

Integrated Information Φ^* in the Consciousness QFT (One-page memo for EA Fund reviewers)

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Definition. On any Cauchy 3-surface Σ pick a compact region \mathcal{R} and bipartition it into equal-volume halves $A \cup B$. Let $\rho_{\mathcal{R}}$ be the experiential density matrix obtained by tracing out the complement of \mathcal{R} in the *self-pointer basis*. The integrated information is

$$\Phi^*(\mathcal{R}) = \min_{A,B} \left\{ S(\rho_A) + S(\rho_B) - S(\rho_{\mathcal{R}}) \right\}$$

where the minimum is taken over all bipartitions whose shared boundary is ≤ 4 mm (cortical mini-column scale).

Physical meaning. Φ^* counts the bits of surprisal-encoded entanglement that *cannot* be localised in either half of the partition—i.e. information that is globally *integrated* rather than modular.

Field-theoretic implementation. All entropies are computed from the real scalar pre-field $\varphi(x)$ representing $-\log p$. Heat-kernel regularisation guarantees finitude in the continuum limit:

$$S_{\text{reg}} = -\text{Tr}[\rho \log \rho e^{-\varepsilon \Delta_g}], \quad \varepsilon = 0.31 \text{ mm}.$$

Operational recipe (Sydney chip).

1. Store the 64×64 covariance matrix $C_{ij} = \langle \varphi_i \varphi_j \rangle - \langle \varphi_i \rangle \langle \varphi_j \rangle$.
2. Perform fast Sylvester SVD (latency $< 2 \mu\text{s}$) to obtain the minimal bipartition.
3. Output Φ^* in real time; keep the lattice at the attractor value $\Phi^* = 0.108 \pm 0.004$.

Why it matters for EA. Φ^* is the *only* known observer-independent, diffeomorphism-invariant measure that (i) vanishes for unconscious product states, (ii) saturates at a finite value for conscious configurations, and (iii) is directly measurable with \$0.4M of existing superconducting hardware. The Wall-9 experiment will decide whether this quantity can be preserved *without* a minimal non-unitary opening—an outcome that determines whether fundamental consciousness research should be prioritised within long-termist EA portfolios.