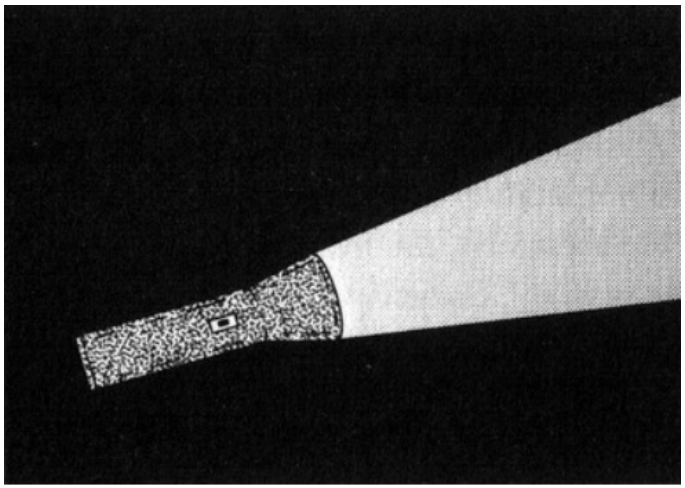
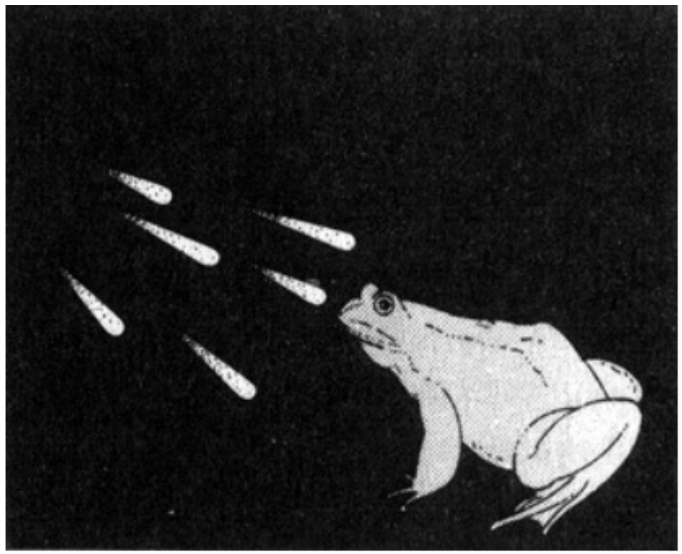
Multiverse

February 12, 2026

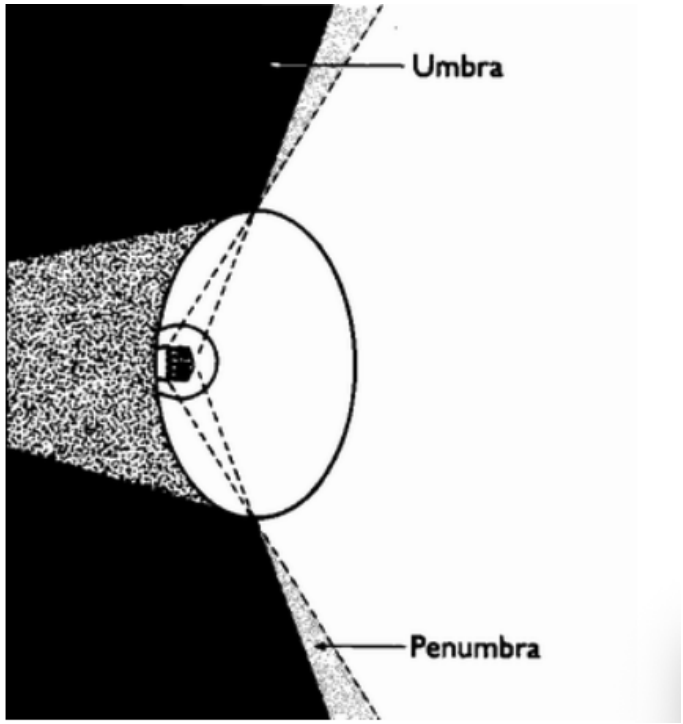
Light from an electric torch



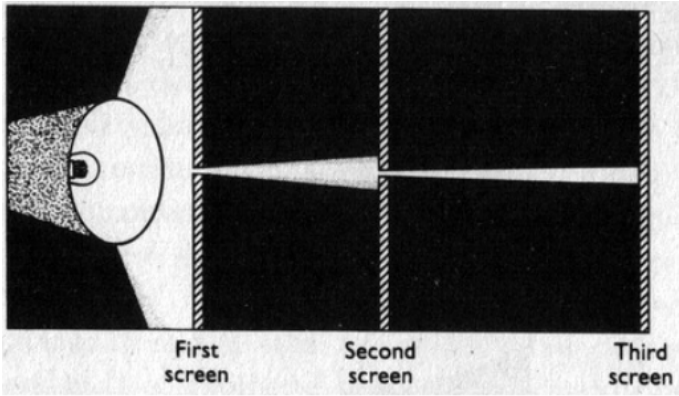
Frogs can see individual photons



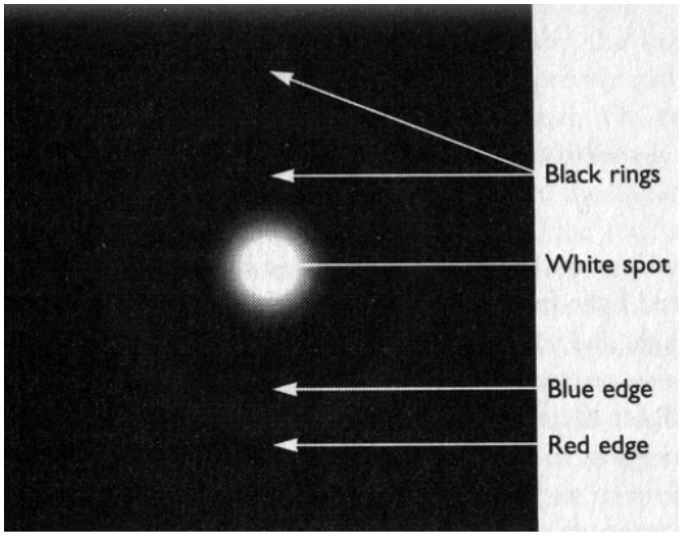
Light travels in straight line?



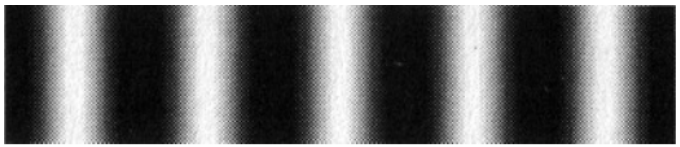
Beam of light through two narrow holes



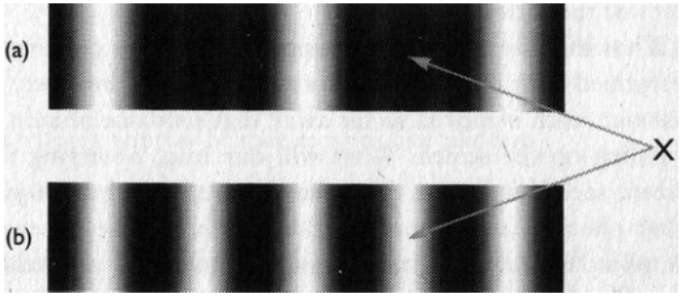
Pattern for a white beam



Shadow cast by a barrier of two straight parallel slits



4 vs 2 slits



Hilbert Space Structure

Let

$$\mathcal{H} = \mathcal{H}_S \otimes \mathcal{H}_A \otimes \mathcal{H}_E$$

denote the Hilbert space of system, apparatus, and environment.

Initial state:

$$|\Psi_0\rangle = \left(\sum_i c_i |s_i\rangle\right) \otimes |A_0\rangle \otimes |E_0\rangle, \qquad \sum_i |c_i|^2 = 1.$$

Unitary Measurement Interaction

Measurement interaction is unitary:

$$U\big(|s_i\rangle \otimes |A_0\rangle\big) = |s_i\rangle \otimes |A_i\rangle.$$

By linearity:

$$|\Psi_1\rangle = \sum_i c_i \, |s_i\rangle \otimes |A_i\rangle \otimes |E_0\rangle.$$

No collapse invoked.

Decoherence

Environment interaction:

$$|A_i\rangle|E_0\rangle \longmapsto |A_i\rangle|E_i\rangle, \qquad \langle E_i|E_j\rangle \approx \delta_{ij}.$$

Final global state:

$$|\Psi_{\text{final}}\rangle = \sum_i c_i \, |s_i\rangle \otimes |A_i\rangle \otimes |E_i\rangle.$$

Decoherence suppresses interference between branches.

Copenhagen Interpretation

Add projection postulate:

- With probability $|c_k|^2$, the state collapses to

$$|s_k\rangle \otimes |A_k\rangle \otimes |E_k\rangle.$$

- All other components are removed.

$$|\Psi_{\text{final}}\rangle \longrightarrow |s_k\rangle \otimes |A_k\rangle \otimes |E_k\rangle.$$

Non-unitary, stochastic postulate.

Everett (Many-Worlds) Interpretation

No projection postulate.
The full state

$$|\Psi_{\text{final}}\rangle = \sum_i c_i \, |s_i\rangle \otimes |A_i\rangle \otimes |E_i\rangle$$

is physically complete.

Each decohered term defines a branch.
Observers in branch i experience outcome i.

Born rule:

$$p(i) = |c_i|^2$$

interpreted as branch weight.

Double-Slit: No Which-Path Detection

After slits:

$$|\psi\rangle = \frac{1}{\sqrt{2}}(|L\rangle + |R\rangle).$$

Screen amplitude:

$$p(x) = \left|\frac{1}{\sqrt{2}}(\psi_L(x) + \psi_R(x))\right|^2.$$

Interference term:

$$2\,\mathrm{Re}(\psi_L^*(x)\psi_R(x)).$$

Double-Slit: With Which-Path Detection

Entanglement with detector:

$$|\Psi\rangle = \frac{1}{\sqrt{2}}\left(|L\rangle|D_L\rangle + |R\rangle|D_R\rangle\right), \qquad \langle D_L|D_R\rangle \approx 0.$$

Reduced density matrix:

$$\rho_S = \frac{1}{2}\left(|L\rangle\langle L| + |R\rangle\langle R|\right).$$

No interference:

$$p(x) = \frac{1}{2}|\psi_L(x)|^2 + \frac{1}{2}|\psi_R(x)|^2.$$

Essential Difference

Shared Formalism:

- Hilbert spaces
- Unitary evolution
- Decoherence
- Born probabilities

Single Divergence:

- Copenhagen: collapse is a physical process.
- Everett: universal unitary evolution; collapse is branch-relative conditioning.

Mathematics identical. Ontology differs.