform the signals to that basis: y = B†z.
2. Read through the comparator with threshold w = |y0|².
3. After the outcome v, prepare the signals z⁺ = B ev = bv.

We obtain:

$$P_V\,(v = a, z, B) = \ | \, b_a^{\dagger} z|^2, \qquad z_{\text{post}} = b_a \ .$$

The corresponding projective measurement of Q has those same probability values and prepares the same basis vector, up to a global phase. Q's update rule is made explicit here; V is not required to perform any update absent from the reference Q model. See IBM Quantum Learning: Quantum information, multiple systems for the measurement rule and the update conditioned on the outcome.

Renewal of the readout reference

It is not enough for each rk to be marginally uniform. To reproduce sequences, it must be uniform conditioned on the previous history hk−1 and on the present protocol controls:

$$r_k \ | \, (h_{k-1}, C) \sim \text{Uniforme}\,(0, 1).$$

A fresh, independent reference at each readout satisfies this condition. Reusing an unknown phase without justifying its correlations is not enough. The preparation of those references and their independence are physical obligations of this candidate construction, not results already obtained through the observer's lack of knowledge.

Proof for finite sequences

$T_{SECUENCIACOND}$ — Equivalence of sequences conditional on the declared ideal rules and reference renewal.

Deps: D_PROTOCOLO, D_ACTUALIZACION, P_LECTURAUNIFORME

We assume the same initial preparation, V blocks implementing the corresponding unitary operations, the above readout and feedback, and references satisfying the renewal condition. We consider a finite protocol on an isolated qubit, with ideal projective measurements in any basis and decisions that may depend on previous outcomes. The same previous outcomes allow the same decisions in both machines.

Before the first operation, their amplitude descriptions match. Each operation applies the same transformation U, so that this correspondence is preserved until the first measurement. Conditional uniformity of r1 provides the same probability for each output. After output a1, V prepares b_a1 and Q is left in that same basis state.

By induction, for each history of nonzero probability, both machines preserve that correspondence before the next operation, assign the same conditional probabilities to the next measurement and prepare corresponding subsequent states. In the following equality, $c_{\text{protocolo}}$ fixes the protocol and its control rules; the vertical bar indicates conditioning. For k = 1, the previous history is empty. By the product rule:

$$P_V(a_1, \ldots, a_m \mid c_{\text{protocolo}}) = \prod_{k=1}^{m} P_V(a_k \mid a_1, \ldots, a_{k-1}, c_{\text{protocolo}}) = P_Q(a_1, \ldots, a_m \mid c_{\text{protocolo}}).$$

Impossible histories have probability zero in both machines; they do not require defining a state conditioned on an impossible event.

Result. This ideal construction reproduces all distributions of finite sequences of unitary operations and projective measurements of an isolated qubit, under the declared conditions. Within that model it resolves subsequent readout and temporal composition, not just the distribution of a final measurement.

Checks distinguishing a complete readout from simple sampling

Common protocol	Prediction in Q and in the defined ideal V
Two consecutive readouts in the same basis, with no intermediate operation	The second outcome repeats the first with certainty
Prepare e0, apply H twice and measure in the reference basis	Output 0 with certainty
Measure first in the reference basis and then in the H basis	The second output has probabilities 1/2 and 1/2, conditioned on either first outcome

The first row requires feedback; obtaining only the correct distribution of one output does not guarantee it. The second requires preserving phase and amplitudes during composition, without intermediate readouts.

The result is conditional on implementation of the ideal blocks. It does not yet prove a validated physical machine, general measurements with effects different from those defined here, behavior of a unit entangled with another or full equivalence of a register of n qubits. Nor does it prove a resource advantage. Those extensions need their own development and do not follow from repeating isolated units.

13. Frequency does not mean a probabilistic physical cause

$D_{FRECUENCIAS}$ — Observable frequencies and probabilities of the comparison.

Deps: D_LECTURA, D_PROTOCOLO

After n_ensayos measured experiments, with n_ensayos greater than zero, we can count N_0 and N_1 and construct:

$$F(0) = \frac{N_0}{n_{\text{ensayos}}}, \qquad F(1) = \frac{N_1}{n_{\text{ensayos}}}.$$

The operational comparison asks whether:

$$F_Q(0,\phi) = F_V(0,\phi), \qquad F_Q(1,\phi) = F_V(1,\phi),$$

or:

$$(P_Q(a,\phi), P_V(a,\phi)).$$

14. Each measurement constitutes an experiment

A measurement at $t = t_0$ and another at $t = t_1$ are different experiments unless there is an explicit preparation connecting them:

$$E_0 : \xi \mapsto b \in \{0,1\},$$
$$E_1 : \xi \mapsto b \in \{0,1\}.$$

E_0 is observed at t=t0 and E_1 at t=t1, with their respective preparations.

We do not introduce a known trajectory that we have never measured.

15. Alternative measurements

Let M_0, M_1 and $x \in \{0,1\}$. Beforehand:

$$K(Q) = \xi, \qquad K(V) = \xi.$$

At $t = t_0$:

$$M_x(Q, t_0) \mapsto q \in \{0, 1\},$$
$$M_x(V, t_0) \mapsto v \in \{0, 1\}.$$

The measurement not chosen does not thereby receive an observed outcome. It requires another experiment, which starts again with unknown values.

16. Two correlated units

$D_{DISTRIBUCIONCONJUNTA}$ — Output distribution of two units.

Deps: D_FRECUENCIAS

We have:

$$K(Q_A) = \xi, \quad K(Q_B) = \xi, \qquad K(V_A) = \xi, \quad K(V_B) = \xi.$$

With settings $x, y \in \{0, 1\}$, when measuring at $t = t_0$ we obtain (a, b) with:

$$a, b \in \{0, 1\}.$$

We construct:

$$P_Q(a, b, x, y), \qquad P_V(a, b, x, y).$$

The replication condition is:

$$P_V(a, b, x, y) = P_Q(a, b, x, y).$$

17. Do not invent unmeasured outcomes

We do not impose on V a prior table (a_0, a_1, b_0, b_1) if those outcomes have never been jointly observed. Each setting requires its experiments and the same rule applies to Q and V.

18. Observable correlations

We can map $0 \mapsto -1$, $1 \mapsto 1$ and construct:

$$E(x, y) = \sum_{a, b \in \{0, 1\}} (2a - 1)(2b - 1)\, P(a, b, x, y).$$

Also:

$$S = E(0, 0) + E(0, 1) + E(1, 0) - E(1, 1).$$

The question is:

$$(E_V(x, y), E_Q(x, y)).$$

If an observable difference appears we find a limit; otherwise, the parallel remains.

18.1. Joint correlation and separation conditions

$D_{CORRELACIONES}$ — Correlations of recorded bits and local conditions.

Deps: D_DISTRIBUCIONCONJUNTA

Equality of marginal probabilities is not sufficient for equivalence. Two outputs can be individually balanced and yet have different joint correlations. We use signs A, B in {−1,+1} to distinguish them from the recorded bits a, b. With the convention of this section, A = 2a − 1 and B = 2b − 1:

$$E(x,y) = \sum_{a,b \in \{0,1\}} (2a-1)(2b-1)P(a,b,x,y)\,.$$

If the two V units are separated and their responses satisfy a local description with shared conditions λ independent of the choices x, y, the distribution has the form:

$$P_V(a,b,x,y) = \int d\mu(\lambda)\, P_A(a \mid x,\lambda) P_B(b \mid y,\lambda)\,.$$

Here λ describes the shared physical conditions of the preparation; it is not the symbol ξ or an additional readout. This factorization is a locality hypothesis that must be declared, not automatically attributed to any V architecture.

We define the mean responses A_x(λ), B_y(λ) in [−1,1]. For each λ:

$P_{CHSHLOCAL}$ — Bound on correlations under the local factorization explicitly declared in D_CORRELACIONES.

Deps: D_CORRELACIONES

$$|A_0(B_0+B_1)+A_1(B_0-B_1)| \le |B_0+B_1| + |B_0-B_1| \le 2\,.$$

Integrating gives |S_V| ≤ 2. This derivation does not require jointly observing outcomes of alternative measurements: it uses conditional probabilities and local factorization, not a table of counterfactual observations. Lack of knowledge of λ does not remove that bound.

$$P_{CHSHLOCAL}: \quad |S_V| \le 2\,.$$

Q can produce S_Q = 2√2. For example, for the reference state (|00⟩ + |11⟩)/√2 and the observables A0 = Z, A1 = X, B0 = (Z + X)/√2 and B1 = (Z − X)/√2, the correlations are:

$$E_{00} = E_{01} = E_{10} = \frac{1}{\sqrt{2}}, \qquad E_{11} = -\frac{1}{\sqrt{2}}\,.$$

The CHSH comparison and its bounds are documented in IBM Quantum: CHSH inequality.

Consequence for the symmetric premises. If the Q protocol requires independent choices and no communication between the stations during readout, V must respect those same restrictions. A V architecture with the above local factorization cannot replicate that result. Refraining from observing its internal values is not enough.

A central device accessing x and y can generate that joint distribution, but does not prove equivalence with two separated stations without communication. They are different protocols. The absence of signaling in the marginals does not prove the absence of internal communication either.

This limit does not rule out all central computational protocols of V. It does require distinguishing their scope from universal physical equivalence, including distributed Bell experiments.

19. Composition

We start from $K(V_0) = \xi$ and compose:

$$V_n = R_n \circ R_{n-1} \circ \cdots \circ R_1 (V_0).$$

From the standpoint of our knowledge:

$$\xi \mapsto \xi \mapsto \xi \mapsto \cdots \mapsto \xi$$

and at the end:

$$\xi \mapsto b \in \{0, 1\}.$$

20. From one unit to n units

Before measurement:

$$K(V_1) = \xi, K(V_2) = \xi, \ldots, K(V_n) = \xi.$$

With a network:

$$R = \{R_1, R_2, \ldots, R_m\},$$

we can know R without knowing the individual values. The relations evolve:

$$R_0 \mapsto R_1 \mapsto \cdots \mapsto R_k,$$

while:

$$\forall i, \quad K(V_i) = \xi.$$

20.1. Symmetry audit: common protocol and independent machines

$D_{SIMETRIA}$ — Scope of the comparison and its symmetric obligations.

Deps: D_PROTOCOLO

The statement “if the units and connections are equivalent and equivalence is preserved when they are composed, the networks are equivalent” is a conditional theorem. It does not by itself verify any physical connection or prove that the hypotheses hold. The checks must correspond to the operations and connections of the author's V machine, not to a representation added from the Q model.

The comparison criterion must start from a common protocol C, defined without presupposing the outcome of either machine. It includes operationally corresponding preparations, controls, permitted connections, access restrictions, readout times and settings, comparable outputs and permitted resources. Each implementation implements that protocol through its own physical mechanisms.

Comparison element	Q's obligation	V's obligation
Preparation	Declare how it implements the protocol input	Declare how it implements the corresponding input
Operation	Declare or characterize its response to the common control	Declare or characterize its response to the same control
Connection	Specify interfaces and joint physical transformation	Specify interfaces and joint physical transformation
Internal access	Respect the observations permitted by C	Respect the same restrictions
Readout	Record outputs according to C's times and settings	Record outputs according to C's times and settings
Evidence	Identify model predictions and available data	Identify model predictions and available data
Resources and errors	Declare communication, control, precision and losses	Declare the same types of resources and errors

V is not required to have a Hilbert space, stored amplitudes or an update mechanism identical to Q's as a condition of admission. Nor is Q required to adopt V's electronics or relational representation. What must be compared is the full observable distribution:

$$(P_Q(a, c_{\text{protocolo}}), P_V(a, c_{\text{protocolo}})).$$

Predictions must be derived from the declared rules of each implementation, without adding to V an architecture or mechanism different from those specified by the author. The comparison may be theoretical between ideal models or experimental between characterized devices; which one is being performed will be expressly identified. An ideal mathematical agreement will not be confused with a physical validation of either machine.

The need to compare joint distributions is a common rule: a Q network is likewise not characterized for all protocols by knowing only the distributions of its isolated units. The absence of prior measurement does not remove that obligation in either network.

If a composition correspondence is proposed, it must be checked with the operations and connections independently specified in both models. Different internal structures may produce the same outputs; the proof does not require imposing Q's structure on V.

Therefore, the pending step is not “adapting V to Q's internal definition,” but defining the proposed physical connection, its common protocol with the Q connection and comparing both responses without assuming their equality.

20.2. Local construction of V1, V2 and V3

The three V machines are deterministic and are built with conventional electronics or software. Preparation declares the connections and controls; it does not read internal outcomes not fixed by that preparation. Measurement is triggered only once at $t = t_0$.

- V1 preserves the operations H, H, the received reversible oracle and H, with the declared preparation $(0, 1)$.
- V2 preserves the work register prepared in 1, the controls prepared in 0, the controlled modular multiplications and the inverse Fourier connections.
- V3 preserves the preparation and operation order of the received protocol.

These descriptions do not store a table of joint amplitudes. The programs v1.py, v2.py and v3.py use the controller v_relacional.py. They are also included in the portable folder Traductores_V.

The connected implementation receives `preparar(plan)` and `disparar(t0)`. Preparation delivers no outcomes; triggering records a single joint readout. Querying again returns the bits already recorded and does not repeat the measurement. A detector failure consumes that preparation.

The controller does not traverse the gate plan or possible outcomes upon triggering. Recording and validating the received bits do not replace the dynamics of the connections. The signal formulas for one unit are not converted into a state table for all units.

The current code prepares the plans and manages measurement. Connecting and verifying the joint implementation of the operations of the three machines remains to be done. Without that connection, it reports what is pending: it does not calculate an output from Q or invent one. This distinction describes the state of the code; it does not add a physical condition to the definition of V.

The test detectors check the preparation and triggering contract. Their test bits are not results of the complete algorithms. Results from simulated Q references belong to the checker, not to V. Complete tasks and timings will be compared with the implementations and execution conditions identified for both.

20.3. Composition of internal machines and collapse propagation

Construction rule clarified by the author on 19 October 2026: a V machine may contain modules that are themselves V machines. Their circuits and relations are known and prepared, not the values of variables that have not yet been fixed:

$$V_t(V_1, \ldots, V_m), \qquad \mathbf{x}_i(t_i) \in \{0,1\}^{r_i} .$$

Here V_t is the machine containing the V_i modules, and r_i counts the inputs of module i. The instant t_i identifies when these inputs become fixed by measurement or propagation from another module. Values propagate through the prepared relations to the outputs and subsequent modules. Knowing the relation is not knowing its values before they become fixed.

Values explicitly defined as 0 or 1 and their consequences propagate first. Shared dependencies are preserved: an independent output is not chosen at each connection, and a source is not read again to resolve each node.

In a protocol with a single trigger at $t = t_0$, internal instants t_i describe the fixing and propagation responding to that trigger; they do not introduce earlier external observations. No external detector per module or prior knowledge of unfixed internal values is required. This rule also applies to the modular and Fourier composition of V2. Its implementation status is documented separately in the current results.

21. There is no stored ξ

$D_{REGISTROBINARIO}$ — Recorded output of multiple units.

Deps: D_DESCONOCIDO, D_LECTURA

ξ represents lack of knowledge of the internal state until measurement at $t = t_0$, not a stored physical word:

$$K(V_1) = \xi, \quad K(V_2) = \xi, \quad \ldots, \quad K(V_n) = \xi .$$

Upon measurement:

$$V(t_0) = (v_1, v_2, \ldots, v_n), \qquad v_i \in \{0, 1\} .$$

We obtain an outcome, never ξ.

22. The question of the 2^n states

A system of n bits mathematically admits 2^n possible combinations. For certain relations, V does not have to represent them explicitly during each run. Extending this property to all Q protocols is a separate question that still needs justification.

For example:

$$V_2 = (1 - V_1), \qquad V_3 = V_1, \qquad V_4 = (1 - V_3) .$$

We do not need to construct a table of $2^4 = 16$ combinations to implement those relations.

$$\text{n valores desconocidos} \neq \text{una representación física de } 2^n \text{ estados} .$$

23. V does not represent Q's state vector

$D_{OBJETIVORELACIONAL}$ — Open objective of avoiding the exponential representation of amplitudes; not a proven result.

Deps: D_RELACIONES

A classical simulation may attempt to represent a register of n units, where n is a nonnegative integer and D = 2^n. The vectors e_0, ..., e_{D-1} form the orthonormal computational basis of the complex space of dimension D. The coefficients α_j are complex and j ranges over the integers from 0 to D-1. For a normalized pure state, the sum of their squared moduli is one. With those conventions, the vector expansion is:

$$\text{ket}\,(\Psi) = \sum_{j=0}^{2^n-1} \alpha_j e_j \,.$$

The proposed V architecture aims to avoid storing $\alpha_0, \ldots, \alpha_{2^n-1}$. Whether it can do so for all protocols of the chosen Q model must be checked against V's own rules. The relational procedure proposed for investigation is:

$$R_0 \mapsto R_1 \mapsto \cdots \mapsto R_k \mapsto (v_1, \ldots, v_n)\,.$$

24. Replication, not simulation

V has its own physical implementation, signals, relations, propagation, time and measurement. We require equivalence of observable outcomes:

$$\text{phys}\,(Q) \neq \text{phys}\,(V)$$

while we investigate:

$$Q \equiv_{\text{op}} V\,.$$

Physically different, operationally equivalent.

25. General replication criterion

$D_{EQUIVALENCIA}$ — Definition of the observable criterion, not an assertion that universal physical equivalence has been established.

Deps: D_PROTOCOLO, D_DISTRIBUCIONCONJUNTA

For a protocol C with a fixed correspondence between the output labels q and v of both machines:

$$P_Q(q, c_{\text{protocolo}})\,.$$

and:

$$P_V(v, c_{\text{protocolo}})\,.$$

Operational replication requires:

$$P_V(v, c_{\text{protocolo}}) = P_Q(q, c_{\text{protocolo}})\,.$$

It is an experimentally refutable claim.

26. Q-V symmetry principle

No exigir a V lo que no exigimos a Q.

And reciprocally: do not grant V information that Q does not have. The comparison must be performed under the same rules.

27. What we have found

We have considered unknown value, binary measurement, relations, operations without intermediate measurement, time evolution, propagation, phase ϕ, interference, frequencies, alternative measurements, related units, independent settings, correlations, composition, extension to n units and joint measurement.

We have not needed to introduce ξ as a physical state or measure intermediate values. The information needed to continue computation may reside in physical relations.

28. A different conventional electronic machine

We can build a machine whose principle is:

no medir mientras se calcula.

It can use logic gates, delays, oscillators, phases, sum and difference, feedback, pulses, excitation, inhibition and temporal relations. The novelty may lie in **the architecture and the way information is used**.

29. Beyond the qubit

Here V is deliberately restricted to an output $b \in \{0, 1\}$ to compare it with Q. A general V architecture could admit richer states and relations, including a complex domain and architectures inspired by the biological neuron. That extension is outside this first work.

30. The question changes

The question is not “how do we simulate Q?” but:

> **Is there any observable operation performed by Q that a machine V, subjected to exactly the same conditions of knowledge, propagation and measurement, cannot replicate?**

31. Potential consequence

If V can reproduce the relevant operations of Q, we could investigate machines built with:

componentes convencionales + valores desconocidos + relaciones conocidas + propagación + medida

for tasks currently associated with quantum architectures.

32. What I am not claiming

$D_{ALCANCE}$ — Scope and pending physical questions.

Deps: D_HIPOTESISV, D_EQUIVALENCIA, D_OBJETIVORELACIONAL

This work does not yet present a physically built V, a complete electronic architecture, an experimental speed advantage or an experimental demonstration of all quantum algorithms.

It establishes a construction principle and a comparison protocol. The remaining questions are precisely what makes building it interesting.

33. Working hypothesis

> **A conventional electronic machine capable of keeping its internal values unknown while physically constructing, preserving, composing and transforming their relations can operationally replicate a quantum machine if, under the same preparations, transformations and measurements, it reproduces the same observable distributions.**

$$Q \equiv_{\text{op}} V$$

is the hypothesis we propose to study.

Its minimal scheme:

$$\xi \mapsto \xi \mapsto \cdots \mapsto \xi \mapsto b \in \{0,1\}$$

And always:

$$\xi\text{:resultado binario no observado}\,.$$

34. Conclusion: an open working hypothesis

$D_{ESTADOINVESTIGACION}$ — Conclusions of the development and status of the hypothesis.

Deps: D_ALCANCE, D_SIMETRIA, T_AMPLITUDECOND, T_SECUENCIACOND

The idea presented in this work is simple: **we can build a machine with conventional electronics that operates under the same fundamental conditions we have imposed on a quantum machine.**

The starting point is:

$$\xi\text{:resultado binario no observado}\,.$$

ξ is not a third state, is not a stored value and does not belong to the machine's logical domain.

The machine continues working with 0 or 1, but we forgo knowing the value while computation takes place.

What we can know and transform are the relations:

$$R_0 \mapsto R_1 \mapsto \cdots \mapsto R_n\,.$$

Only when we perform the measurement $t = t_0$ do we obtain:

$$b \in \{0, 1\}\,.$$

We never obtain ξ.

V does not aim to mathematically simulate Q:

$$\text{V replica Q; no simula Q.}$$

This opens a technological and conceptual possibility: **investigating machines built with conventional electronics capable of operationally reproducing what we currently build quantum machines for**, and exploring V architectures that need not be limited to Q's structure.

What is presented here is a **working hypothesis**.

The added development establishes phase identities and conditional ideal constructions for readout and update of one unit, and the connection plans of the three V machines. It also makes explicit the CHSH bound when a local distributed protocol without communication is required. These results do not constitute a proof of universal physical equivalence or an experimental validation of V.

The attached record NOTAS_DESARROLLO_ES_52.md preserves the conditions, checks and open questions so that they are not lost as the work continues.

I encourage researchers in quantum computing, electronics, physics, mathematics and computer science to study it, debate it, attempt to refute it, extend it and, above all, build it.

I do not consider this article an endpoint.

It is a starting point.

Much work remains to be done.

Invitation to an independent experimental comparison

With the resources available, we have developed the conceptual analysis, identities and one-unit constructions specified here, and the connection and measurement-control plans of V1, V2 and V3. The controller tests check preparation and triggering; they are not presented as results of the complete algorithms of those machines.

These positive results correspond to the models and protocols analyzed; they do not constitute proof of universal equivalence of the physical V architecture. The analysis also identifies limits, in particular that of a local implementation without communication against CHSH correlations. Experimental testing and characterization of the proposed relational architecture remain pending.

I am an independent researcher with modest means. If I do not have access to a real quantum processor to perform the comparison, I invite those who do to test the proposal and share their results, whether they find agreements or differences.

The comparison must respect the premises set out at the beginning: corresponding preparations, independence of inputs when the protocol requires it, declared operations and connections and the same readout and evaluation criteria for Q and V. No external synchronizations or correlations that are not part of the protocol will be introduced into V.

A Python implementation may help specify and compare V's own rules; if it models a circuit not yet built, its results will be identified as predictions of that model. If it controls and records a physical V circuit, that implementation will be documented. Q results must distinguish between simulation and execution on real hardware. The V implementation will respect its relational architecture and its own rules, without replacing them with a simulation of Q.

To allow the comparison to be reviewed and repeated, I ask that the protocols, implementations used, processor identification, relevant configurations and calibrations, number of repetitions, output data and their statistical uncertainties be shared. Losses, data selections and discrepancies must also be declared.

Lack of access neither confirms nor refutes the hypothesis: it leaves the experiment pending. An agreement will establish the scope of the protocols compared; a reproducible difference will make it possible to locate a limit or a condition of the proposal that needs revision.

If the proposal passes these comparisons, I hope the results will facilitate future collaborations and that access to the necessary means will cease to be a barrier to further investigation. That possibility is a motivation for making the work available to others, not an anticipated experimental conclusion.

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